Sunday, 16.00-17.30

■ SA-50

Sunday, 16.00-17.30 - Plenaries room

Opening Session

Stream: Plenary Sessions
Invited session

Monday, 8:30-10:00

■ MA-01

Monday, 8:30-10:00 - Room 118

Railway Scheduling Problems

Stream: Railway and Metro Transportation
Invited session
Chair: *Thomas Schlechte*

1 - Maintenance in the Rolling Stock Rescheduling Model
Joris Wagenaar

In this paper we propose a formulation to take maintenance into account in disruption management models for passenger railway transportation. During a disruption part(s) of the railway infrastructure can no longer be used. To uphold as much of the passenger service as possible, a new rolling stock schedule should be created as soon as possible. A selected amount of the allocated rolling stock units are scheduled to have a maintenance check somewhere during the operations. That is why we propose an integrated formulation to take maintenance right from the start of the disruption into account.

2 - The Demand Balancing Problem in Rail Freight Service
Hanno Schülldorf

One major issue in rail freight service is the volatility of the demand matrix. Optimization models usually try to handle this using stochastic optimization techniques or robust optimization. We propose a different approach in optimizing the demand matrix. We try to find a balanced matrix by asking some customers to ship another day or from a different terminal (if possible), so the problem we try to solve is: which customer should we ask and what should we offer him for his inconvenience? We will discuss some modelling issues on this problem and present some results on real-life instances.

3 - A Decomposition Method for Multi-Period Network Expansion
Andreas Bärmann, Alexander Martin

We present a mixed-integer model for the expansion of the edge capacities in a multi-commodity flow network over multiple periods. It allows several different types of upgrades per edge with varying implementation times. Its output is a schedule indicating the expansions to be realized in each period to maximize the throughput. For the solution of this large-scale problem, we propose a timewise decomposition scheme to obtain high quality solutions. The method is applied to data for the German railway network and traffic forecasts until 2030 from our partner Deutsche Bahn AG.

4 - Optimization Based Real-Time Decision Support at Motorail Terminals
Pascal Lutter, Brigitte Werners

Motorail transportation deals with long distance transportation of passengers along with their vehicles on a train. Vehicles are loaded onto special motorail transportation wagons at motorail terminals which differ from container terminals regarding layout, storage space and transport goods. Due to limited loading time, shunting and loading operations have to be performed very fast. A mathematical optimization model is developed to select subsets of vehicles for rapid shunting and loading operations. We present the implementation and show results of our real-world decision support system.

■ MA-02

Monday, 8:30-10:00 - Room 111

Routing Problems with Profits and Other Applications

Stream: Vehicle Routing
Invited session
Chair: *Jose M. Belenguer*

1 - A New Vehicle Routing Problem: Models and Algorithm
Qie He, Ricardo Fukasawa, Yongjia Song

We study a capacitated vehicle routing problem (CVRP) where the objective is to minimize the total energy consumption. Different from the traditional CVRP, the objective is a nonlinear function of the edge variables. Further, we proposed two formulations for the problem: a one-commodity flow formulation and a set partitioning formulation. We compare the strength of the LP relaxations of the two formulations and other related formulations. Finally, we also provide some preliminary computational results based on the two formulations.

2 - Routing for Blood Supply Management
Ali Ekici, Okan Ozener

In this paper, motivated by the practices in blood supply management, we study a variant of the vehicle routing problem. Considering processing requirements of donated whole blood in order to extract platelets, we analyze the pickup operations from donation centers and develop algorithms to maximize the platelet production.

3 - Modeling and Solving the Traveling Salesman Problem with Priority Prizes
Reinaldo Morabito, Henrique Luna, Vitoria Pureza

The Traveling Salesman Problem with Priority Prizes (TSPPP) is an extension of the classical TSP where the node visitation orders are taken into account in the objective function. A representation of the TSPPP is here grounded in the point of view of Koopmans and Beckmann (1957), where the TSPPP is viewed as a special case of a quadratic assignment problem. The objective is to find a maximal profit sequence of the client visitations considering the collecting prizes and traveling costs. Mixed-integer programming formulations and an ant colony heuristic are presented to cope with the TSPPP.

4 - A Branch-and-Cut Algorithm for the Capacitated Team Orienteering Problem
Jose M. Belenguer

In the capacitated team orienteering problem, a given set of potential customers, each one with a demand and a profit, can be collected by a fleet of capacitated vehicles. The task is to select a subset of customers with maximum profit and to design a set of routes to collect them in such a way that constraints on the demand collected and the maximum time duration of each route are satisfied. Based on a new two-index formulation, a branch-and-cut algorithm is implemented. The model is strengthened by new families of constraints. Computational results on benchmark data sets are reported.

■ MA-03

Monday, 8:30-10:00 - Room 001

Airline/Airport Optimisation in Operations and Scheduling

Stream: Aviation
Invited session
Chair: *Cheng-Lung Wu*

1 - An Operational-Safety Oriented Optimization of Airport Gate Assignment
Yi Gao, Wei Dongxuan

Capacities of many international airports are constrained by shortages of available gates for arrival flights. This study considers operational efficiency as well as operational safety, particularly the potential conflict between adjacent gates, in assigning aircraft to airport gates. Instead of relying on ad hoc adjustment to push back timing at gate, we proposed a model that proactively avoids potential conflicts without significantly sacrificing efficiency. The testing based on scenarios of different scales proved that the method is effective in solving conventional gate assignment problem.

2 - The Single Day Aircraft Maintenance Routing Problem
Stephen Maher, Guy Desaulniers, Francois Soumis
Aircraft maintenance planning is of critical importance to the safe and efficient operations of an airline. Unfortunately, it is common for maintenance plans to become infeasible due to schedule perturbations. This talk presents a novel approach that ensures a sufficient number of aircraft routes are provided each day to satisfy maintenance requirements that night. Solving this problem each day nulls the effects of schedule perturbations from preceding days. The results demonstrate the ability of this novel planning approach to improve the maintenance plan for a variety of schedules.

3 - Constraint Programming Model of Integrated Recovery for Aircraft and Crew of Irregular Flight Schedules
Jinfu Zhu, Bo Zhu
The minimum total recovery cost is taken as objective function, the essential constraint conditions are considered, and the constraint programming model of integrated schedule recovery for aircraft and crew is built. The searching algorithm is designed by using mixed set programming method. Then examples were analyzed with POEM, the results show that the total flight delay of the recovered schedule given by the proposed model were reduced by about 25% compared with the sequential recovery method and at least one satisfactory solution can be obtained for all examples.

4 - Auto ID Enhanced Management of Ground Service Equipment in Concurrent Aircraft Turnarounds
Maurizio Tomasella, Katerina Kalamara, Alan Thorne, Duncan McFarlane
We study the problem of coordinating ground service equipment in multiple aircraft turnarounds at the same airport. We quantify the potential for improving operational performance by adopting technologies for automated identification and data capture (Auto-ID), more precisely Radio Frequency Identification and Real Time Locating Systems. We study the impact of Auto-ID on performance indicators such as turnaround delays per flight and number of delayed flights per day. We show results from a discrete event simulation study of the operations of a European Low-Cost-Carrier at a major UK airport.

■ MA-04
Monday, 8:30-10:00 - Room 119

Supply Chain Planning 1

Stream: Supply Chain Management
Invited session
Chair: *Achim Koberstein*

1 - Designing a Planning System for Suppliers of the Machine Building Industry
Nicolas Justus, Herbert Meyr
ERP-based (Enterprise Resource Planning) advanced planning systems use Operations Research methods for solving planning tasks within ERP-systems as optimal as possible. The companies using such planning systems mostly make quite diverse demands on them. Still in most cases it is possible to find a number of common demands for a group of companies which operate in the same industry sector. The dissertation analyzes how the planning tasks of the Supply Chain Matrix can be modeled for such a planning system taking into account the specific demands of the machine building industry.

2 - Analysis, Design and Optimization of the Transport of Less than Container Load (LCL) Shipments for Intercontinental Sea Freight
Cornelia Warmer
The presentation proposes an appropriate mathematical formulation for a real case scenario of the Hub Location Problem. The real-case problem of a leading global supplier of technology deals with the transport of LCL shipments from suppliers (external as well as internal) to consignee plants while the transport between the consolidation points is by sea. To set up a worldwide consolidation network, different potential consolidation points can be chosen and nonlinear costs are considered. The presentation compares a path and a stage oriented formulation for real life situations.

3 - A Production Model for an Automobile Plant with Multiple Main Stages to Support the Bid Process with a Coordinated Cost Estimation
Andrea Borenich, Peter Greistorfer, Marc Reimann
In the automobile supplier industry companies frequently need to make bids, typically based on cost estimates for the production process, to obtain incoming orders. This process is executed in several main stages which are linked by intra-plant logistics. We consider two separate optimization approaches as cost estimates: (1) Optimize all the main stages via a central authority. (2) Inspired by current practice, where each main stage makes its own cost estimate, we analyze different mechanisms to coordinate this decentralized approach. The resulting MILPs are solved with Cplex.

4 - A Stochastic Programming Approach to Determine Robust Delivery Profiles in Area Forwarding Inbound Logistics Networks
Achim Koberstein, Tim Schöneberg, Leena Suhl
One technique to coordinate the suppliers' and the producers' production plans in a supply chain is the use of delivery profiles, which provide fixed delivery frequencies for all suppliers. In this work, we present a two-stage stochastic mixed integer linear programming model to determine robust delivery profile assignments under uncertain and infrequent demands and complex tariff systems in area forwarding based inbound logistics networks. We evaluate our approach using real-world data from the automotive industry.

■ MA-05
Monday, 8:30-10:00 - Room 002

Offshore Upstream Logistics

Stream: Petroleum Logistics
Invited session
Chair: *Irina Gribkovskaia*

1 - Modelling of Supply Vessel Operations With Simulation
Yauhen Maisiuk, Irina Gribkovskaia
Supply vessel schedules are generated according to service requirements of offshore installations characterized by cargo demand and weekly visit frequency. Stochastic factors such as weather uncertainty influence on the execution of schedules so that some visits are not performed. We consider several strategies how the cargo not delivered as planned may be shipped later. To compare the strategies and analyze their performance a discrete-event simulation model is developed. Tests on real data illustrate how application of these strategies for annual horizon reduces the number of delayed visits.

2 - Offshore Oilfield Design
Yury Redutskiy
We address modeling and optimization tools behind the Smart Oilfield technology, dominantly used for unconventional wells in offshore oil production. Decision upon location of the intra-oilfield pipelines network is made during the design phase of the oilfield development project. We apply a multi-stage combinatorial optimization algorithm for the pipelines structure design and for determining pipelines' capacities. The algorithm is used to analyze how decisions made on different stages of the pipeline network design influence production efficiency during the phase of exploiting the reservoir.

3 - Evaluating Robustness of Speed Optimized Supply Vessel Schedules
Aliaksandr Hubin, Ellen Karoline Norlund, Irina Gribkovskaia
Offshore installations need supply vessel services on a regular basis. Weather uncertainty impacts on how service is performed. We incorporate different robustness and speed optimization strategies into the two-phase optimization procedure for generation of supply vessel schedules. To compare performance of these strategies by evaluating robustness of generated schedules with different service parameters a discrete-event simulation model is developed. Based on results from simulation strategies for improving robustness incorporated into the simulation model are applied to modify the schedules.

4 - Robust Supply Vessel Planning with Speed Optimization
Irina Gribkovskaia, Ellen Karoline Norlund

The oil and gas industry needs reliable transport of cargo between onshore bases and offshore installations. Weather uncertainty and sailing speed should be taken into account in supply vessel planning. To address the problem of generating robust and green supply vessel schedules a method combining discrete-event simulation with speed optimization algorithms for voyage generation and applying stochastic optimization for schedule construction is developed. Results of tests on real instances show increased robustness and reduced emissions compared to deterministic planning with constant speed.

■ MA-06

Monday, 8:30-10:00 - Room 211

City Logistic Operations

Stream: City Logistics and Freight Demand Modeling
Invited session
Chair: *Eiichi Taniguchi*

1 - Parking Slot Assignment for Urban Distribution: Models and Formulations
Mireia Roca-Riu, Elena Fernandez, Miquel Estrada

The adequate management of parking space, particularly loading and unloading areas, is a key element in urban distribution. An in-advance booking system can be very useful for city councils and transport operators. The Parking Slot Assignment Problem is defined to aid the implementation of such a system. Mathematical programming formulations are presented for different optimization criteria. Models are analyzed and compared among them, also through extensive computational experience, which provides quantitative indicators of the quality of each formulation.

2 - Evaluating City Logistics Measures for Efficient Management of Road Network Using Multi-agent Systems Model and Geographic Information Systems
Joel S-E Teo, Eiichi Taniguchi, Ali Qureshi

The road authorities in many countries are placing more emphasis on freight traffic and their impacts on the current road infrastructure in recent years due to the effects of rapid urbanization. This research seeks to provide the road authorities with a decision tool using a multi-agent systems approach. The tool incorporates the vehicle routing problem with time window models and is supported by geographic information systems. The evaluated city logistics measures are mainly associated with road infrastructure and network management to achieve an overall benefit for all stakeholders.

3 - Assessing Impacts Of Sustainable Freight Transport Measures On Urban Areas
Carina Thaller, Uwe Clausen

In agglomerations a growth of population and economic activities is observed. The consequences are an increase in handling of goods and urban freight transport. To assess and simulate the impacts on environment, valid models should be developed to identify effective sustainable transport and logistics measures. Therefore, the authors present an evaluation of system dynamics and freight transport models. Outcome is that it is necessary to enable a combination. Hence, the forecast capability of system dynamics and the detailed resolution of transport simulation could be used mutually.

4 - Network Simulation versus Big Data: A Case Study of Traffic Impact Analysis for Off-Hour Deliveries in New York City
Kaan Ozbay, Ender Morgul

In this paper estimation of the impacts of an Off-Hours Delivery (OHD) program to the traffic network of Manhattan and the New York metropolitan area are studied. First, a transportation network simulation is used to simulate the effects of the OHD program on the entire NYC network. Then, GPS data collected from delivery trucks and taxis are used to estimate potential travel time savings for shifting commercial vehicle movements to off-peak hours. The study concludes with a discussion of the predictions from big data based analysis and network simulation model.

■ MA-07

Monday, 8:30-10:00 - Room 003

Models for Gas and Electricity Markets

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Asgeir Tomasgard*

1 - A Multi-Period Stochastic Equilibrium Model for Global Energy Markets
Zhonghua Su, Ruud Egging, Asgeir Tomasgard

We present a multi-period stochastic equilibrium model for global energy markets with players in the supply chains of various fuels. By using multi-horizon scenario trees, uncertainties are classified into long-term and short-term, both of which affect strategic investment decisions and operational decisions. 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. Finally, a case study of Chinese CO2 cap policy is discussed.

2 - Market Power in the German Electricity Market - Increasing Renewable Shares and Congestion Management
Jonas Egerer

Market power has been an important research question for electricity market models, since the market liberalization in the 1990s. Since then, the increasing share of renewable generation has altered the possibilities to execute market power in Germany. We analyze the effects for the German electricity market with an equilibrium model representing a Cournot market. The model is applied to different market designs, including uniform pricing, zonal pricing and nodal pricing schemes.

3 - Modeling Renewable Energy Support Policies for the European Power Sector
Christian Skar, Per Ivar Helgesen, Asgeir Tomasgard

We present a capacity investment model for the European power sector, formulated as a two-stage stochastic game between generation companies. The aim is to analyse different support policies for renewable power production, and how size and location of new capacity investments are affected by the policy scheme selected. The model is tested on three scenarios: a European wide green certificate market, a European wide feed-in tariff system, and a mixed scheme where each nation define independent policies.

4 - Interaction Between Energy Systems Models and Computable General Equilibrium Models
Per Ivar Helgesen, 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. Empirical models are usually linked by a heuristic approach. The purpose of an integrated approach is twofold: 1) Check whether heuristic approaches are able to find equilibrium solutions, and 2) Replace heuristic linking by integrated models.

■ MA-08

Monday, 8:30-10:00 - Room 120

Energy and Environmental Management

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session

Chair: *Peter Letmathe*
Chair: *Wolf Fichtner*

1 - Classification of Power Quality Considering Voltage Sags Occurred in Feeders
Pedro Steiner Neto, Anderson Roges Teixeira Goes, Maria Teresinha Arns Steiner

In this paper we propose a methodology to classify Power Quality for feeders, based on sags and by the use of KDD technique, establishing a quality level printed in labels. To support the methodology, it was applied to feeders on a substation located in Curitiba, Paraná, Brazil. The attributes considered were sag length, duration and frequency (number of occurrences) on a given period of time. On the Data Mining phase, three different techniques were used comparatively: ANN; SVM and GA. With this kind of work, the utilities companies can get better organized for mitigation procedures.

2 - Long-term Effects of Power-to-Gas Storage Technology on Power Plant Dispatch Optimisation in Germany
Tobias Heffels, Russell McKenna, Wolf Fichtner

In the context of structural changes within the German power system, the bottom-up optimisation model PERSEUS-NET performs an integrated long-term dispatch and expansion planning of the power plant mix, considering transmission network restrictions. Since the size of the optimisation problem restricts the temporal resolution and the possibility to model non-linear dependencies, a more detailed dispatch model, based on a rolling horizon approach and a higher temporal resolution, is developed to analyse the effects of storage capacity, especially power-to-gas, on the power system in detail.

3 - Optimization Methods for the Dimensioning of Distributed Energy Systems
Sabrina Ried, Melanie Reuter, Birte Carstens, Patrick Jochem, Wolf Fichtner

Distributed energy systems (DES) generate electricity close to the demand centers. They can be grid-connected or not, but they usually always aim at a high degree of self-sufficiency by integrating renewable energy sources. When planning a new DES, dimensioning the system is the first step of the technical and financial planning. This contribution gives an overview on different approaches for the dimensioning of the components of DES based on a literature review. An analysis is conducted on the suitability of the different approaches and their advantages and disadvantages.

4 - Synthetic Generation of Solar Radiation Data Sets
John Boland

The evaluation of the performance of a system governed by climate variables is best achieved by mathematical models of the performance of the system. The climate inputs to the model must be realistic, representing the climate plus weather variations where the system will be installed. The most effective way of creating test data sets is the construction of synthetic sequences of climatic variables. I model a solar radiation time series and from that construct an algorithm to generate any number of years of synthetic data, using methods in Magnano and Boland (2007) and Huang et al. (2013).

■ MA-09

Monday, 8:30-10:00 - Room 121

Dynamical Systems and Mathematical Modelling

Stream: Dynamical Systems and Mathematical Modelling in OR
Invited session

Chair: *Gerhard-Wilhelm Weber*
Chair: *Yutaka Kimura*
Chair: *Yukihiro Maruyama*

1 - Optimal Control of Treatment of HIV Infection Using Neural Network
Samir Talssi, Noura Yousfi

We developed a new approach for optimal control of drug treatment of HIV infection using neural network techniques. This approach provides us with an independent perspective mechanism of ideas specific to the therapy, and has allowed rapid understanding of the behavior of HIV during treatment, this speed will help us to make good decisions with the aim of reducing the cost of treatment and avoid critical infection. A numerical simulation was performed to demonstrate the efficiency of this neuronal approach.

2 - A New Statement of the Optimal Control Problem of the Metal Crystallization Process in Casting
Alla Albu, Vladimir Zubov

An optimal control problem of the metal crystallization process is investigated for a new model of the furnace. The mathematical model is based on a three-dimensional two-phase initial-boundary problem of the Stefan type. The problem was solved numerically using the gradient methods. To calculate the gradient of the cost function the Fast Automatic Differentiation methodology was used. It is shown that the new model of the furnace leads to a much better crystallization process. This work was supported by RFBR N12-01-00572- and by the Program for Fundamental Research of Presidium of RAS P18.

3 - Maintenance Policies for Modular Monotonic Multi-State Systems
Michael Krause

Modular monotonic multi-state systems consist of several components (modularity), where the maintenance of one component does not impair the performance of the system (monotonicity) and every component may have n states. We assume that the structure function, the stochastic processes for the deterioration of the single components, and the (opportunity) cost for the deterioration of the system performance and for repairs are known. We seek a component-specific strategy which minimizes the sum of the costs for maintenance and deterioration of the system performance in the planning horizon.

■ MA-10

Monday, 8:30-10:00 - Room 122

Optimization Methods for Smartgrid Management

Stream: Optimization Models and Algorithms in Energy Industry
Invited session

Chair: *Cristina Corchero*
Chair: *Miguel Cruz-Zambrano*

1 - Optimal Energy Management System for a Residential Microgrid
Cristina Corchero, Lucia Igualada, Miguel Cruz-Zambrano

The optimal management algorithm presented in this work covers from short-term decisions to the real-time ones. Starting with a 24 hours horizon discretized in quarter-hourly intervals, the algorithm solves a problem based on a Unit Commitment and Economic Dispatch problems. The management system takes measures at real time to correct the deviations regarding to the initial forecast data. The corrections are optimally computed every 30 seconds, and they are recalculated before to send the set-points every 3 second to the microgrid.

2 - Cooperative Day-Ahead DSM for Expected Cost Minimization in Microgrids
Italo Atzeni, Luis G. Ordóñez, Gesualdo Scutari, Daniel Palomar, Javier Fonollosa

Microgrids are the local-level building blocks of the smart power grid that intelligently integrate renewable sources and enable customer participation. We discuss a holistic-based, distributed day-ahead DSM method where the subscribers of a microgrid derive the bidding, dispatchable production, and storage strategies that minimize their overall expected monetary expense. In this setting, we propose a cooperative algorithm providing such optimal strategies in a distributed fashion. We show that collaboration yields greater savings with respect to the corresponding user-oriented optimization.

3 - Operational Planning in Smart Grids: Concept and Recent Developments
Julio Usaola

Smart Grids and Operational Planning are a challenge for Operational Research. This planning assesses the benefits of the smart grid technology before the implementation of new control technologies for distribution grids. Operational planning includes generation of random profiles of prosumers including the output of REN and DER resources and the probabilistic scheduling for customers with a given level of flexibility. This schedule must comply with grid constraints. Methods for solving these problems will be presented and the results of ongoing research within an EU project.

4 - Optimal Sizing of EV Fast Charging Stations Including Energy Storage and PV Systems
Lucia Igualada, Miguel Cruz-Zambrano, Cristina Corchero

This work focuses on the optimal design of electric vehicle fast charging stations, including storage systems and PV generation for reducing its impact on the electricity distribution network. The mathematical model includes system CAPEX, OPEX and technical constraints. Different energy cost, usage levels and meteorological scenarios are considered. The technical viability and cost-effectiveness of installing storage systems and PV panels for supporting EV fast charging stations are analyzed and compared for each scenario.

■ MA-11

Monday, 8:30-10:00 - Room 113

Optimization Methods in Transportation Systems

Stream: Combinatorial Optimization
Invited session
Chair:
Chair: *Roberto Roberti*

1 - The Multiple Vehicle Pickup and Delivery Problem with LIFO Constraints
Enrique Benavent, Mercedes Landete, Enrique Mota, Gregorio Tirado

In this paper we consider a time constrained multi-vehicle pickup and delivery routing problem with LIFO (last-in-first-out) rule of service and capacity constraints. We propose two mixed integer formulations of this problem and a tabu search heuristic. The first formulation is a compact one, that is, the number of variables and constraints is polynomial in the number of requests, while the second one contains an exponential number of constraints and is used as the basis of a branch-and-cut algorithm. The proposed methods are able to optimally solve medium size instances with up to 61 nodes.

2 - New Results for the Directed Profitable Rural Postman Problem
Renata Mansini, Marco Colombi

In the Directed Profitable Rural Postman Problem some required arcs may not be served provided that penalty costs are paid. The problem looks for a tour visiting the selected service arcs while minimizing both traveling and penalty costs. We develop a branch and cut algorithm using new valid inequalities and a matheuristic exploiting information provided by a problem relaxation. A final refinement is also applied that inserts connectivity cuts in a heuristic way. All methods are tested on benchmark instances and compared to state of art algorithms. We solve to optimality all open instances.

3 - A Large Neighborhood Search based Matheuristic for a Real Life Vehicle Routing Problem
Simona Mancini

In this paper a new Vehicle Routing Problem arising in real life context is introduced and formalized. The problem goal is to minimize the total delivery cost. An heterogeneous fleet is considered and a limit on the maximum route duration is imposed. For each customer is known the set of periods in which the delivery may be carried out. A Large Neighborhood Search (LNS) based Matheuristic is proposed, in which the neighborhood exploration is performed by the means of the MIP formulation that is able to find the optimal solution in the neighborhood within very few seconds.

4 - An Exact Branch-and-Price Algorithm for the Fixed-Charge Transportation Problem
Roberto Roberti, Enrico Bartolini, Aristide Mingozzi

In the Fixed-Charge Transportation Problem, destinations request goods from origins, and a flow from an origin to a destination implies a variable cost plus a fixed cost. The objective is to minimize the total cost for serving the destinations. In this talk, we propose a branch-and-price algorithm based on a new formulation with exponentially many variables and a pseudo-polynomial number of constraints. The resulting exact algorithm is able to solve instances with more than 100 origins and 100 destinations, outperforming the state-of-the-art exact algorithms from the literature.

■ MA-12

Monday, 8:30-10:00 - Room 004

Graphs and Networks I

Stream: Graphs and Networks
Invited session
Chair: *Marc Demange*

1 - On City Logistics Pickup and Delivery Systems
Abdelkader Sbihi, Marc Demange, Juan Carlos Espinoza Garcia

City logistic problems aim to use the existent city infrastructure to improve the transportations network for goods delivery to the city centres. In this work, we attempt to build a model for the transportation of goods in a city with existing tramlines. Each car being a rack where to store containers, we consider the problem of organizing the containers in each tram so as to make the delivery possible. We first investigate very simple tram networks. The underlying problem leads to some Coloring Problems in particular classes of permutation graphs. We present some first complexity results.

2 - Pursuit-Evasion Games
David Ellison

The cops and robber game is played on a given graph G by one robber and a set of cops. The cops work together in order to catch the robber. First, the cops choose their initial positions on vertices of G, then the robber does the same. During the cops' turn, each cop makes a move along an edge. Then the robber also makes a move along an edge, and so on. The objective is to determine the minimum number of cops required to catch the robber. 1-cop-win completely looped graphs have been characterised. In this work, we consider partially looped graphs for which more complex behaviours may arise.

3 - Complexity of Recognition Algorithms for G-Graphs
Jean-François Culus, Cerasela Tanasescu, Marc Demange, Ruxandra Marinescu-Ghemeci

We will explore some results about complexity of recognising G-Graphs. Like Cayley Graphs, G-Graphs are defined using a group G. Here, we analyze some properties of G-graphs' structure, in the case where G is an abelian group. These properties lead to a polynomial recognition algorithm for G-graphs.

4 - An Optimal Level of Placing a Liaison with Long Communication Lengths between All Members of the Same Level in an Organization Structure of a Complete K-ary Tree
Kiyoshi Sawada

This study proposes a model of placing a liaison which forms relations to all members of the same level in an organization structure of a complete K-ary tree of height H such that the communication of information between every member in the organization becomes the most efficient. When lengths of edges between the liaison and the other members are more than those of edges between members except the liaison, we have obtained an optimal level which minimizes the total distance which is the sum of lengths of shortest paths between every pair of all nodes in a complete K-ary tree.

■ MA-13

Monday, 8:30-10:00 - Room 123

Scheduling Cluster Tools

Stream: Scheduling
Invited session
Chair: *Yuchul Lim*

1 - Optimizing the Job Shop Scheduling Problem - a Neuro-Genetic Approach
Tomas Eloy Salais Fierro, Jania Saucedo, Giovanni Lizarraga

The purpose of this work is to make use of fuzzy adaptive resonance theory to look for patterns in data generated by a genetic algorithm performing a scheduling operation. Fuzzy ART approximates the genetic algorithm's output developing a rule set scheduler. In using a genetic algorithm for job shop scheduling, the solution is an operational sequence for resource allocation. The knowledge acquired by the ANN is applied in solving similar problems duplicating the genetic algorithm's performance and provides solutions that may be superior to simple dispatching rules for similar problems.

2 - Feedback control of cluster tools for wafer delay regulation
Chulhan Kim, Lee Tae-Eog

As a wafer gets bigger and thinner, quality of a wafer has become an important factor to consider as well as productivity. In a cluster tool, variation of wafer delay (waiting time after processing) in each process module has to be kept as low as possible in order to improve and standardise the quality of wafers. In this study, we suggest a feedback control technique to operate cluster tools while maintaining the level of wafer delay. In addition, conditions required for a feasible feedback control are presented. Finally, we examine the minimum wafer delay that satisfies the conditions.

3 - Scheduling of Cluster Tools with Complex Scheduling Requirements
Taesun Yu, Lee Tae-Eog

As technology evolves, new types of cluster tools have been invented in semiconductor manufacturing. A quad-armed cluster tool is the most advanced equipment that involves complex scheduling requirements such as four robot arms, chamber cleaning, and input/output modules. In this study, we examine a robot scheduling problem for quad-armed cluster tools. We develop an optimization model and derive properties of the optimal schedule. In addition, we suggest rule based scheduling techniques to improve the computational efficiency. Finally, the tool performance is compared with conventional tools.

4 - Efficient Scheduling of Inline Cluster Tools by Decomposition Method
Yuchul Lim, Lee Tae-Eog

An inline cluster tool is a multi-cluster tool that consists of linearly arranged radial type cluster tools. The architecture of an inline cluster tool is much more complicated compared to those of traditional cluster tools due to multiple robots, chamber cleaning, and intermediate buffers between two adjacent tools. In this study, a cyclic scheduling problem of an inline cluster tool is examined. First, the system is simplified using decomposition method. Then, we suggest an efficient algorithm to obtain near-optimal and minimum-cycle schedules from the decomposed models.

■ MA-14

Monday, 8:30-10:00 - Room 124

Realistic Production Scheduling

Stream: Realistic Production Scheduling
Invited session
Chair: *Ruben Ruiz*

1 - Bi-Criteria Scheduling on a Batching Machine to Minimize Maximum Lateness and Makespan
Edgar Possani, Marta Cabo Nodar

We study the problem of scheduling n jobs on a batching machine to minimize the maximum lateness and makespan simultaneously, motivated by the burn-in operations of semiconductors. The batching machine has a restricted batch size of b < n, and the processing time of a batch is equal to the largest processing time of all jobs in a batch. We present an exponential neighborhood that can be searched in polynomial time for the maximum lateness objective. Based on this, we develop dynamic programming algorithms to approximate and/or find the Pareto optimal solutions for the bi-criteria problem.

2 - On Generic Approaches to Prove NP-Hardness and to Construct Efficient Algorithms for some Scheduling Problems
Radoslaw Rudek, Agnieszka Rudek

A generic approach to prove NP-hardness of some scheduling problems with variable job processing times is proposed. Although it does not follow "use a formula", but it significantly supports the construction of relevant transformations. Additionally, some sufficient and acceptable simplifications are discussed, which bring closer the idea. The considered method is depicted on the basis of examples. Furthermore, to make the results complement, some approaches to construct efficient algorithms for such problems are provided and analysed.

3 - New Results for the Distributed Permutation Flowshop Problem
Ruben Ruiz, Bahman Naderi

The distributed permutation flowshop problem has been recently proposed as a generalization of the regular flowshop setting where more than one factory is available to process jobs. Despite being recently introduced, this interesting scheduling problem has attracted attention and several heuristic and metaheuristic methods have been proposed in the literature. In this paper we present a scatter search (SS) method for this problem to optimize makespan. A comprehensive computational comparison against 10 existing methods shows that the proposed algorithms produces the best results.

4 - Bottleneck Based CONWIP System in Make-to-Order Manufacturing
Uğur Kahya, Nihal Erginel

CONWIP (CONstant Work-In-Process) has proposed a system by considering both push-based MRP and pull-based Kanban systems. In this work, a bottleneck based CONWIP (B-CONWIP) mathematical model is developed to make-to-order manufacturing environment to aim create backlog list which has scheduled orders. The mathematical model which emerges production scheduling and lot sizes with using bottleneck machine's data is proposed. Its objective function has lateness as manufacturing cost and unbalanced workload cost as the requirements of B-CONWIP. It is solved with a real world data by CPLEX.

■ MA-15

Monday, 8:30-10:00 - Room 125

Network Pricing

Stream: Revenue Management I
Invited session
Chair: *Patrice Marcotte*

Chair: *Rob Zuidwijk*

1 - Bilevel Modelling of Energy Pricing Problem
Luce Brotcorne, Sezin Afsar, Patrice Marcotte, Gilles Savard

Pricing models for demand side management methods are traditionally used to control energy demand which became quite irregular with the recent technological developments and resulted in fluctuations and inefficiency in supply. We propose several bilevel models along with exact and approximate solution procedures to explore the relation and conflict between energy suppliers and customers who are interconnected via smart meters. Besides, this approach enables to integrate customer response into the optimization process of supplier who aims to maximize revenue or minimize capacity requirements.

2 - Joint Design and Pricing of Intermodal Port-Hinterland Network Services: Considering Economies of Scale and Service Time Constraints
Panagiotis Ypsilantis, Rob Zuidwijk

Container terminal operators actively participate in landside transport networks to enhance their connectivity to inland destinations. They have developed so-called extended gates in which sea port container terminals are connected to inland container terminals via frequent services via river vessel and train. We formulate the joint design and pricing of such intermodal freight network services as a bi-level MIP. We consider the intermodal nature of the problem by considering frequency dependent economies of scale and service times. A solution approach and managerial insights are presented.

3 - A Branch-and-Price Algorithm for the Network Pricing Problem with Connected Toll Arcs
Alessia Violin, Bernard Fortz, Martine Labbé

We propose a branch-and-price approach to solve a pricing problem on a network with connected toll arcs. The model is obtained with a Dantzig-Wolfe reformulation, and a column generation algorithm is used to solve the linear relaxation. Various techniques have been considered to improve the efficiency of the solving algorithm, such as stabilisation and different branching strategies. Numerical results show the effectiveness of this approach.

4 - A Mathematical Programming Approach to Compute Booking Limits under a Non-Parametric Choice Model
Gilles Savard, Morad Hosseinalifam, Patrice Marcotte

We present a new customer choice-based approach for computing booking limits in revenue management. The mathematical formulation is based on the CDLP linear model, where customer behavior is characterized by preference lists, and where additional constraints enforce that booking limits be nested. We propose for its solution a column generation procedure based on the efficient (heuristic) solution of the NP-hard subproblem. Computational results show that this approach outperforms alternatives from the current literature.

■ MA-16

Monday, 8:30-10:00 - Room 127

Copositive and Polynomial Optimization I

Stream: Copositive and Polynomial Optimization
Invited session
Chair: *Mohab Safey El Din*

1 - Computing Efficiently Real Points on Determinantal Varieties
Simone Naldi, Didier Henrion, Mohab Safey El Din

We are interested in the study of algebraic varieties defined by rank constraints on matrices whose entries are linear forms with rational coefficients. Our main contribution concerns the construction of efficient exact algorithms for finding real points in every connected component of these determinantal varieties. Solving this problem in a good complexity class, taking advantage of the geometric structure of the problem, is required in many scientific areas, like convex optimization or convex algebraic geometry. I will present a joint work with Didier Henrion and Mohab Safey El Din.

2 - Exact Safety Verification of Hybrid Systems Based on Bilinear SOS Representation
Zhengfeng Yang

In this talk, we address the problem of safety verification of hybrid systems. A symbolic-numeric method is presented to compute inequality invariants of hybrid systems efficiently. Some numerical invariants of a hybrid system can be obtained by solving a bilinear SOS programming via PENBMI solver or iterative method, then the modified Newton refinement and rational vector recovery are applied to obtain exact polynomial invariants with rational coefficients, which satisfy the conditions of invariants. Experiments on some benchmarks are given to illustrate the efficiency of our algorithm.

3 - Border Basis Relaxation for Polynomial Optimization
Marta Abril Bucero

A relaxation method based on border basis reduction which improves the efficiency of Lasserre's approach is proposed to compute the optimum of a polynomial function on a basic closed semi algebraic set. A new stopping criteria is given to detect when the relaxation sequence reaches the minimum, using a sparse flat extension criteria. We also provide a new algorithm to reconstruct a finite sum of weighted Dirac measures from a truncated sequence of moments. We propose a new algorithm to compute zero-dimensional minimizer ideals and the minimizer points or zero-dimensional G-radical ideals.

■ MA-17

Monday, 8:30-10:00 - Room 005

Global Optimization, Modelling and Data Mining

Stream: Global Optimization
Invited session
Chair:
Chair: *Inci Batmaz*

1 - The Problem of Covering Solids by Spheres of Different Diameters
Marilis Venceslau, Renan Pinto, Helder Venceslau, Nelson Maculan

An alternative mathematical programming model for the problem of covering solids by spheres of different diameters will be presented. Given a set of spheres, possibly with different diameters, and a solid, the goal is to locate the spheres in such a way that their union forms a coverage for this solid, using the smallest possible number of spheres of this set. This problem has a specific application in the radiosurgical treatment planning known as Gamma Knife and can be formulated as a nonconvex optimization problem with quadratic constraints and a linear objective function.

2 - External Sensors for Monitoring of Domains
Sergey Astrakov

Let the scope of the sensor be a disc. Then a model of domain monitoring is a cover of a region S by a set of disks C. The cover density is defined as the ratio of the area of all disks C to the area of S. We determine a min-density of external cover where the disc's centers shall not be inside the domain. It is shown that the best external monitoring models of the circular area use three or four sensors. In both cases it is possible to achieve a minimum density D=3. The best external monitoring model of the square area uses four sensors and determines the minimum density D=3/42,3562.

3 - Adaptive Artificial Bee Colony Algorithm for Global Optimization
Erdal Emel, Alkin Yurtkuran

Artificial bee colony (ABC) algorithm is one of the most popular swarm based meta-heuristic algorithms. ABC simulates the intelligent foraging behavior of honeybee swarms. This study proposes a modified ABC algorithm that benefits from a variety of search strategies in literature to balance exploration and exploitation. In the modified version of the ABC algorithm, an adaptive search strategy selection mechanism is used in each cycle. Proposed algorithm is tested on well-known benchmark functions and computational results reveal that the proposed technique is very efficient.

4 - Predicting the Amount of Precipitation of Eastern Black Sea Region by VARMA Models
Ceyda Yazici, Ceylan Yozgatligil

Global warming has many effects on climate including droughts, extreme weather events, changes in temperature, etc.. Extreme amount of precipitation, which is experienced frequently in the last years, can cause floods, harm on crops and damage on urban areas. Thus, it is important to predict the amount of precipitation to take precautions if possible. There are several methods used for this purpose in the literature. In this study, VARMA, which is a time series model, is used to predict the amount of precipitation of Eastern Black Sea Region of Turkey.

■ MA-18

Monday, 8:30-10:00 - Room 112

Multiobjective Optimization in Practice

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair:
Chair: *Volker Maag*

1 - Multiobjective Layout Planning of Photovoltaic Power Plants
Martin Bischoff, Ingmar Schüle, Kai Plociennik

We present an innovative layout planning and optimization concept for large-scale ground-mounted photovoltaic power plants. By analyzing multiple technical and economical quality measures for a set of automatically generated candidate solutions, planners obtain an overview on the solution space. We highlight interaction functionalities at various stages of the workflow, which facilitate attaining the best project-specific planning result with little effort of time. We have realized this concept in the software PVplanet, which is succesfully used by Siemens engineers since more than two years.

2 - A Ray Tracing Technique for the Pareto Set Navigation
Dimitri Nowak

In practice, we often encounter the problem of choosing between solutions determined by multiple conflicting criteria. The goal is to identify the non-dominated solutions and present them to the decision maker. A good presentation of such Pareto frontier is essential.

We introduce a new interactive approach to navigate the decision maker on a possibly non-convex approximation of the Pareto frontier. Given a finite number of precalculated Pareto solutions, we generate an adapted Delaunay triangulation. Combining this with a ray tracing technique, we obtain a new navigation method.

3 - Multiple Criteria Decision-Making in Medical Treatment Planning - is Pareto Efficiency Enough?
Philipp Süss

Planning an intensity-modulated radiation therapy (IMRT) is to determine an energy fluence to so that the resulting dose in the patient's body balances the potential for treatment success and risk of side-effects. The planning problem can be formulated as a convex optimization problem with multiple criteria and several methods to balance the involved trade-offs exist. However, can multicriteria optimization solve real-life problems? We focus on practical aspects of decision support in IMRT planning and present mathematical approaches for modern multicriteria treatment planning.

4 - A Dimension Reduction Approach for the Nondominated Set Approximation
Volker Maag

For a interactive presentation of the non-dominated set of a non-trivial MCO problem it is often necessary to replace the original set by an approximation. This is the more difficult to get the more objectives there are. In the talk we present an approach for convex MCO problems to reduce the number of dimensions by introducing a new, lower-dimensional space for the approximation. This space is obtained by a clever projection of the original image space, which minimizes the error introduced by the loss of dimensions. The approach is illustrated by numerical examples from radiation therapy.

■ MA-19

Monday, 8:30-10:00 - Room 128

Retail Shelf and Inventory Planning

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Heinrich Kuhn*

1 - A Decision Support System for Retail Assortment Planning with Substitution Effects
Alexander Hübner, Heinrich Kuhn

As the increasing product variety in the retail trade is in conflict with the limited shelf space available, managing assortment and shelf space is a core Problem in retailing. We identify the underlying planning problems and develop a Newsvendor-based capacitated assortment problem with stochastic demand and substitution effects. Our numerical examples reveal, that out-of-assortment and out-of-stock substitution effects have a significant impact on total profit and solution structure. We show that our model is scalable to practically relevant problem sizes.

2 - A New MIP Formulation for the Location and Allocation of Products and Product Families on Retail Shelves
Teresa Bianchi-Aguiar, Elsa Silva, Luis Guimarães, Maria Antónia Carravilla, José Fernando Oliveira

We present a new formulation for the location and allocation of products on shelves. Besides deciding the number of facings for each product, the model includes products' sequencing and positioning, respecting real word constraints such as product families grouping in rectangular shapes. We shifted from traditional literature formulations based on the multi-knapsack to commodity flow formulations and used goal programming to handle nonlinearities. An extension to the formulation considers multi-level product grouping. We embedded the formulation in a matheuristic to derive faster solutions.

3 - Data-Driven Order Policies with Censored Demand and Substitution in Retailing
Anna-Lena Sachs, Stefan Minner

We formulate a data-driven model for perishable products that takes prevalent retail characteristics into account. The model integrates forecasting and inventory optimization by considering the effects of external factors on demand, unobservable lost sales and substitution behavior. Our numerical study and real data from a large European retail chain show that the model achieves higher profits than existing approaches. We find that fitting the model on highly censored data yields higher profits since more can be learnt about substitution behavior than based on data with almost no censoring.

4 - A Conic Optimization Approach for SKU Rationalization
Tanguy Kegelart, Mathieu Van Vyve

This paper develops a mixed-integer nonlinear mathematical program to support efficient product portfolio reductions. In our model, the fixed costs elimination and the risk-pooling effects balance the demand contraction due to customer dissatisfaction. Off-the-shelve MIQP solver provides optimal solution to the proposed conic quadratic reformulation, and a real-life industrial case illustrates the program and the algorithm efficiency. Findings show that our mathematical programming subject to various assumptions and estimations is efficient to rationalize portfolios up to at least 400 SKUs.

■ MA-20

Monday, 8:30-10:00 - Room 129

IFORS Prize for OR in Development 2014 - 1

Stream: IFORS Prize for OR in Development 2014
Award Competition session
Chair: *Andrés Weintraub*

1 - Emergency Engineering Rescue Scheduling and its Application in Disaster Relief Operations in China
Zheng Yu-Jun, Ling Hai-Feng, Xu Xin-Li, Chen Sheng-Yong

Disaster relief operations typically involve a large number of engineering rescue tasks, the completion of which is vital to the success of the operations. The paper establishes a model of emergency engineering rescue scheduling, which involves multiple rescue teams and tasks, different and perhaps fuzzy processing times, as well as different importance weights of the tasks. We then propose a solution method based on biogeography-based optimization (BBO), develop effective migration and mutation operators, and employ a multiobjective optimization approach for provide a set of candidate solutions for decision support. Computational experiments demonstrate that our approach can provide competitive performance in test problems. The proposed model and method have been successfully applied to the very recent 2013 Dixi Earthquake occurred in China. Keywords: Emergency engineering rescue scheduling, multi-expert decision, multiobjective optimization (MOO), biogeography-based optimization (BBO).

2 - A Multi-Period Fleet Allocation Model for the Santiago Fire Department
Juan Perez, Sebastian Maldonado

The city of Santiago de Chile has experienced significant but uneven growth in the last few decades, while the location of fire stations and their resources have experienced little change. Additionally, the lack of a centralized and coordinated assignment of resources has caused a significant increment in the average response times in some zones, leading to inefficient and inequitable service. In this study we propose a multi-period fleet assignment model for the Santiago Fire Department. In order to include the seasonal effects observed in the data, a time-series analysis is also presented for forecasting the occurrence of future events, and used as input for the mathematical programming problem. According to our results, an improvement of 10% can be achieved in terms of response time compared to the current scenario by reallocating the existing resources in an optimal way, without the need of adding more fire engines.

3 - Public Transit Planning and Scheduling Based on AVL Data in China
Yindong Shen

The public transit operation planning process commonly includes the following activities: network route design, service planning (frequency setting and timetabling) and scheduling (vehicle scheduling, crew scheduling and rostering). However, the network route design is generally the only one widely recognized, whilst the service planning and scheduling are often ignored in China. This leads to the lack of elaborate timetables and schedules, hence, transit operation is often in disorder with high operating cost. To raise the service level and the utilization of resources, this paper presents an applied study for three cities in China, focusing on the enhancement of the cognition and means of public transit planning and scheduling. A comprehensive framework of public transit planning is first proposed, which is composed of Chinese traditional three items (i.e., network route design, land use for depots and equipment with vehicles) and the following newly added items: intelligent public transit system (IPTS) planning, service planning and scheduling. This is pioneering work in China, during which an IPTS is planned and a random model and solution methods for vehicle scheduling based on AVL data are developed. Experiments under the actual projects show that vehicle schedules with high on-time probability and low cost were compiled, while the essential input parameters such as headways and trip times were set automatically. It is anticipated that the research fruits and practical experiences obtained would be of great benefit in increasing service and management level and resource use to the public transport in China and some other developing countries.

■ MA-21

Monday, 8:30-10:00 - Room 006

Optimization Modeling Software & Systems 1

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *Robert Fourer*

1 - Recent Enhancements in GAMS
Toni Lastusilta

From the beginning in the 1970s at the World Bank till today, GAMS, the General Algebraic Modeling System, has evolved continuously in response to user requirements, changes in computing environments and advances in the theory and practice of mathematical programing. We will outline several recent enhancements of GAMS supporting efficient and productive development of optimization based decision support applications.

2 - Network Algorithms, Constraint Programming, and Decomposition in the SAS/OR OPTMODEL Modeling Language
Leo Lopes, Rob Pratt, Jack Rouse

We present three new features of the OPTMODEL modeling language in SAS/OR software: solving many network-based problems, including Linear Assignment, Minimum-Cost Network Flow, Shortest Path, and Traveling Salesman, without requiring any formulation at all; solving Constraint Logic Programming problems; and solving problems with block-angular structure that is either detected automatically or conveyed by the user with a minimal amount of syntax.

3 - New AMPL Interfaces for Enhanced Development and Deployment of Optimization Models
Robert Fourer

Although modeling languages are best known for providing a high-level interface to optimization solvers, it is just as important that they interface well with users and with applications. This presentation describes new interfaces that have been developed to meet the interface needs of the AMPL modeling language and system. AMPL IDE provides an integrated command interpreter and file editor for model development. AMPL API supports model deployment by enabling applications to invoke many AMPL functions directly, using calls written in popular programming and analytics languages.

4 - Supporting Business Decision Making
Sofiane Oussedik

This presentation will give you an insight into some of the latest clients use cases using IBM ILOG Optimization, and in which decision aid to support the user making the decision was key. The use cases developments have been driven by the need to accomplish key business objectives and deploy the right flexible solution to the user. The presentation will include details on the business problem solved and the challenges faced, as well as the need for a seamless integration with existing systems and processes.

■ MA-22

Monday, 8:30-10:00 - Room 007

Stochastic Models

Stream: Health Care Data Analytics
Invited session
Chair: *Kelvin Yau*

1 - A Simulation Approach to Assess the Adequacy of Survival Mixture Models: Application to Public Health
Andy Lee, Kelvin Yau, Yer Van Hui

The Weibull proportional hazards model is commonly used in survival analysis. It is important to determine adequacy of the fitted model, yet formal testing is lacking, as residual-based measures are inappropriate for censored data. This study develops a diagnostic method for assessing the adequacy of Weibull survival mixture models with random effects. An assessment procedure using Cox-Snell residuals is constructed based on a simulated envelope approach, with further simulations performed to investigate the validity of the procedure. The method is illustrated with public health applications.

2 - A POMDP Model to Evaluate the Inclusion of HPV-DNA Test for Cervical Cancer Screening
Raha Akhavan-Tabatabaei, Esma Gel, Martha Isabel Namen Leon

Cervical cancer is one of the main causes of death among women in developing countries. Different screening polices have been proposed in order to prevent this disease, in the medical community. One of the newest and most popular is the HPV-DNA test as primary screening. This paper proposes a POMDP model in order to evaluate the inclusion of HPV-DNA as co-testing along with cytology, and also to determine the optimal number of tests to be performed in the lifetime of a patient. Age-specific cost-effective optimal policies comparing both QALYs and the costs of tests are presented.

3 - Admission Policies for Walk-in Patients at a Diagnostic Clinic
Nomesh Bolia, Naman Garg, Rahul Malhotra

This paper identifies a walk-in admission policy to minimize revenue loss in case of appointment no-shows in diagnostic scan centers. A dynamic programming model helps decide whether to admit a walk-in, for each state of the system, that is, for all values of system time and walk-in queue length. The optimal choice is obtained by comparing the expected reward contingent on such a choice. A simulation is run after introducing additional stochasticity in the model and the admission policy is compared with alternative heuristics. Results favor the use of the dynamic programming model in practice.

■ MA-23

Monday, 8:30-10:00 - Room 008

Perspectives on Behavioural Operations Research

Stream: Behavioural Operational Research
Invited session
Chair: *L. Alberto Franco*

1 - On the Importantance of Behavioural Operations Research
Raimo P. Hämäläinen

We describe Behavioral Operational Research (BOR), a new research area, defined as the study of behavioral aspects related to the use of operational research (OR) methods in modeling, problem solving and decision support. We need controlled comparative studies on the OR process. Interesting BOR topics include: Model building; Communication with and about models; Behavioral biases and cognitive aspects; Personal, social and group processes in OR facilitation; People in problem solving situations; Learning; Bounded rationality; Comparative analysis of procedures and best practices; Teaching.

2 - Have I been doing Behavioural OR for the Last 20 Years?
Stewart Robinson

Recently there has been much interest in Behavioural OR, possibly following the developments in Behavioural Economics and Behavioural Operations Management. However, the exact nature of what Behavioural OR involves is not well determined. In this paper we shall explore the concept of Behavioural OR. This shall be done with reference to research, primarily in simulation, that I have undertaken over the past 20 years that broadly fit with the motivations of Behavioural OR. What will emerge are two types of Behavioural OR: modelling people behaviour and the behaviour of people with models.

3 - How to Conduct Behavioural OR Studies: A Typology
L. Alberto Franco, Etienne Rouwette

In this presentation we discuss a typology of four approaches for conducting Behavioural OR studies. Although the four approaches could be seen as representing competing perspectives, we see them as being complementary. Each approach provides a different -yet partial-understanding of the behavioural dimension of OR. We argue that coordinating the pluralistic insights from the four approaches can provide a richer understanding of Behavioural OR as a field.

4 - An Outlook on Behavioural OR — Three Tasks, Three Pitfalls and One Definition
Kai Helge Becker

In their recent paper, Hämäläinen, Luoma and Saarinen (2013) have made a strong case for the importance of Behavioural OR. With the motivation to contribute to a broad academic outlook in this emerging discipline, my rather programmatic talk intends to further the discussion by describing three types of research questions I envision as the primary focus of Behavioural OR. Moreover, by relating Behavioural OR to similar academic endeavours, I will discuss three potential pitfalls Behavioural OR should avoid. I will sum up all points addressed by suggesting a definition of Behavioural OR.

■ MA-24

Monday, 8:30-10:00 - Room 212

Preference Learning I

Stream: Preference Learning
Invited session
Chair: *Roman Slowinski*

1 - Deriving Rankings from Incomplete Preference Information: A Comparison of Different Approaches
Rudolf Vetschera

We compare central parameter methods and volume-based methods for decision making under incomplete information. Central parameter methods directly lead to a complete ranking of alternatives. We formulate models to derive ranking from probabilistic preference information (rank distributions and preference probabilities) obtained from volume-based methods. In a computational study, we compare the resulting rankings and analyze information anomalies, i.e., situations in which more information leads to worse results. Preliminary results indicate a high level of correspondence between methods.

2 - Testing for the Multivariate Stochastic Order among Ordered Populations with Application to Ranking and Selection Problems
Ori Davidov

The comparison and ranking of two or more ordered populations based on multivariate data is common in a variety of applications. We develop a nonparametric methodology for analyzing such data. In particular we propose a global K sample nonparametric test for order among vector valued outcomes. The testing procedure can also be used in a post-hoc fashion to answer questions about the ordering of subgroups and/or single outcomes within any subset of groups. The tests can be also used for ranking and selecting the best among K populations.

3 - Handing Inequity Averse Preferences
Alec Morton, Nikolaos Argyris, Ozlem Karsu

We investigate the situation where there is interest in selecting a subset of "good" distributions across a population, where there is some limited information about the Decision Maker (DM)'s preferences. We discuss the unanimity relation when DM's utility function is assumed to belong to any one of the following sets: additive, concave, quasi-concave or S-concave. We propose solution approaches that incorporate DM's preference information to obtain a most preferred solution or a subset of good solutions. The approaches are based on tractable linear programming formulations.

4 - Inducing Probability Distributions on the Set of Value Functions
Salvatore Greco, Salvatore Corrente, Milosz Kadzinski, Roman Slowinski

Recently Stochastic Multicriteria Acceptability Analysis (SMAA) has been coupled with Robust Ordinal Regression (ROR) with the aim of measuring the set of compatible value functions for which alternative a is preferred to alternative b, or for which alternative a is ranked in the k-th position. Usually, the distribution of compatible value functions is supposed to be uniform, which is, in general, not true. We propose a methodology for inducing a distribution of probability on the space of value functions depending on the preferences of the Decision Maker (DM).

■ MA-25

Monday, 8:30-10:00 - Room 009

Infinite-Horizon Problems of Mathematical Economics

Stream: Mathematical Economics
Invited session
Chair: *Alexander Zaslavski*

1 - Infinite-Horizon Variational Problems and Oscillations
Joel Blot

We consider infinite-horizon variational problems in presence of a discount rate where the initial value is fixed, as in macroeconomic optimal growth models, and when the unknown function belongs to special classes of functions from the nonnegative real numbers set into a finite-dimensional normed space, as the class of the bounded functions, the class of the almost periodic functions. We present results of existence and results on the solutions of the associated Lagrangian systems.

2 - Infinite-Horizon Differential Games in the Discrete-Time Case
Naila Hayek

We study infinite-horizon differential games in the discrete-time case and use Pontryagin principles on the infinite-horizon optimal control problems associated to the differential games. We give an application to a management problem of competition between two internet service providers, for which a unique Markov-Nash equilibrium is obtained.

3 - Optimal Control Problems with Infinite Horizon and Budget Constraints
Sabine Pickenhain

We consider a class of infinite horizon optimal control problems. This special class of problems arises in the theory of economic growth and in processes where the time T is an exponentially distributed random variable. Budget constraints are also typical for this applications. We show that in natural way the state and control variable belongs to a Weighted Sobolev space and Lebesgue space, respectively. In this spaces the problem can be treated by Hilbert space methods.

4 - Optimal Control Problems with Nonsingleton-Turnpikes
Alexander Zaslavski

We study stability of the turnpike phenomenon for approximate solutions for a general class of discrete-time optimal control problems with nonsingleton-turnpikes and with a compact metric space of states. This class of optimal control problems is identified with a complete metric space of objective functions. We show that the turnpike phenomenon is stable under perturbations of an objective function if the corresponding infinite horizon optimal control problem possesses an asymptotic turnpike property.

■ MA-26

Monday, 8:30-10:00 - Room 010

Fuzzy Goal Programming

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Mariano Jimenez-Lopez*

1 - Model and Algorithms to Generate Group-Rankings from Interval Fuzzy Preference Relations
María Luisa Martínez, Esther Dopazo, Mauricio Ruiz-Tagle

This paper presents a model and algorithms for the group-ranking problem based on interval fuzzy preference relations given by various stakeholders. The problem is formulated as an optimization problem for constructing a consensus priority weight vector. The proposed approach is made operational by using goal programming techniques. Moreover, the proposed framework provides performance measures to evaluate and visualize the effectiveness of the solution and the deviations from the preferences of the individual stakeholders. To illustrate the methodology a numerical example is presented.

2 - A Fuzzy Goal Programming Approach for the Assignment Problem in Textile Rotary Printing Processes
Manuel Díaz-Madroñero, Josefa Mula, Raul Poler

We propose a fuzzy goal programming (FGP) approach to solve an assignment problem of production orders in a textile rotary printing company. The model contemplates the trade-off between the setup times and the waiting time for orders to be processed. We also present an interactive solution methodology to convert this FGP model into an auxiliary crisp single-objective integer model and to find a preferred compromise solution in an interactive fashion. For illustration purposes, an example based on a real-world industrial problem is presented.

3 - Ordinary Goal Programming with Fuzzy Goals
Mariano Jimenez-Lopez, Amelia Bilbao-Terol, Mar Arenas-Parra

A goal programming (GP) variant, in which some goals can be fuzzy, is proposed. In it, contrary to what happens in ordinary fuzzy GP (FGP) approaches, the tolerance thresholds of the fuzzy goals (FGs) can be surpassed. By an alternative formulation of FGs membership functions a new GP model is built. The objective values not exceeding their threshold are positively valued, accordingly to their membership degree to the FG, like in a FGP approach, otherwise their deviation regarding the threshold are penalized, like in an ordinary GP approach. An application to portfolio selection is shown.

4 - Fractional Transportation Problem with Fuzzy Parameters
Shiang-Tai Liu

This paper investigates the fractional transportation problem (FTP) where the cost coefficients and right-hand sides are represented by fuzzy parameters. Based on Zadeh's extension principle, a pair of two-level mathematical programs is formulated to calculate the fuzzy objective value of the FTP with fuzzy parameters. By applying the dual formulation and variable substitution techniques, the two-level mathematical programs are transformed into ordinary one-level linear programs to solve. Solving the pair of linear programs produces the bounds of the objective value of the fuzzy FTP.

■ MA-27

Monday, 8:30-10:00 - Room 213

OR in Quality Management I

Stream: OR in Quality Management
Invited session
Chair: *Hafize Yılmaz*

1 - Determination of Premium for Service Contracts
Amitava Mitra

Services span a variety of functions such as the transportation of raw materials, assemblies, and sub-assemblies of products to manufacturers. We assume customers may purchase damage protection insurance based on product value. The service company makes every effort to protect the goods and may adopt a system whereby highly-valued goods are provided adequate protection against damage. In this paper we create a model to determine the premium to be charged assuming that it is a function of product value. Further, we assume that a volume discount is given to the purchasing company.

2 - Important Performance among Perceived Service Quality, Customer Attitudes, Satisfaction and Revisit Intention in Traditional Cultural Facility at the IIAC
Changhee Kim, Soo Wook Kim

Today duty-free shops in airports make a lot of profits in the airports where they are located. As a result, managers of duty-free shops can experience profit growth, sale increase, and improvement of service quality. Thanks to this, an airport can experience profit and sales rise; ultimately, a nation can get enhanced and improved national images and GDP rise. This study found some key factors for Traditional Cultural Facilities at airport that improve service quality for customer satisfaction and induce intention of revisit via Important Performance Analysis (IPA).

3 - Bi-Objective Modelling Approach for New Product Development using the Belief Rule-Based Methodology: A Case Study from the Pastry and Confectionery Specialties Industry
Emanuel Savan, Jian-Bo Yang, Dong-Ling Xu, Yu-Wang Chen

In this paper, a bi-objective modelling approach is employed for supporting the decision making in the context of NPD for traditional sponge cakes. Given the features of the industry, modelling both the production prices and the quality of the cakes, was considered essential. A BRB methodology was developed to predict the cake quality based on the different recipes tested; a panel consisting of three cooking chefs was employed to assess the sensory attributes and the overall quality. An additional panel of experts was involved in selecting the optimal solution from the generated Pareto front.

4 - A Decision Model For Assessment of the Firms' Competiviness Level in Terms of Quality
Hafize Yılmaz, Sait Gül, Umut H. Inan

The ferocious competition enforces firms to impose quality management system (QMS). QMS provides many opportunities for improvement of process efficiency and customer satisfaction. With this study, we aim to build a decision model for ordering the selected packaging firms with respect to the conditions of a QMS and to determine the competitiveness of firms in the view of QMS understanding. We utilized Simos' procedure to determine the importance of the criteria (conditions of QMS) and VIKOR method to order them in terms of their scores obtained from the quality consultants.

■ MA-28
Monday, 8:30-10:00 - Room 130

Challenge ROADEF/EURO 1

Stream: Challenge ROADEF/EURO
Award Competition session
Chair: *Christian Artigues*

1 - Decision Support for Rolling Stock Management — A Contribution to the 2014 EURO/ROADEF Challenge
Sebastian Langton, Martin Josef Geiger, Sandra Huber, Marius Leschik, Christian Lindorf, Ulrich Tüshaus

The 2014 EURO/ROADEF Challenge describes an optimization problem arising in the operative management of trains in a station. It includes the assignment of arriving trains to departures as well as the planning of parking, maintenance and shunting activities. We contribute with a recently developed decision support system using a set of heuristics, each of which tries to optimize a sub-aspect of the problem. In the talk, besides a short description of the solution approach, our computational results on the datasets of the EURO/ROADEF 2014 Challenge and the main insights gained will be presented.

2 - A Math-Heuristic Approach for the Roadef Challenge 2014
Jørgen Thorlund Haahr, Simon Bull

Handling all train operations between arrivals and departures at large terminal train stations can easily become a difficult task. Every train unit must be assigned a non-conflicting route through the available shared resources, with consideration given to operational costs. We propose a solution method for the ROADEF/EURO 2014 Challenge. We present a heuristic framework which decomposes the problem into subproblems and solves the subproblems sequentially, using a combination of MIP formulations, column generation, and heuristic methods. We present results for the provided test instances.

3 - Solving a Train Assignment Problem by Decomposition
Gregoire Spiers

The optimization problem formulated in the 2014 ROADEF Challenge consists in assigning arrival trains to departures. Since it contains various constraints and many decisions have to be taken for the path of each train, we propose an approach that decomposes the problem into smaller ones. These smaller problems are designed in order to reveal well-known mathematical structures such as the hitting set problem, the shortest path problem or all different constraints and are then solved iteratively to converge toward local minima of the problem.

■ MA-29
Monday, 8:30-10:00 - Room 011

Behavioral Economics and Finance

Stream: Financial Optimization
Invited session
Chair: *Xuedong He*

1 - Cost-Efficient Contingent Claims under Knightian Uncertainty: A Distributional Analysis
Mario Ghossoub

In complete frictionless securities markets, no-arbitrage implies a unique linear positive pricing rule inducing a state-price density. Dybvig (1988) showed that the cheapest way to acquire a certain distribution of a security is when this security is anti-comonotonic with the state-price density. We examine a related problem in a market where pricing is via a Choquet integral as in Cerreia-Vioglio et al. (2013), representing some ambiguity in the market. We show that the cheapest derivative instrument Y on an underlying X is anti-comonotonic with X. Finally, we consider a simple example.

2 - Equilibrium Asset Pricing with Rational and Irrational Investors
Jing Guo, Xuedong He

We study a multi-period equilibrium asset problem with a rational investor and an irrational investor. The rational investor maximizes expected log utility and the irrational investor has additional realization utility evaluated by cumulative prospect theory. We prove the existence and uniqueness of the equilibrium price. We derive a stock performance measure and show that the irrational investor invests less in the risky stock than the rational if and only if his loss aversion degree is higher than this measure. We also find that the rational investor dominates the market in the long run.

3 - Quantile Formulation: A Link between Rank Dependent Utility Theory and Expected Utility Theory
Zuo Quan Xu

Under monotonicity assumptions, several schemes to solve quantile optimization problem are proposed in the literature. We propose a change-of-variable and relaxation method to solve the problem without making any assumptions. We show that solving a portfolio choice problem under rank-dependent utility theory (RDUT) reduces to solving a Merton's problem under expected utility theory. With this, the feasibility, well-posedness, attainability and uniqueness issues for the portfolio choice problem under RDUT are solved. The method is applicable to general models with law-invariant measures.

4 - A Processing-Consistent Non-Bayesian Inference Model
Xuedong He, Di Xiao

We consider in the dynamic setting a generic inference model, which is a generalization of the Bayesian inference model by applying distortion on the prior density and replacing the likelihood with the so-called quasi-likelihood. We show that this model is processing consistent, i.e., the posterior density resulting from this model does not depend on how the samples are grouped and processed, if and only if there is no distortion on the prior density at any time except for the initial time and the quasi-likelihood satisfies the so-called product rule.

■ MA-30

Monday, 8:30-10:00 - Room 012

Advances in Financial Mathematics, Economics and OR

Stream: Financial Mathematics and OR
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Thomas Burkhardt*

1 - Multiobjective Optimization of Credit Capital Allocation in Financial Insitutions
Kamil Mizgier, Joseph Pasia

Financial firms allocate capital to business divisions in order to withstand the materializing credit losses and to measure performance of various business lines. We introduce a methodology for optimal credit capital allocation in financial institutions based on Operations Research approach. In particular, we focus on the efficient allocation of economic capital to business divisions characterized by credit risk losses. We compare different allocation methods and provide a rationale behind using OR approach.

2 - Dependence of the Oil Companies' Financial Results on Volatility of the World Oil Price
Elena Kuchina

This paper is focused on the econometric analysis of the differences in responses of the financial results of the world biggest oil companies to the changing volatility of the world oil price. As control variables, some other qualitative factors are used, e.g., the headquarters' or parent company's location, the volume of oil production, company's policy and etc. Panel data of 15 oil companies from 11 countries from the 1st quarter of 2006 to the 3rd quarter of 2013 are used for this analysis.

3 - Effectiveness of Different Trading Strategies for Price-Takers
Lyudmila Egorova

We introduce simulation models of stock exchange to explore which traders are successful and how their strategies influence to their wealth and probability of bankruptcy. The results of our experiments show that there is a critical level of agent's experience such that agents with this or higher level almost sure will survive on the market in the long run. This critical level is just slightly higher and such small value explains why so many people try to trade on the stock exchange.

4 - Portfolio Optimization Using Forecast and Data Envelopment Analysis
Fernando Salomon, Edson Pamplona, Paulo Rotela Junior

This paper aims to analyze the behavior of assets portfolio selected using forecasting techniques associated with Data Envelopment Analysis and optimized by the Sharpe approach. The research method used was mathematical modeling and followed the Box-Jenkins methodology to forecast return, variance, beta, and others indicators using the ARIMA model. These indicators were used as input and output variables in Data Envelopment Analysis model to evaluate the efficiency of Sao Paulo Stock Exchange assets. Finally, we used the Sharpe approach to optimize the composition of the portfolio.

■ MA-31

Monday, 8:30-10:00 - Room 013

Elicitation

Stream: Decision Processes
Invited session
Chair: *Love Ekenberg*

1 - Cardinal Ranking as a Means for Efficient Elicitation
Mats Danielson

The elicitation of preference information in MCDA processes and the lack of practical means supporting it is a significant problem in real-life applications of MCDA. There is obviously a need of methods that neither require formal decision analysis knowledge, nor is too cognitively demanding by forcing people to express unrealistic precision or to state more than they are able to. We suggest a method that tries to balance between the need of simplicity and the requirement of accuracy. The method uses ordinal knowledge.

2 - A Verbal-Numerical Scale for the Evaluation of the ICT Contribution to Development in a Developing Country Context
Florence Kivunike

Typically the use of ICT to support decision making is highly dependent on stakeholder participation. However the situation changes if the aim is to adopt decision making techniques to facilitate the evaluation of the ICT contribution to development (in a developing country context). In essence this requires the adaptation of the elicit action process to suit the developing country context. It is envisaged that stakeholder perceptions can be sought through questionnaires or interviews, aggregated and input into the decision support systems for analysis and evaluation.

3 - Interval Criteria Weights Trough a Slider: The CROC Way
Aron Larsson

Many elicitation methods are cognitively demanding. This may be remedied by an inference engine facilitating interactive use supported by simple visualizations representing imprecise input statements, but still representing these statements quantitatively and formally enabling for quantitative decision evaluation conforming to common decision rules. We show a design for weight elicitation called CROC, using rank-orders supplemented with imprecise cardinal information accessible through a one-dimensional slider.

4 - Participation, Elicitation and Democracy
Love Ekenberg

Simply enabling more participation will not result in enhanced democracy by itself and an adequate mechanism for participation exercises is vital regardless of the democracy model. Furthermore, it seems reasonable that various new media are of relevance in this context. There have been some suggestions lately, but contemporary methods are to a large extent locked into traditional ways of using computer-based texts and images that largely hamper the capacity for communicating and we will discuss how this might be changed.

■ MA-32

Monday, 8:30-10:00 - Room 014

Decision Analysis and Intelligence Processing

Stream: Humanitarian Operations Research
Invited session
Chair: *Erik Kropat*
Chair: *Silja Meyer-Nieberg*
Chair: *Moshe Kress*

1 - A Structured War-Gaming Framework to Support Collective Preparedness for Managing Extreme Risks
Shuang Liu

Characterized by high impacts and low probability, extreme risks pose challenges for conventional risk analysis. We describe an innovative approach to improve the efficiency and effectiveness of management of such risks and applied it in a case of biosecurity management. Our framework integrates a war-game model and a structured decision making approach, and the two are integrative as the role of the model is to serve as an aid to group learning and decision-making. Through this interaction, stakeholders developed a better understanding of the risk and reached consensus in how to manage it.

2 - On Evaluating Conflict and Power of Players within Coalition Formation Games
Kentaro Kojima

This paper aims to construct mathematical methods to analyze conflict and power within coalition formation games. It is one of important topics of game theory that we know how deep conflict of a game is and how much power each player has. Constructing indices to evaluate these factors will help decision making. A coalition formation game is modeled by a game in strategic form associated with a hedonic game. The proposed index evaluates interest opposition on players' preferences and influence of players as a real number. Some numerical examples of the proposed index are provided in this paper.

3 - Finding the Needles in the Haystack: Efficient Intelligence Processing
Moshe Kress, Ned Dimitrov

The advent of computer, communication and sensing technologies has resulted in unprecedented capabilities to gather defense intelligence data from communication networks. As a result, the main intelligence challenge has shifted from collecting data to efficiently processing it. We propose a methodology for searching for relevant data on a social network. The novelty of this methodology is two-fold: (1) a knowledge accumulation model for intelligence processors, and (2) an efficient prioritization algorithm based on graphical models and Bayesian learning.

4 - Strategic Allocation of Medical Surplus
Wee Meng Yeo

Medical surplus recovery organizations engage in take-back program for the benefits of underserved hospitals in developing world. The goal is to bridge the gap between surplus and need. With game theory, we analyse the interactions among recipients when MSRO operates under the pull model that provides inventory transparency. Next, we analyse a push model where the MSRO pushes shipment to the recipients. With the shift of strategic intent from being profit-driven to welfare provision, we present several reversals associated with choice between push and pull within the realm humanitarian OM.

■ MA-33

Monday, 8:30-10:00 - Room 015

Stochastic Inventory Models with Environmental Constraints

Stream: Environmental Sustainability in Supply Chain
Invited session
Chair: *Peter Kischka*

1 - Newsvendor Model with a Second Order Opportunity and Consideration of Transport Emissions
Katja Rettke

One reason for integrating environmental issues into operations management are numerous regulations related to pollutant emissions caused by economic activities. In this study a newsvendor model is developed in which a company faces stochastic demand when ordering a product from two different supply modes and can still improve its forecast by observing a market signal during the sales period. In addition, the company has to comply with an environmental regulation concerning transport emissions. The optimal order quantities are determined and analyzed with respect to relevant model parameters.

2 - The Single Period Inventory Model Under Dual Sourcing and Product Carbon Footprint Constraint
Emel Arikan, Werner Jammernegg

We present a single period inventory control model under a product carbon footprint constraint with an emergency supply option. An upper bound for the carbon footprint is specified as benchmark derived either from the company's environmental target or from an industry standard. While the first order requires long lead times, the emergency order can be supplied in short notice either by an onshore supplier or by an offshore supplier through a faster transportation mode. By comparing the two scenarios, the tradeoff between economic and environmental performance is discussed.

3 - Inventory Models with Transshipment and Environmental Constraint
Peter Kischka, Werner Jammernegg

We consider a single period inventory model with centralized distribution of a product to two retailers. The impact of transshipment with respect to the joint demand distribution is analyzed for different dependency structures. The environmental constraint includes emissions from production, transportation, transshipment and leftovers. At first glance the distribution system with transshipment leads to higher expected profit but also to higher product carbon footprint because of additional transportation operations. In this framework we investigate the potential benefits of transshipment.

4 - Inventory Control with Environmental Criteria and Stochastic Lead Times
Jörg Ries, Johannes Fichtinger

The consideration of environmental impacts has become an increasingly important concern for companies, where major causes of GHG emissions are storage and transportation activities. Additionally, the management of lead times and inherent uncertainties, which are a result of variable transportation times and cause variable emissions, becomes important from an economic as well as an environmental perspective. Thus, we present a multi period inventory control model with stochastic lead times and discuss the impact of lead time uncertainty on the environmental performance of the inventory system.

■ MA-34

Monday, 8:30-10:00 - Room 016

Big Data and Network Methods

Stream: Data Mining in Finance and Commodities
Invited session
Chair: *Dejan Stokic*
Chair: *Marcus Hildmann*

1 - Community Structure in Networks and Modularity
Leonidas Pitsoulis, Theodoros Gevezes

Community structure in a graph is an important large scale characteristic and detection of community structure remains up to this date a computationally challenging problem. The modularity value of a set of vertex clusters in a graph is a widely used quality measure for community structure. In this talk we prove that modularity can fail to detect community structure by showing the existence of a family of graphs upon which modularity maximization underestimates the number of clusters. We also examine alternative quality functions based on a random model.

2 - Nonlinear Profile Monitoring using MARS (Multivariate Adaptive Regression Splines)
JaeYeol Hong, Seung Hwan Park, Daewoong An, Jun-Geol Baek

The signal generated in the process over the time has a certain type. Because this signal has a time-varying average and non-uniform variance, the problem occurs when the signal is applied to the Statistical Process Chart (SPC). In our paper, to solve this problem, the nonlinear profile monitoring chart is proposed using Multivariate Adaptive Regression Splines (MARS). First, the center line of the control chart is constructed by using MARS. Second, Box-Jenkins model is used to set the control limit. Also, comparative experiment is performed between proposed method and SPC chart

3 - Fast Search in Big Data without Indexing
Alexander Ponomarenko

A standard approach for searching data distributed across the Internet is to use a search engine which builds an index for it. So two copies of data appear. It leads the index to become irrelevant over time. In this talk we propose a novel approach how to organize data for further search without building a traditional index. We suggest that data should be organized into a data structure which is designed for search in a higher dimensional metric space. We build an overlay network on the level of separate information objects such as HTML pages or RDF triples, based on similarity between them.

4 - User recommendations for discovering consensus temporal patterns
Cheng-kui Huang

The aggregation of individuals' preferences into a consensus is a decision support problem. A new type of preference aggregation model was proposed to provide temporal relationships between items; for example, b can occur during the duration of c, or c can occur before a. The idea of this model stemmed from the approach of mining sequential patterns to reveal only two point-based relations, i.e., the co-occurrence and order of items. However, in real life, there are lots of interval-based circumstances, which can describe the temporal relations of items more precisely.

■ MA-35

Monday, 8:30-10:00 - Room 131

Stochastic Modeling and Simulation

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair:
Chair: *Erik Kropat*
Chair:
Chair: *Manuela Maria de Oliveira*

1 - The Phycotoxins' Impact in the Technical Efficiency of the Portuguese Artisanal Dredge Fleet
Manuela Maria de Oliveira, Ana Camanho, Miguel B. Gaspar

The bivalve dredge fleet, considered as one of the most important artisanal fleets, essentially due to the high value of the catches, is by far the most extensively studied among the Portuguese artisanal segment. In the growing presence of marine phycotoxins, this study explores its impact in the technical efficiency of the fleet which operates in the Portugal mainland using stochastic frontier analysis models. Considering as exogenous variables, the phycotoxins presence and the mean wave height, the results allowed to clarify interesting issues about the performance of the fleets by area.

2 - Driver Sensitive Modeling of Spatio-Temporal Drivers of Land use Land Cover Change (LULCC)
Gülendam Baysal, Christine Fürst

Modeling LULCC based on time series provided by remote sensing data poses the problem of insufficient differentiation of drivers which might provoke a severe shortcoming in projection of reliable scenarios. Main purpose of the study is developing statistically based LULCC scenarios and their impacts on ecosystem service provision. To overcome described weaknesses we suggest to apply Principal Component Analysis and Multiple Logistic Regression Models. We will demonstrate potential use of them for identifying explanatory value of different drivers and how to combine them for scenario building.

3 - Economic Evaluation of Self-Monitoring of Blood Glucose as a Key Component for Type-2 Diabetes Treatment in Mexico Using Stochastic Simulation
David Fernando Muñoz, Olivo Omar Zanela, Hermilo Cabra

We report the development and application of a simulation model that was used to estimate the effects on the level of glycosylated hemoglobin (HbA1c) and the cumulative costs of four different regimes of self-monitoring of blood glucose (SMBG) with type-2 diabetes (T2D) in a typical Mexican public health institution (MPHI). The simulation model was designed to imitate the individual experience of a patient with T2D at a MPHI; the main drivers for cost computation were HbA1c evolution and its effect on the incidence and treatment (or not) of comorbidities, complications and acute events.

4 - Modeling Artificial Neural Networks and Fuzzy Support Vector Machine for Heart Disease Detection
Memmedaga Memmedli, Ozer Ozdemir

Artificial neural networks become effective tool for researchers by determining medical diagnosis correctly in recent years. In many medical diagnosis applications, heart disease detection has become more important than others nowadays. So, we aimed to use artificial neural network models such as multilayer perceptron, radial basis function neural network and generalized regression neural networks for heart disease detection. We also used a fuzzy support vector machine to compare with artificial neural network models. Empirical results are shown at the end of the study.

■ MA-36

Monday, 8:30-10:00 - Room 132

Fisheries

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Stein Ivar Steinshamn*

1 - Sustainable Harvest of a Native Species and Control of an Invasive Species: A Bioeconomic Model of a Commercial Fishery Invaded by a Space Competitor
Marjolaine Fresard, Carole Ropars-Collet

This paper deals with the control of an invasive species, void of market value, and acting as a space competitor for a valuable native harvested species. It presents a theoretical bioeconomic model describing the interacting dynamics of the two species and accounting for the undesirable consequences of native stock harvesters' behaviour on the spread of invasion. Dynamic optimisation of the model displays the existence of a time-path leading to an optimal stationary steady-state solution. Then, the optimal control model is applied to the bay of Saint-Brieuc scallop fishery (France).

2 - Big Gain, Little Pain: A Multi-Species Competition Model of Pelagic Fisheries
Nils-Arne Ekerhovd, Stein Ivar Steinshamn

The main objective is to maximize the net present value from the herring, mackerel and blue whiting fisheries in the North East Atlantic using an aggregated biomass three-species bioeconomic model. The value could have been about 50% higher if the stocks had been optimally managed from a multi-species perspective. An initial low harvest of mackerel to build the stock up to almost twice the initial level accompanied by stabilization of both stock and harvest of the other two stocks around their initial levels achieves this.

3 - Harvesting in a Fishery with Stochastic Growth and a Mean-Reverting Price
Sturla Kvamsdal

We analyze a continuous, nonlinear bioeconomic model to demonstrate how stochasticity in the growth of fish stocks affects the optimal exploitation policy when prices are stochastic, mean-reverting and harvest dependent. Price stochasticity induces conservative exploitation with little or no biological uncertainty, but has no strong effect when the biological uncertainty is larger. We observe that resource exploitation should be conservative when the price reverts slowly to the mean. We simulate the system to observe long run system behavior under the optimal solution.

4 - A Continuous-Time Age-Structured Bioeconomic Model for Optimal Resource Management
Stein Ivar Steinshamn, Peter Golubtsov

An age-structured bioeconomic model, continuous in state and time, is developed. The model is used for bioecomic analysis and optimization. The objective is to investigate how optimal harvesting patterns vary under different assumptions. The purpose is to find out how persistent pulse fishing patterns are with this kind of modeling framework. Emphasis is put on cost and demand parameters. The main results are that pulse fishing patterns are sensitive both to cost and demand parameters, and pulse fishing tends to disappear when there is a significant relationship between price and quantity.

■ MA-37

Monday, 8:30-10:00 - Room 017

AHP

Stream: AHP (Analytic Hierarchy Process) /ANP (Analytical Network Process)
Invited session
Chair: *Michele Lundy*

1 - A Clustering Approach to Measure Inconsistency in Pairwise Comparison Judgements
Michele Lundy, Sajid Siraj

Measuring/improving the inconsistency in pairwise comparison judgements is a much debated issue. We propose a method for measuring inconsistency using a graph-theoretic approach that helps gain insights into the provided judgements, and also give some suggestions for improving the level of inconsistency in these judgements. Firstly, the set of all possible preferences is generated, and then cluster analysis is performed to detect whether the decision maker has two (or more) different sets of preferences in mind. We suggest exploiting this mindset information for better decision making.

2 - Application of an Analytic Hierarchy Process (AHP) Model to Assess Academic Corruption and Values in the Nigerian Educational System
Adebola Adekoya, Olanrewaju Sulaimon Adebiyi, Olateju Emmanuel Oyatoye, Bilqis Amole

Education contributes to the growth and development of any nation but allowing corruption in such a sector will be a bane to such expected growth and development contribution. This paper used the AHP to build a hierarchical model for the eradication of corruption in the Nigerian educational system using selected universities. Five main elements were used as criteria while three main possible outcomes were used as the alternatives. 400 questionnaires were filled out correctly and returned. It was revealed that corrupt elements are present but the magnitude differs among the universities.

3 - Market Attractiveness Evaluation of Sub-Saharan Africa by Using SWOT Analysis and AHP Methods
Peter Nganga

The aim of this study is to evaluate the market attractiveness in Sub-Saharan African countries. Literature review and the Analytical Hierarchy Process Method were applied for the complex multi-criteria decisions with respect to global macro environment indicators. Statistical data from various sources was adopted for the weights calculation in sub criteria level. Absolute measurement criteria were weighted independently of the evaluation of the alternatives. The resulting priorities indicated that, in standalone market attractiveness Mauritius have integrated social cultural and politics with

4 - Identification and Evaluation of the Effective Criteria in Customer Satisfaction, Case Study: Wood Furniture Market
Majid Azizi, Alireza Deghan

Identifying the amount of customer satisfaction and informed of the field of strength and weakness in this regard, helps wooden furniture manager programming in line with customers better maintenance and planning future sales programs with the purposes of admirable competitive advantages. After investigation and interviews with experts in furniture designing and manufacturing industry 37 criteria and sub criteria collected. The priority rates were determined by AHP. Results shows price, fame, quality, durability and resistance and paying conditions have the highest priority respectively.

■ MA-38

Monday, 8:30-10:00 - Room 214

Biomass-Based Supply Chains I

Stream: Biomass-Based Supply Chains
Invited session
Chair: *Christian Trinks*

1 - Requirements of a Mathematical Approach for Optimizing Biomass Value Chains for Material and Energetic Utilization
Ann-Kathrin Mueller, Magnus Fröhling, Frank Schultmann

Biomass is a renewable feedstock which can be used for multiple purposes. Their supply chains face many challenges: low energy density, high transportation costs, large collection areas and seasonal availability. The objective is to analyze existing models with regard to the sketched challenges in order to derive further research needs. Many models only include a regional, technically specific value chain. Few approaches model the essential storage of biomass. Future works will develop a generic model which optimizes the location, technology and capacity of biomass utilization plants.

2 - Design of Lcoal Biomann to Energy Supply Chains with District Heating Systems under Uncertainty
Şebnem Yılmaz Balaman, Hasan Selim

To design biomass to energy supply chains efficiently, decision makers should consider economical, environmental and social concerns and uncertainties related with the decision environment. To handle these issues, this study presents a multiobjective mixed-integer linear programming model for the planning of biomass to energy supply chains in an uncertain decision environment. The model deals with the local supply chain design integrated with district heating system. Fuzzy goal programming is used to incorporate the uncertainties in the problem parameters into the decision making process.

3 - Setting Priorities for the Performance Assessment of a Biomass-Based Supply Chain
Christian Trinks

This work presents an approach to determine and aggregate the priorities of a relevant group of actors in order to assess the performance of different woodchips supply chain configurations. Methodologically, the study is based on a disproportionate stratified random sampling, standardized stakeholder survey, Analytic Hierarchy Process and the exact eigenvector method. The analysis will focus on organized small-scale forestry in the administrative districts of Bavaria and on forest owner associations/forest management cooperatives as key decision makers in the future woodchips supply network.

■ MA-39

Monday, 8:30-10:00 - Room 018

ORAHS I - Effectiveness & Performance

Stream: Health Care Applications
Invited session
Chair: *Sally Brailsford*
Chair: *Marion Rauner*

1 - Establishing a Framework for the Effective Evaluation of OR in Healthcare
Martin Pitt, Tom Monks

Evaluations of OR interventions in healthcare are a rare, but essential, component in the effective application of modelling solutions for health improvement. The complex and dynamic nature of healthcare requires an evaluation framework which accounts for the many different dimensions by which OR interventions can influence healthcare organisation. Against this background a stratified mixed methods framework is proposed and a case study presented showing how successful evaluation has been applied to a simulation model used for the re-design of the emergency stroke pathway at a UK hospital.

2 - Optimising the Operating Room Utilisation Rate and the Patient Waiting Time in a Spanish Hospital
Francisco Ballestin, M. Angeles Pérez, Sacramento Quintanilla, M.Pilar Lino, Vicente Valls

We study how to select the patients to operate on in the next two weeks in a specific operating room in a Spanish hospital. We also decide at what time to operate on each of these patients. We treat this problem as a multi-objective problem as we maximize the utilisation rate of the operating room and minimize the waiting time of patients. Patients are classified according to the urgency of their operations. Several restrictions should be fulfilled: some operations must be performed by a specific doctor, others belong to specialties and should be performed in specific sessions, etc.

3 - Online Allocation and Routing for Blood Delivery in Conditions of Variable and Insufficient Supply: A Case Study in Thailand
Pornpimol Chaiwuttisak, Honora Smith, Yue Wu, Chris Potts

We consider the blood delivery problem to hospitals under variable and insufficient supplies of blood. Hospitals are assigned either to fixed routes or variable routes according to their location. Blood is supplied weekly to hospitals in the fixed route, while the frequencies of blood distribution to hospitals in the variable routes changes with the quantity of blood available daily. We propose an online system for updating the schedule over the planning horizon. Different policies for allocation and routing are compared, with a case study in Thailand.

4 - Impact of Environmental Conditions on Efficiency of Austrian Red Cross Departments: Data Envelopment Analysis (DEA) & Second Stage Regression
Marion Rauner, Margit Sommersguter-Reichmann

The efficiency assessment of the 52 Austrian Red Cross departments of one region is based on a three input (e.g., number of working hours, number of vehicles) and two output (e.g., index on duration of rides & number rides) radial and input-oriented variable returns-to-scale (VRS) Data Envelopment Analysis (DEA) model. We performed a second stage regression to account for environmental conditions (i.e., number of acute care hospital beds, share of citizens aged 64+, number of ice days, size in km2 of the catchment area).

■ MA-40

Monday, 8:30-10:00 - Room 019

Scheduling and Lot Sizing Problems

Stream: Production and the Link with Supply Chain
Invited session
Chair: *Farouk Yalaoui*
Chair: *Gonzalo Enrique Mejia Delgadillo*

1 - Multiple-Stage Parallel-Machine Capacitated Lot-Sizing and Scheduling with Sequence-Dependent Setup: A Case Study in the Wheel Industry
Lalida Deeratanasrikul, Shinji Mizuno

We study a real-word problem of simultaneous lot-sizing and scheduling in a capacitated flow shop. This challenging case combines two complicated characteristics in production which are multiple-stage production with heterogeneous parallel machines and sequence-dependent setup times. We proposed a MIP formulation with no subtour and tested on real data sets. The model takes several days to solve exactly and so MIP-based Relax and Fix heuristics are developed. Test results show that the formulations are computationally effective and the model schedule improves on that practiced at the plant.

2 - Optimization Model for Scheduling Steelmaking and Continuous Casting Production
Eduardo Salazar

A generalized MILP model to scheduling orders in the steelmaking and continuous casting production is developed. The general structure of the production system considers an arbitrary number of machines at each stage, producing orders of several steel grades and types (e.g., slabs and billets). Optimization criteria such as makespan and technological constraints such as continuous casting between batches and in process time of liquid steel are discussed. For illustration purposes, small sized problems are solved and further research on heuristics solution approaches are discussed.

3 - Lot-Sizing in an Export-Oriented Winery: Models and Heuristics under the Principle of Postponement
Sergio Maturana, Mauricio Varas, Jorge Vera, Ignacio Vargas

The growth of exports and of private label brands forces export-oriented wineries to allocate their production across a variety of sales channels with different labeling requirements, which complicates their production planning. One way to deal with demand uncertainty is by postponing product differentiation. A critical order decoupling point for wineries is the labeling process. We present an MIP model for determining the lot size on multiple production lines with decoupled bottling and labeling stages. This model is tested on a rolling horizon framework with error-prone demand forecasts.

4 - A Reactive Scheduling Framework via Off-line Optimization
Georgios Kopanos, Efstratios Pistikopoulos

In this work, we present a new approach for the reactive scheduling of production systems with uncertain parameters of bounded form. Our method follows a state-space representation for the scheduling problem, and relies on the use of a rolling horizon framework and Parametric Optimization (PO) techniques. We show how we can effectively formulate PO problems that are solved just once and off-line. The results of the PO are used in a rolling horizon basis without the need for on-line optimization. Our approach is applied in the scheduling problem of a network of combined heat and power units.

■ MA-41

Monday, 8:30-10:00 - Room 216

Lot-Sizing and Related Topics 1

Stream: Lot-Sizing and Related Topics
Invited session
Chair: *Grigory Pishchulov*

1 - Production Inventory Model for Perishable Items whose Deterioration Starts after a Fixed Time
Sarbjit Singh

In the last two decades' study of deteriorating items has gained importance, but almost all the production models formulated for perishable items have considered that the deterioration of the items starts immediately as the production starts, which is absurd. In this model deterioration of inventory starts only after some fixed time. The optimal production schedule has been derived to obtain the minimum total cost. The optimality of the model has been checked and numerical illustrations with sensitivity analysis are given to prove the validity of the model.

2 - Continuous-Time Model for the Operational Pulp and Paper Production Planning
Gonçalo Figueira, Pedro Amorim, Luis Guimarães, Mário Lopes, Bernardo Almada-Lobo

Motivated by a real-world case study in the pulp and paper industry, we tackle the operational multi-stage production planning and scheduling in an integrated mill. We formulate a continuous-time model which allows easily incorporating several practical constraints. The model is solved with a fix-and-optimize method that applies different decomposition schemes. A post-optimization is performed to smooth production rates. These models are the core component of a decision support system. The plans provided by our system are compared to those manually generated by the company's staff.

3 - Supply Chain Contracting under Asymmetric Information and Partial Vertical Integration
Grigory Pishchulov, Knut Richter, Sougand Golesorkhi

We study a bargaining problem in a partially integrated supply chain where the buyer holds an equity stake in the supplier. Assuming information asymmetry and a principal-agent form of relationship in this supply chain, we study optimal contracting between the parties within the framework of the joint economic lot size model. We demonstrate that the full vertical integration is not necessary to achieve supply chain coordination in the presence of asymmetric information; a minority stake may be capable of eliminating the transaction costs owing to information asymmetry and enable coordination.

■ MA-42

Monday, 8:30-10:00 - Room 215

Green Freight Transportation 1

Stream: Green and Humanitarian Logistics
Invited session
Chair: *Emrah Demir*

1 - A Conic Reformulation and a Local Search Heuristic for the VRP with Controllable Travel Times
Sinan Gürel, Onur Can Saka, Tom Van Woensel

We examine the vehicle routing problem with controllable travel times, which is also known as pollution routing problem. We consider multiple vehicle types and deadlines. We control travel times and fuel consumption by setting vehicle speeds. Fuel consumption is a nonlinear function of speed. We show that the problem can be reformulated as a mixed integer second order cone program. We propose a local search heuristic for the problem. We present the results of computational experiments.

2 - The Time-Dependent Two-Echelon Capacitated Vehicle Routing Problem with Environmental Considerations
Mehmet Soysal, Jacqueline Bloemhof, Tolga Bektas

In two-echelon distribution systems, freight is delivered to customers via intermediate depots rather than directly. This talk will present a comprehensive MILP formulation for a time-dependent two-echelon CVRP that accounts for vehicle type, distance, speed, load, multiple time zones, fuel and emissions. A case study in a supermarket chain shows the applicability of the model to a real-life problem. The results suggest that the two-echelon distribution system results in an environmentally-friendly solution, but a single-echelon system provides the least-cost solution.

3 - Modelling and Solution Approach for the Environmental Travelling Salesman Problem
Georgios K.D. Saharidis, George Liberopoulos, George Kolomvos

We consider the environmental traveling salesman problem in a connected graph driven by a novel cost function describing the impact of environmental externalities over the routes. The cost function aims to reflect the increase or decrease of fuel consumption for each route by taking into account the special features of the route such as weather conditions, use of air condition, speed, etc.. For the solution of the TSP, we apply the 7 basic mixed integer linear formulations and compare the results. We apply Benders decomposition techniques and we eventually test a new separation cut strategy.

■ MA-43

Monday, 8:30-10:00 - Room 217

Algorithms and Applications - 1

Stream: Algorithms and Computational Optimization
Invited session
Chair: *Basak Akteke-Ozturk*
Chair: *Ulf Lorenz*

1 - Penalizing Fractional Directions in the Integral Simplex Algorithm
Samuel Rosat, Issmail Elhallaoui, Zaghrouti Abdelouahab, Driss Chakour

The Integral Simplex Using Decomposition algorithm (ISUD) is a constructive method able to find optimal solutions to set partitioning problems via a sequence of basic integer solutions with decreasing costs. ISUD solves iteratively a complementary problem to find an integer descent direction, i.e., leading to an improving integer one. We introduce for the first time a technique that penalizes fractional directions and hence helps obtain integer directions, most of the time without any branching or cutting. Numerical results on bus driver and aircrew scheduling problems show high potential.

2 - Improving ILP Solutions by Zooming around an Improving Direction
Zaghrouti Abdelouahab, Issmail Elhallaoui, Francois Soumis

The Integral Simplex Using Decomposition (ISUD) is an efficient primal algorithm that finds a decreasing sequence of integer solutions leading to an optimal solution for the set partitioning problem. In this paper, we introduce an approach that improves different aspects of ISUD. The new approach improves a local solution by zooming around an improving fractional direction. This zooming approach is globally primal and exact and is locally dual on a reduced problem. It works well on problems emanating from transportation industry.

3 - A Decision Support System for Optimization in the Face of Uncertainty
Susara van den Heever, Ban Kawas, Marco Laumanns, Chungmok Lee, Radu Marinescu, Martin Mevissen, Nicole Taheri, Rudi Verago, Ali Koc

Optimization under uncertainty involves many challenges, such as large numbers of scenarios, complex mathematical models and lack of business user adoption. We describe a decision support system aimed at addressing these challenges. This system includes a methodology for soliciting information from practitioners, automated model conversion and visual analytics for trade-off analysis. We present the architecture of a prototype implemented as a plug-in to the IBM Decision Optimization Center and demonstrate its use through an example involving unit commitment for power generation.

4 - MIP Generation for System Synthesis Tasks
Ulf Lorenz, Lena Altherr, Thorsten Ederer, Peter Pelz, Philipp Pöttgen, Benjamin Saul, Wolf Zimmermann

Our research deals with synthesis tasks for fluid systems. A typical job is to decide a system topology considering investment costs, operational costs and system control which again depends on various load profiles. We present a stationary optimization model for a booster station. In principle, such a fluid system consists of a flow problem with some non-linear constraints that are linearized. We also aim at an automatic conversion from Engineer's language into this MIP. We present the basics of such a domain specific language which enables us to utilize classic compiler techniques.

■ MA-44

Monday, 8:30-10:00 - Room 218

Simulation in Management Accounting and Management Control I

Stream: Simulation in Management Accounting and Management Control
Invited session
Chair: *Friederike Wall*

1 - A new Portfolio Risk Evaluation Model Including Huge Loss Events Derived from Market Prices: Continuous-Time Model
Yukio Muromachi

Recently we proposed a new risk evaluation model of a portfolio considering potential huge losses implied from market prices. Its numerical examples were consistent with typical features in the CDO market during the financial crisis. However, it was a one-period model. Although many kinds of economic state were considered, its transition was omitted. In this article, we propose a continuous-time version of the model. The transition of the economic state is considered as a stochastic "multiplier" process, and a simple but effective model of the process and its simulation procedure are proposed.

2 - An Agent-Based Simulation of new Product Adoption for Multiple Technology Generations
Markus Günther, Christian Stummer

When introducing new products that rely on multiple successive technology generations and, thus, have novel features, firms seek for insights in the adoption behavior of their potential consumers. Their individual decision to adopt, postpone, or leapfrog the new product generation is typically complicated by an uncertainty concerning the performance and usefulness of the new features. Therefore, word-of-mouth communication within the customers' social networks and normative influences may play a distinctive role. We present an agent-based simulation that allows for investigating such effects.

3 - A Simulation-Based Approach for the Analysis of Allocation Methods for Cost-Center Accounting
Sina Hocke, Matthias Meyer

Different allocation methods in cost accounting create a certain tolerance for the distribution of costs but the scope of their inaccuracies is not quantified so far. In this paper, three allocation methods of German cost-center accounting are investigated with regard to accuracy by using a simulation. The results suggest that for a small proportion of mutual service exchange, the supposedly less precise method is to be preferred. For practitioners, a medium degree of mutual service exchange would be enough to abdicate the more complex and apparently not always more precise step-ladder method.

4 - Frequency and Mode of Changing the Management Control System: Results of an Agent-Based Simulation
Friederike Wall

In this paper we investigate, whether, or not, frequent changes in the management control system could induce improvements in organizational performance. We apply an agent-based simulation model based on the framework of NK-fitness landscapes to compare the search processes of organizations with different types of change processes against each other. The results indicate that changes in the management control system per se might increase organizational performance. Moreover, results suggest that value-driven changes may be more efficient than purely time-triggered changes.

■ MA-45

Monday, 8:30-10:00 - Room 219

Computational Stochastic Programming

Stream: Stochastic Programming
Invited session
Chair: *Suvrajeet Sen*

1 - Sell or Hold: A Simple Two-Stage Stochastic Combinatorial Optimization Problem
George Nemhauser, Shabbir Ahmed, Qie He

The sell or hold problem (SHP) is to sell k out of n indivisible assets over two stages, with known first stage prices and random second-stage prices, to maximize the total expected revenue. We show that SHP is NP-hard when the second-stage prices are realized as a finite set of scenarios. We show that SHP is polynomially solvable when the number of scenarios in the second stage is constant. A max1/2, k/n-approximation algorithm is presented for the scenario-based SHP.

2 - Approximation Strategies for Multistage Stochastic Programs
Tsvetan Asamov, Warren Powell

Using the contextual setting of optimizing grid-level energy storage, we study the effect of dimensionality (the number of storage devices) on the performance of different approximation strategies, including regularized stochastic decomposition and piecewise linear, separable approximations. We build on the algorithmic framework of approximate dynamic programming to introduce novel machine learning strategies which overcome the curse of dimensionality inherent in scenario trees.

3 - Mitigating Uncertainty via Compromise Decisions
Suvrajeet Sen, Yifan Liu

We introduce a new concept which we refer to as the compromise decision which is applicable to sampling-and-replication-based convex optimization algorithms. For such replicated optimization, we show that the difference between an average solution, and a compromise decision provides a natural stopping rule. We demonstrate the practicality of this approach by reporting computations which cover a range of applications, including a detailed study of SSN, a network planning instance which is known to be more challenging than other test instances in the literature.

4 - Parallelization and High Performance Computing Adjustment of the Cluster Benders Decomposition Algorithm
Francesc Solsona, Jordi Mateo, LluisM Pla, Josep Lluis Lerida

This work proposes the parallelization of the Cluster Benders Decomposition proposed by Laureano et al., a newer and faster version of the L-shaped algorithm. The parallel version has been implemented in a multicore and in a cluster system, as the base frameworks of shared and distributed HPC systems, respectively. Extensive performance evaluation and comparison of the computational costs between the serial and parallel models in their execution in the HPC systems has been performed. The final goal is to apply this technique to solving real cases with a minimal computational time.

Monday, 10:30-12:00

■ MB-01

Monday, 10:30-12:00 - Room 118

Train Timetabling and Dispatching

Stream: Railway and Metro Transportation
Invited session
Chair: *Thomas Schlechte*

1 - Energy Efficient Freight Train Scheduling
Frederik Fiand, Uwe T. Zimmermann

Based on a real world problem we optimize energy efficiency in railway transportation. Our project partner, DB Germany, provides a set of shipment requests and predefined train schedules that can be slightly varied during the solution process. Energy efficiency is optimized by assigning shipments to trains considering power consumption. The tremendous problem size can be reduced via tailor-made preprocessing. This approach enables us to generate models that can be handled with the help of large-scale Mixed-Integer Programming techniques. (BMBF-supported joint project "e-motion")

2 - On Comparing Robustness Approaches for Timetabling
André Chassein, Marc Goerigk

We consider the acyclic train timetabling problem that aims at minimizing weighted activity durations. As train schedules are highly susceptible to delays, various robustness approaches have been proposed. Still, as each approach uses its own definition of robustness, it is an open problem how to compare the quality of such solutions under uncertainty, and how to guide the practitioner deciding which robustness approach to use. To this end, we propose a scenario-based performance comparison for robust solutions and show the benefits and drawbacks of robust formulations from the literature.

3 - Automatically and Quickly Planning Platform and Route of Trains in Railway Stations
Peter Sels, Thijs Dewilde, Dirk Cattrysse, Pieter Vansteenwegen

When creating a railway timetable, a sub-problem that occurs for every station is the Train Platforming Problem (TPP). With our tool called Leopard, we show that we are able to automatically and quickly solve the TPP and create the platform and route plan for each of the 553 stations in Belgium, for all trains. Leopard also evaluates the plan created by human planners, if it already exists. For both the human and the Leopard created plan, we produce graphical images that are easily interpreted and compared by humans. As such Leopard both evaluates and improves train platforming plans.

4 - A Real-Life Implementation of an Exact Train Dispatching Algorithm
Carlo Mannino

Train dispatching consists in managing railway traffic in real-time. In recent works, we showed how, under "mild" assumptions on the instances, the real-time train dispatching problem can be solved to optimality, for relevant real life cases, by applying Benders'-like decompositions. As of February 2014, a system based on our exact decomposition approach has been put in operation on the Stavanger - Sira line in western Norway. Implementing such system has required tackling cases where the above mild assumptions do not apply. We present exact and heuristic techniques to handle this.

■ MB-02

Monday, 10:30-12:00 - Room 111

Models and Algorithms for Arc Routing Problems

Stream: Vehicle Routing
Invited session
Chair: *Marcos José Negreiros*

1 - On the Distance-Constrained Generalized Directed Rural Postman Problem
Isaac Plana, Thais Ávila, Angel Corberan, Jose Maria Sanchis

The Generalized Directed Rural Postman Problem (GDRPP) has interesting real-life applications, such as routing for meter reading. In the GDRPP, there is a family of arc subsets and the goal is to find a minimal cost tour traversing an arc in each subset. The Distance-Constrained GDRPP is a generalization in which a fleet of vehicles is available and the goal is to minimize the sum of the costs of all the routes, provided that no route exceeds a maximum distance. Here we introduce several formulations, present different families of valid inequalities, and report some computational results.

2 - Studing Arc Routing Models
Cândida Mourão, Luís Gouveia, Leonor S.Pinto

New flow based compact models are proposed and studied for the mixed capacitated arc routing problem (MCARP). These models, use two sets of flow based variables, in contrast to a single set known from previous works. The two sets permits us to obtain stronger linking constraints. Some new side constraints, motivated by real world case studies, are also handled. Computational results with some benchmark instances are provided and discussed.

3 - Hybrid Arc Routing Models
Leonor S.Pinto, Luís Gouveia, Cândida Mourão

Arc routing studies have been recently increasing motivated by real world applications. Our work derives from a waste collection routing problem, and mixes the resolution of hybrid compact models (HCM) with some heuristics. The HCM arise from a combination of two capacitated arc routing models: a valid one, that is able to solve medium size instances, and a relaxation providing good lower bounds. In a heuristic way some preliminary services are assigned to the vehicles, in an attempt to reduce the instances dimensions. Computational results with data instances for a case-study are analysed.

4 - New Heuristics for the Mixed General Routing Problem
Marcos José Negreiros

This work does a detailed description of new polynomial heuristic procedures based on the General Travelling Salesman Problem (GTSP) and Generic Minimum Spanning Tree Problem (GMST) for the Mixed General Routing Problem (MGRP). The procedures transform the MGRP to a pure Directed Rural Postman Problem (DRPP) in polynomial time to obtain high quality solutions in reasonable time. The instances used from the literature are evaluated. We show here we have obtained some results that are better than the previously heuristics reported for the MRPP.

■ MB-03

Monday, 10:30-12:00 - Room 001

Air Traffic Management

Stream: Aviation
Invited session
Chair: *Antony Evans*

1 - Decision Support for Improving the SESAR Key Performance Areas
Krystsina Bakhrankova, Patrick Schittekat, Amela Karahasanovic, Aslak Eide, Hans Erik Swendgaard, Volker Grantz, Stian Støer Ødegård, Dag Kjenstad, Carlo Mannino

Productivity enhancement in the control room is needed to accommodate the expected growth in air traffic and meet demands for increased safety, predictability and efficiency of Air Traffic Management (ATM) systems. Following a four-step improvement process, an optimization-based decision support tool is developed. The system is evaluated based on the outcomes of a controlled experiment. The results indicate that active operational use of the tool provides direct economic savings, greater flexibility, efficiency, overview and safety, while improving the SESAR Key Performance Areas.

2 - A Decision Theoretic Approach for Trajectory Planning with Risk Mitigation
Husni Idris

Constraint violation risk is a key factor in air traffic planning. Decision theory was used to measure the risk mitigation ability of a traffic control strategy, by forming a discrete time-space reachable tree that does not violate constraints such as safe separation requirements. The ability to mitigate risk, measured by the expected number of feasible trajectories available at each state, was maximized by a dynamic program to plan trajectories. Presented simulations showed that maximizing risk mitigation induced organized traffic and how strategies trade between capacity and risk mitigation.

3 - Airline-Driven Performance-Based Air Traffic Management: Game Theoretic Models and Multi-Criteria Evaluation
Antony Evans, Vikrant Vaze, Cynthia Barnhart

An important objective of future air traffic management (ATM) systems is to support airline business objectives. We propose several approaches for collecting inputs from airlines and for combining them into ATM initiatives. We apply a game-theoretic approach to examine the potential for gaming, both theoretically and by simulating a generic initiative and ground delay programs at Newark and LaGuardia airports. We conclude that voting represents the most promising approach, allowing ATM initiatives to be designed that optimize system performance while respecting the objectives of airlines.

4 - GRASP for Planning Multi-City Air Routes
Mariá C. V. Nascimento, Kátia Yoshime Nakamura

Nowadays, air transportation has been adopted by millions of people over the world. A prior route planning by the customers makes necessary for better economical choices for purchasing air tickets. We present a study of a mathematical formulation to provide a minimum cost route with regard to the air tickets. To solve the problem a metaheuristic is proposed. Concerning the computational experiments, the metaheuristic provided satisfactory results regarging the real test cases.

■ MB-04

Monday, 10:30-12:00 - Room 119

Supply Chain Planning 2

Stream: Supply Chain Management
Invited session
Chair: *Mirko Vujosevic*

1 - A Quasi-fixed Cyclic Production Scheme for a Multi-Item Production System with Stochastic Demand
Philipp Zeise, Dirk Briskorn

We present a nested approach to generate a production scheme that consists of a fixed periodic production sequence (cycle) whereby each product may occur more than once in the sequence. Given a lot-sizing strategy we decide when to use a facility for production, setup or idling while the time between two successive completions of the cycle is quasi-fixed, i.e., a target cycle length with boundaries. Complicating factors are the sequence-dependent setup times, the limited stock space and the stochastic demand. The results, using practical data, are compared to approaches from literature.

2 - Supply Chain Management using an Optimization-Simulation approach for the Pharmaceutical Distribution
Sara Martins, Pedro Amorim, Gonçalo Figueira, Luis Guimarães, Bernardo Almada-Lobo

Medlog is one of the leading distributors of pharmaceutical products operating in Portugal. It commercializes approximately 17.000 products from over 300 different suppliers to more than 1500 pharmacies using 5 warehouses. Nowadays Medlog has an improved supply chain management as it was able to reduce their operating costs, while still keeping similar customer fill rates thanks to an optimization-simulation driven approach. In this talk we present the developed framework responsible for shaping and tuning the new supply chain management, as well as the change management challenges faced.

3 - Modeling Humanitarian Logistics in the Philippines
Brian Canlas Gozun, Arlyn Villanueva

The onslaught of the destructive and powerful Super Typhoon Haiyan that devastated the central parts of the Philippines in November 2013 has shown the importance of an efficient and effective logistics system. The Philippines has its shares of natural disasters ranging from typhoons to volcanic eruptions and earthquakes. The need for humanitarian logistics to address pre-and-post disaster logistics concerns to serve the needs of the survivors is crucial. This study models the requirements for humanitarian logistics as well as the issues that arise from its implementation.

4 - A New Integrated Forward and Reverse Logistics Model: A Case Study
Mirko Vujosevic, Jasenka Djikanovic

A new integrated forward and reverse logistics model is presented. The following three objectives are considered: (1) minimization of the total cost in forward and reverse flows, (2) minimization of traveled distance in forward and reverse flows, and (3) minimization of inventories in plants in order to achieve just-in-time delivery. The optimization problems are solved using CPLEX and GUROBI solvers. A case study based for a company which produces electrical household devices is presented. The analysis is focused on the impact of changing recovery rate of reversed products.

■ MB-05

Monday, 10:30-12:00 - Room 002

Oil and Gas Transportation

Stream: Petroleum Logistics
Invited session
Chair: *Yury Shcherbanin*

1 - Medium Term Forecasts of World Oil and Gas Consumption
Liudmila Studenikina

We assess the trends in global oil and gas demand and supply, and analyze changes in world energy consumption by sector and by fuel up to 2035. We compare the outlooks performed by an international energy organization and a public oil company, and identify the differences in forecasting. Both outlooks are based on large-scale simulation models designed to generate sector-by-sector and region-by-region prognoses. The results of the analysis demonstrate various research approaches to estimating future hydrocarbon consumption in the world in the medium-term period.

2 - Changing Logistic Approaches in International Oil Trade Movements
Anastasia Mikhaylova

We analyze the effect on the existing global oil trading patterns of the changes in energy policy and the market structure of the leading oil and gas consumers, mainly the USA which are becoming an oil and gas exporter in the medium-term period. It calls for a need for new logistic approaches in international oil trade movements. The assessment is based on the forecasts of the International Energy Agency and the US Energy Information Administration, generated by simulation tools. We study the implications of the changes in trading patterns on the global oil supply chain architecture.

3 - Analysis of Logistics Capabilities for Gas Transportation in the Arctic
Yauheni Kisialiou, Yury Shcherbanin, Irina Gribkovskaia

Exploration of hydrocarbons reserves in the Arctic requires development of logistics capacities and transport infrastructure. Effect of the global warming and year-around navigation on the Northern Sea Route facilitate downstream transportation of gas extracted in the Arctic via the route to Asia-Pacific markets. Using simulation model we study the implications of the ice breaking fleet availability, climate conditions and regulations for navigation on the route throughput. Simulation is performed for several scenarios of LNG transportation between different ports by different LNG carriers.

4 - Oil Pipelines Transportation: Evaluation of Logistics Expenses
Yury Shcherbanin
While crud oil is transported using pipelines logistics expenses are evaluated not only taking into account tariffs and different other taxes. Compounding of different types of crude oil, loses in the system etc. influence on the final costs. The task is to try to evaluate the level of such kind of expenses using methods of comparative analyses and statistical analyses. Previous dates illustrate quite high influence of paraffin crude oil over the maintaining of well known types and some new logistics technologies could be used to maintain properties needed.

■ MB-06

Monday, 10:30-12:00 - Room 211

Strategic Freight Demand Models

Stream: City Logistics and Freight Demand Modeling
Invited session
Chair: *Lorant Tavasszy*
Chair:
Chair: *Panagiotis Otapasidis*

1 - Developing a Multi-Scale Multi-Region Input-Output Model
Matthew Roorda, Chris Bachmann, Chris Kennedy
Global multi-region input-output (GMRIO) models do not capture the heterogeneity of regions within a single country. Multi-scale models capture the global economy while preserving regional differences. This research develops methods for integrating multi-region input-output (MRIO) datasets from multiple spatial scales to develop multi-scale multi-region input-output (MSMRIO) models. A Canadian-centric GMRIO model was developed that includes 47 countries and Canada's 13 subnational regions. Results show that it is possible to link scales with a reasonable degree of accuracy.

2 - Elasticity Estimations for Continental Intermodal Freight Transport
Bart Jourquin, Lorant Tavasszy
Elasticities for continental intermodal container transport are expected to be different from values found in the literature for traditional freight transport, as trucking can be used as a substitute or a complement to rail or inland waterway transport. Elasticities estimated by a simple theoretical synthetic model and values estimated with a complete European multimodal network model are presented. It appears that the demand for intermodal rail-road transport is inelastic and that elasticities decrease with the pre- and post-haulage distance but increase with the total length of the trips.

3 - Transport Mode Selection During Cargo Movement Operations in the South East Europe Area
Panagiotis Otapasidis, Christina Arampantzi, Vasileios Zeimpekis, Ioannis Minis
We assess different freight transportation options for cargo movement within the SEE area. An extension of Dijkstra's algorithm is used to identify the most suitable transportation mode based on cost, trip duration, and CO2 emissions. We apply the proposed algorithm between the Port of Piraeus and four capital cities of the SEE (Sofia, Bucharest, Budapest, and Ljubljana). The results show that the use of road transport is the most convenient solution if trip duration is the main criterion, whereas combined transport is selected when minimization of cost and CO2 emissions is the objective.

■ MB-07

Monday, 10:30-12:00 - Room 003

Complementarity Models in Natural Gas and Renewable Markets

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Sauleh Siddiqui*

1 - Risk Aversion in Imperfect Natural Gas Markets
Ruud Egging, Alois Pichler, Øyvind Iversen Kalvø, Thomas Walle-Hansen
We consider risk aversion by natural gas supply companies considering investments in conventional and shale gas resources in a mixed complementarity problem. Uncertainties considered include political risk and resource sizes. We discuss investment decision results and expected welfare loss due to risk aversion.

2 - LNG Market Modeling
Steven Gabriel, Seksun Moradee
In this talk, we report on the recent World Gas Model (WGM 2014) which includes more details on the liquefied natural gas (LNG) market. We consider a variety of scenarios involving LNG and canal expansion and the overall effects of U.S. natural gas LNG exports combined with other pipeline and LNG expansion activities globally. WGM2014 is a large-scale Nash-Cournot MCP model that has been used in a variety of settings by U.S. and European governments.

3 - A Complementarity Approach to Analyse the Influence of Renewables on Market Power
Susanne Koschker, Dominik Möst
The paper will investigate with an Electricity Market Model the possibility for the abuse of market power by taking the Lerner-Index as indicator. Especially, the role of renewables and the overcapacity situation will be investigated. Marginal costs of the market model in a competitive environment are taken as reference for electricity prices. This situation will be compared within a Stackelberg game where the influence on capacity withdrawing and market prices will be analysed. The mathematical model of both cases (competition, Stackelberg game) as well as results will be presented.

4 - An Equilibrium Model for the US RIN Market
Sauleh Siddiqui, Adam Christensen
Renewable Identification Numbers (RINs) are used to track the use of biofuels in the US transportation infrastructure and are the primary currency to demonstrate compliance with the mandated biofuel volume requirements. The RIN market and its respective players will be modeled using an equilibrium problem, which will be used to quantify the effects of parallel incentives in the form of tax credits and other policy initiatives.

■ MB-08

Monday, 10:30-12:00 - Room 120

Electricity Markets and Smart Grids

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session
Chair: *Jinwoo Park*

1 - Electricity Futures
Silvana Stefani, Paolo Falbo, Daniele Felletti
In the literature, the elusive behavior of the risk premia in electricity forwards is documented. In fact, electricity futures and forwards may help generators, consumers and marketers to manage volatility, but also introduce risks of their own. We evaluate the ex post performance of monthly base load futures contracts on the Italian market in 2008-2013. The results show that alternative models, different than the "traditional' ones, are needed for pricing futures in electricity markets.

2 - European Day Ahead Electricity Market Structures
Kürşad Derinkuyu
Power exchanges in Europe organize two sided combinatorial auctions every day to determine the electricity prices within an hour for the delivery of electricity next day. Day-ahead market prices are usually accepted as reference prices and affect other electricity markets such as intra-day and futures. This study first gives a brief summary of the electricity market structures. Then, we provide the alternative formulation and solution approaches to the day ahead market optimization problem, and the difficulties appear in practice. Lastly, we discuss the future trends and open research problems

3 - Market Design for Rapid Demand Response - The Case of Kenya
Kurt Nielsen

We suggest a market design for rapid demand response on electricity markets. The collective solution consists of remotely controlled switches, meters, forecasting as well as an auction design to set prices and select end-users job by job. The auction motivates truth-telling and makes it simple to involve the end-users in advance and to activate demand response immediately. The solution is analyzed and simulations are conducted for the case of Kenya. In Kenya we focus on turning the many private backup generators into a part of the on-grid solution by the rapid demand response solution.

4 - Optimal Operation Management for Electric Vehicle Battery Switch Stations in Smart Grid Environment
Jinwoo Park, Donghyun Kim, Joon-Yung Moon

This study considers the application environment of a battery switch station (BSS) for electric vehicles (EVs) as a micro-grid consisting of distributed generation facilities (DGFs) including EV batteries and renewable energy resources. An optimal model for environmentally sound and efficient power generation/use should take into account of the daily and seasonal variations caused by nature as well as by humans. In addition to the operational models, station-to-grid (S2G) concept is proposed to maximize the efficiency of the stations.

■ MB-09

Monday, 10:30-12:00 - Room 121

Dynamical Systems and Mathematical Modelling 2

Stream: Dynamical Systems and Mathematical Modelling in OR
Invited session
Chair: *Yutaka Kimura*

1 - Looking for Optimal Strategies in Agribusiness via Nonlinear Optimal Control
Jitka Janova, Gabriela Ruzickova, David Hampel

The optimal control theory is a promising tool to identify the long run strategies in natural resources economics, but where the optimal control policies have been determined, these often fail. We suppose this is mainly due to the shortcomings of the models stemming from neglecting non-linearities of real systems and miss identification of constraints. In this contribution we formulate key long run decision problems of agribusiness in the Czech Republic in the form of nonlinear optimal control problems, present the solution and thoroughly discuss the validity of the results.

2 - A Study of the Enumeration of the Electoral Districts
Keisuke Hotta

In Japan, there is much criticism for the point that the gap in the value of individual votes is too big. The electoral system is overdue for change. We have been tackling this research, and have been providing the optimal district plan and the k-th optimal solutions to support the decision-making. However, enumerating them faster is expected. So, in this study, I propose the method to enumerate them faster.

3 - The Second Dual of a Primal
Takayuki Ueno, Yutaka Kimura, Seiichi Iwamoto

Recently, we've found out that there are many interesting relations between a certain primal problem and dual problem. It is the trinity between the optimal solutions (optimal point and optimal value) of both problems. That is, it is Fibonacci complementary duality and is Golden complementary duality. This duality is called dynamic dual. In this talk, we introduce a second dual problem by considering another dual problem for a primal problem and derive a relation between the optimal solutions of a primal and a second dual. This second dual is Fenchel dual.

■ MB-10

Monday, 10:30-12:00 - Room 122

Integration of Distributed Energy Resources in Electricity Systems

Stream: Optimization Models and Algorithms in Energy Industry
Invited session
Chair: *Tomas Gomez San Roman*

1 - Transmission and Wind Investment in a Deregulated Electricity Industry
Afzal Siddiqui, Lajos Maurovich-Horvat, Trine Krogh Boomsma

Adoption of dispersed renewables like wind typically requires expansion of the transmission network. While the two decisions could be reconciled within the auspices of a central planner, restructuring of electricity industries has introduced a merchant investor (MI), who earns congestion rents from construction of new lines, in addition to the transmission system operator (TSO). We compare the two market designs via a bi-level model that has the MI or TSO making transmission investment decisions (upper level) and producers making generation investment and operational decisions (lower level).

2 - Aggregated Scheduling of Plug-in Electric Vehicles Under Direct and Indirect Load Control Approaches
Ilan Momber, Tomas Gomez San Roman

Unbundling in power systems regulation stipulates aggregators to coordinate the scheduling of plug-in electric vehicles. This may involve centralized, i.e., direct load control and decentralized, i.e., indirect load control decision making. We compare the two via a bi-level programming approach that has the aggregator procuring electricity from day-ahead and balancing markets (upper level) and PEVs reacting to different combinations of retail and network use-of-system charges (lower level).

3 - Multi-temporal OPF for Maximizing the Integration of Energy from Renewable Sources in Distribution Grids
Andre Madureira, Jose Meirinhos, Joao Pecas Lopes

A multi-temporal OPF was developed for managing distribution network operation, including control of voltage magnitudes and active/reactive power injections. Taking as inputs load and generation forecasts, the multi-temporal OPF will exploit a metaheuristic to produce a set of control actions to coordinate available distributed energy resources for the day-ahead. The main objective is to maximize the integration of energy from variable renewable sources subject to a set of technical/operational constraints. Results from the application of the approach in a distribution grid will be presented.

4 - Tools, Procedures and Principles of Coordination between DSOs & TSOs
Miguel Cruz-Zambrano, Cristina Corchero

European Energy Policy aims to promote the integration of large amounts of RES on the electricity sector. Controllable DER will be able to offer network operators a set of instruments for ensuring a secure and reliable grid operation as well as for reducing or deferring network investment. The aim of this work is to propose a set of preliminary procedures of coordination between DSOs and TSOs, considering both current grid codes and national technical regulations. The development of distribution network management tools for increasing the RES hosting capacity will be addressed.

■ MB-11

Monday, 10:30-12:00 - Room 113

Advances in Specialized Zero-One Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Fred Glover*

Chair: *Manuel Laguna*
Chair: *Gary Kochenberger*

1 - GRASP-based Tabu Search for the Vertex p-Center Problem
Zhipeng Lu, Qingjie Zhao, Taoqing Zhou

The p-center problem consists of choosing p facilities from n vertices of an undirected graph in order to minimize the maximum distance between a client and its closet facility. We present a GRASP-based Tabu Search (denoted as GRASP/TS) algorithm for the p-center problem, which employs a Tabu Search based local search and an adaptive perturbation operator to reconstruct the solution when the search falls into local optimum. Experiments show that GRASP/TS is competitive with the best performing algorithms in the literature and is able to improve some previous best upper bounds.

2 - Convergent Scatter Search and Star Paths with Directional Rounding for 0-1 Mixed Integer Programs
Saïd Hanafi, Raca Todosijevic, Fred Glover

Scatter Search is an evolutionary metaheuristic introduced by Glover (1977) for 0-1 Mixed-Integer Programs (MIP). Based on the Star Paths and directional rounding strategies proposed in Glover (1995), we establish several useful properties of directional rounding and show that it provides an extension of rounding and complementing operators. We provide a convergent scatter search algorithm for 0-1 MIP with a proof of finite convergence, accompanied by two implementation variants and illustrative examples. Finally, we present different heuristics based on our extensions of Scatter Search.

3 - The Boolean Quadratic Programming Problem with GUB Constraints
Yang Wang, Abraham Punnen

We consider the boolean quadratic programming problem with generalized upper bound constraints (BQP-GUB) which subsumes the well-known quadratic semi-assignment problem. BQP-GUB has various applications in engineering and biology. We present various complexity results on the problem along with several metaheuristic algorithms. Results of extensive experimental analysis are presented demonstrating the efficacy of these heuristic algorithms.

4 - Effective Long-Term Memory Strategies for Local Search-Based Optimization
Oleg Shylo, Vladimir Shylo

In this presentation, we explore effective and scalable strategies for accumulation and utilization of the feasible solution properties that can improve performance of optimization algorithms based on local search. In particular, we investigate an extension of the tabu search methodology by embedding a long term memory into the tabu list dynamics. The strategies that we present achieve a state-of-the-art performance for well-established benchmark instances of job shop scheduling and max-cut problems.

■ MB-12

Monday, 10:30-12:00 - Room 004

Graphs and Networks II

Stream: Graphs and Networks
Invited session
Chair: *Reinhardt Euler*

1 - Coloring Circulant Graphs C_n(a,b,c)
Sara Nicoloso, Ugo Pietropaoli

A circulant graph C_n(a_1,...,a_k) is the graph with vertex set v(0), ..., v(n-1), where each vertex v(i) is adjacent to vertices v(j), j=(i+ x) mod n, x in a_1,...,a_k. We characterize a class of 3-chromatic circulant graphs C_n(a_1,...,a_k) with k greater than 2. The approach is based on an array representation of the given graph, and allows the design of a linear coloring algorithm.

2 - On Two Matching Problems in Induced Subgrids
Marc Demange, Tinaz Ekim

Given a graph, finding the maximal matching of minimum size (MMM) and the induced matching of maximum size (MIM) have been very popular research topics during the last decades. In this paper, we give new complexity results for these problems in induced subgrids. In particular, we show that MMM is NP-hard in subgrids of degree 2 and 3 and of arbitrarily large girth. We also show that MIM is NP-hard in 4 regular planar graphs and in subgrids of degree 2 and 4 and of arbitrarily large girth. Finally, we sketch a unified approach to show the NP-hardness of some problems in subgrids.

3 - On the System of Two Submodular Functions
Dimitrios Magos, Yiannis Mourtos

In the current work we present results on the system of two submodular functions each defined on a different ground set. In particular, we provide applications where such systems arise and show that they are totally dual integral. We further generalize this result for systems that are defined in terms of two submodular and two supermodular functions, i.e., intersection of two generalised polymatroids.

4 - There are only 42 Types of 10x10 Latin Squares (LS) to Consider in the Search for a Mutually Orthogonal Triple
Gautam Appa, Reinhardt Euler, Anastasia Kouvela, Dimitrios Magos, Yiannis Mourtos

Existence of 3 MOLS of size 10 is an open question. Mann gave conditions under which a 10x10 LS L10 has no orthogonal mate. These relate to the no. of cells with digits other than 1 to 5 in the 5x5 North-West corner I of L10. We show that in any pair of orthogonal L10 at least one must have all 10 digits 1 to 10 in I. Call such a matrix I10. It follows that for a triple, at least 2 of the 3 must be I10s. So the search for triples can be confined to pairs of I10s only. But there are only 42 types of single I10s. This does dramatically reduce the number of cases that need to be considered.

■ MB-13

Monday, 10:30-12:00 - Room 123

Scheduling Theory and Applications

Stream: Scheduling
Invited session
Chair: *Malgorzata Sterna*

1 - Late Work Minimization on Identical Parellel Machines
Malgorzata Sterna, Xin Chen, Jacek Blazewicz, Xin Han

We study the scheduling problem on two identical parallel machines with a common due date and the total late work criterion. Minimizing late work is equivalent to minimizing late part of jobs, which might represent customer orders or phases of technological process. We analyzed off-line case, when all jobs are known in advance, proving its binary NP-hardness, as well as on-line case, when jobs arrive into the system one by one, showing competitive ratio of list algorithms.

2 - Moldable Tasks in Berth and Quay Crane Allocation Problem
Maciej Machowiak, Jacek Blazewicz

The allocation problem of berths to the incoming ships while assigning the necessary quay cranes is modelled by a moldable tasks scheduling problem. This model considers the tasks as the ships and the processors as quay cranes assigned to these ships. Since the duration of berthing for a ship depends on the number of quay cranes allocated to the ship, the use of moldable tasks is substantiated. In the model, the processing speed of a task is considered to be a non-decreasing function of the number of processors allocated. A suboptimal algorithm to obtain a feasible solution is presented.

3 - Single Track Railway Scheduling Problem
Grzegorz Pawlak, Gaurav Singh

Trains are traveling from the source station to the destination station they are traveling through the transiting stations on the single track. On the track between stations only one train can be traveling. Trains can wait at particular stations, the number of the waiting trains depends on the station capacity. The source and target station had unlimited capacity. Optimization criterion is to maximize the number of trains running from the origin to the final destination and back, in the particular time window.

4 - System Supporting Text Analysis
Grzegorz Fenrich, Malgorzata Sterna

In today's world, where access to information and publications is very simple, the problem of text analysis, especially text similarity detection, becomes more and more important. We present a concept of system supporting text analysis devoted mainly to managing documents generated by students during their academic education. The system covers all levels, from gathering information from different sources to their processing in order to compare them to given text, and includes a library of combinatorial optimization algorithms supporting the text comparison phase.

■ MB-14

Monday, 10:30-12:00 - Room 124

Parallel Machines Problems

Stream: Realistic Production Scheduling
Invited session
Chair: *Federico Perea*

1 - The Parallel Machine Scheduling Problem with Job Priorities and Sequence-Dependent Setup Times
Chun-Mei Lai, Yu Chao

This study considers the parallel machine scheduling problem with job priorities and sequence-dependent setup times (PMSPS). Because the PMSPS involves constraints on multiple job priorities and sequence dependent setup times, it is more difficult to solve than the classical machine scheduling problem. The objective is to minimize the total machine workload. We will provide an efficient transformation which convert PMSPS into the capacitated arc routing problem (CARP). Based on the provided transformation, one can therefore solve the PMSPS near-optimally using existing CARP algorithms.

2 - An Iterated Greedy Algorithm for the Unrelated Parallel Machine Scheduling Problem with Setup Times
Eva Vallada, Diana Gonzalez, Ruben Ruiz

In this work an iterated greedy algorithm is proposed for the unrelated parallel machine scheduling problem with sequence dependent setup times. The iterated greedy algorithm includes a fast Variable Neighbourhood Search (VNS). We review, evaluate and compare the proposed algorithm against some of the best methods known from the literature. After an exhaustive computational and statistical analysis we can conclude that the proposed method shows an excellent performance overcoming the rest of the evaluated methods in a comprehensive benchmark set of instances.

3 - The Unrelated Parallel Machine Scheduling problem with additional Resources
Federico Perea, Ruben Ruiz

Given a number of tasks, a number of machines, a number of available resources, the processing times for each task in each machine, and the necessary resources for the processing of each task in each machine, the unrelated parallel machine scheduling problem with additional resources consists of finding the assignment of tasks to machines so that the largest task completion time is minimized and the number of used resources does not exceed the availability at any time. We here discuss about exact and heuristic approaches for this problem: integer linear programming and GRASP algorithms.

■ MB-15

Monday, 10:30-12:00 - Room 125

Dynamic and Competitive Pricing Models

Stream: Revenue Management I
Invited session
Chair: *María Camila Ramos*

1 - Microeconomic Analysis of Cartel Equilibrium Optimization Model
Michal Fendek, Eleonora Fendekova

Methodological problems of formulating oligopoly models rise from the great diversity of ways in which firms can interact and conclude agreements on the distribution, market shares and market prices. In this paper we examine a general scheme of oligopoly equilibrium model on which we present specific aspects of mutual relations between oligopoly subjects in a process of setting an equilibrium price and supply of oligopoly. We study the economically interpretable implications of Kuhn-Tucker optimality conditions in a cartel in a context of its behavior on the market of imperfect competition.

2 - Pricing Game with Customer Choice Based on the Price-Performance Ratio
Yangyang Xie, Meng Lu, Houmin Yan

We propose a customer choice criterion based on the price-performance ratio of products. This model is a variation of McFadden's random utility model. In this paper, we first characterize the customer choice probability among n substitutable products with a no-purchasing option. We then derive unique close-form equilibrium for the n competing retailers' pricing game. We compare the equilibria of static game and dynamic game, decentralized case and centralized case. Last, we consider how the equilibrium price changes as one competitor leaves the market or a new product enters the market.

3 - A Pricing and Inventory Decision Model with Stochastic Demand for Perishable Products
María Camila Ramos, Alejandro Cataldo, Juan-Carlos Ferrer

We develop a methodology to solve a pricing and inventory management problem for perishable products with stochastic demand and a service level constraint, in a finite time horizon, divided into sub-periods. By solving this problem we obtain the order quantity in each sub-period and the price for the entire horizon. The approach uses Tabu Search to determine order quantity, a bisection method to solve the pricing problem and simulation to assess compliance of service level constraint. We conducted preliminary tests to compare our approach to the deterministic case and to a real case.

■ MB-16

Monday, 10:30-12:00 - Room 127

Copositive and Polynomial Optimization II

Stream: Copositive and Polynomial Optimization
Invited session
Chair: *Markus Schweighofer*

1 - Energy Minimization via Conic Programming Hierarchies
David de Laat

In this talk I will discuss a hierarchy of conic optimization problems which can be used to compute the minimal potential energy of a system of repelling particles. For instance, in the Thomson problem one distributes a fixed number of points on the unit sphere to minimize the Coulomb energy (the sum of the reciprocals of the pairwise distances). I will show how techniques from harmonic analysis and polynomial optimization can be used to compute these bounds.

2 - Computing Rational Solutions to Linear Matrix Inequalities
Mohab Safey El Din

I will describe an algorithm which decides the existence of rational solutions to linear matrix inequalities and computes such solutions in case of non-emptiness. Such an algorithm can be used to compute exact sums of squares decompositions of non-negative polynomials (whenever such decompositions exist). Complexity estimates will also be provided. A first implementation is powerful enough to provide a computer-validation of Scheiderer's example of a multivariate polynomial with rational coefficients that is a sum of squares over the reals but not over the rationals.

3 - Sparse Polynomial Optimization for Urban Distribution Networks
Martin Mevissen, Bissan Ghaddar, Jakub Marecek

In many optimization problems over urban distribution networks, the decision maker faces the combined challenge of nonlinear constraints, system parameters affected by uncertainty, and the scale of the underlying network. However, such problems also exhibit structure, notably sparsity, which can be exploited in order to improve the scalability of polynomial optimization solvers. On challenging problems including AC optimal power flow and pressure management in water networks, we demonstrate an approach, which exploits sparsity and strengthened low-order instances of SDP hierarchies.

4 - Polynomial Optimization with Symmetric Polynomials
Cordian Riener

This talk will present some new results related to exploiting symmetries in the context of polynomial optimization with symmetric polynomials. We will show an efficient way of building a block diagonal moment matrix approach using harmonic polynomials. Further a generalization of the degree principle for symmetric polynomials will be presented.

■ MB-17

Monday, 10:30-12:00 - Room 005

Global Optimization and Applications in Development I

Stream: Global Optimization
Invited session
Chair: *Herman Mawengkang*

1 - An Interavtive Approach for Solving Multi-Objective Model of Logistic System and Waste Management in Crude Palm Oil Industry
Meslin Silalahi, Herman Mawengkang

The crude palm oil industry is an agro-industrial commodity which has a strategic value to be developed for Indonesian economy. However, there are a number of environmental problems at the factories, such as high water consumption, the generation of a large amount of wastewater with a high organic content, and the generation of a large quantity of solid wastes and air pollution. As we adopt environmental economics concept, then there are three objectives which are necessarily to be met. Therefore the formulation would take the form of a multi-objective programming model.

2 - An Active Constrained Based Approach for Solving Problems for Positioning New Products under Risk
Nerli Khairani, Herman Mawengkang

Currently, manufacturers are faced with the rapid change in technology and customer's preferences. The problem for positioning new products is a marketing problem faced by a firm which wishes to position a new brand product considering customer's preferences. The aim of the problem considered is to optimally design a new product in order to attract the largest number of consumers. This paper addresses a mixed integer nonlinear programming model to formulate the positioning problem. A direct search approach is proposed to solve the model. A computational experience is presented.

3 - The Dynamic Selection of Coordination Mechanisms in Indonesian Ministry of Religion Affairs Based on Agent Approach
Azizah Hanim Nasution, Herman Mawengkang

This paper presents and evaluates a decision making framework that enables autonomous agents to dynamically select the mechanism they employ in order to coordinate their inter-related activities in Indonesian Ministry of Religion Affairs. The framework implicates a coordination mechanisms that assign precepts arising during design time, to something that the agents select to fit their prevailing circumstances and their current coordination needs. Then agents make informed choices about when and how to coordinate and when to respond to requests for coordination.

4 - A Strategic Conflict is a Decision Problem Involving several Interest Groups or Decision Makers (DMs), Each of Which has Different Preferences
Zahedi Zahedi, Herman Mawengkang

The allocation, utilization, and management of the forest's resources often give rise to serious strategic conflict, typically involving multiple interest groups, each of whom may have multiple objectives and multiple possible courses of action. We develop the graph model for conflict resolution in order to study and analyses systematically these forestry disputes. Then we model the problem as a multi-objective program. We solve the model using an interactive approach.

■ MB-18

Monday, 10:30-12:00 - Room 112

Applications of Goal Programming

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Markus Hartikainen*

1 - A Real Life Door Assignment Problem with a Multi-objective Structure
Zehra Kamisli Ozturk, Bengül Lepki, Kıymet Özge Güngör

In this study, we consider a real life door-assignment problem in a logistics firm. The objective is to find an optimal assignment of vehicles to doors and door ranks that minimizes the total service time, the total distance traveled by the forklifts in the freight yard, deviations from delivery times and deviations from one-day planning period. These objectives do not have the same priorities. So, first of all we weigh the objectives with an ANP model. Then, because of this multi-objective structure we use goal programming and conic scalarization methods to obtain efficient solutions.

2 - A Goal Programming Approach To Design The Supply Chain Network
Mehmet Alegoz, Zehra Kamisli Ozturk

Supply chain network design is a problem which includes lots of goals like minimizing the cost and maximizing the service level. Generally, the goals contradict each other and it makes the problem complex. In the proposed model, we prefer to use a goal programming approach which gives us the opportunity of putting all the five goals into account. The proposed methodology consist of two important steps. During the first step, we use a fuzzy MCDM approach to determine the goal weights. After determining the goal weight, we create the model and solve it by using goal programming.

3 - A Non-Interactive Calibration Method of Linear-Quadratic Composite Metrics in Compromise Programming
Argyris Kanellopoulos, Aleksander Banasik, G.D.H. (Frits) Claassen

Utility functions have been used widely to support multi-objective decision making. Expansion of an additive utility function around the ideal results in a composite linear-quadratic metric of a Compromise Programming problem. Recovering unknown parameters of the metric requires interaction with the decision maker who is not always available and consistent. We propose a non-interactive method that uses information on observed attribute levels to recover unknown parameters and enable forecasting and scenario analysis.The method is applied on a planning model for sustainable mushroom production.

4 - Prepartaion of Blended Flour by Goal Programming
Abdullah Oktay Dundar, Mehmet Akif Sahman, Mahmut Tekin, Adem Alparslan Altun

Flour plants attempt to blend different kind of wheat in various ratios to sustain certain quality levels; besides, they aim to reduce costs. This situation leads to difficulty in sustaining certain quality standards, and it requires that conflicting targets should be managed in a proper way. Goal programming enables managers to consider problems as a whole by providing solutions to manage conflicting aims. In this paper, a goal programming model regarding to the problem of flour blend preparation of a flour plant is developed, and results are discussed.

■ MB-19

Monday, 10:30-12:00 - Room 128

Business Analytics Methods for Demand and Supply Planning and Control

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Michael Katehakis*

1 - Strategic Inventories and Supply Chain Structure
Sudheer Gupta

We consider a competing supply chains framework where manufacturers sell differentiated products through independent retailers and decide on prices and inventory levels. Retailers can carry inventories forward to next period. We show that in equilibrium retailers will always carry inventories as a credible source of competition for the manufacturers even in the absence of traditional reasons for inventories. We show how intensity of product-market competition and ease of carrying inventories forward (holding costs per unit) affect prices, profits and equilibrium supply chain structure.

2 - Partially Observable Total-Cost Markov Decision Processes with Borel State Spaces and their Applications
Eugene Feinberg, Pavlo Kasyanov, Michael Zgurovsky

This paper describes sufficient conditions for the existence of optimal policies for Partially Observable Markov Decision Processes (POMDPs) with Borel state, observation, and action sets and with the expected total costs. Action sets may not be compact and one-step cost functions may be unbounded. The introduced conditions are also sufficient for the validity of optimality equations, semi-continuity of value functions, and convergence of value iterations to optimal values. We discuss applications of the results of this paper to inventory control.

3 - Inventory Models with Omega-Distributed Demand
Lee Papayanopoulos

In our procurement model, a finite, stable set of retailers place orders for a commodity at random times. We show that total demand in a period is omega distributed when i) the size of the order from any given customer remains constant over time and ii) order placement from a customer in any period is Bernoulli with known expected value that may vary between customers. We also examine conditions under which the total demand distribution can be approximated adequately by a normal or other common, closed-form function. We demonstrate the usefulness of the omega distribution through simulation.

■ MB-20

Monday, 10:30-12:00 - Room 129

IFORS Prize for OR in Development 2014 - 2

Stream: IFORS Prize for OR in Development 2014
Award Competition session
Chair: *Andrés Weintraub*

1 - Optimizing Ambulance Moveable Station Location and Vehicle Repositioning to Reduce Response Times for the City of São Paulo
Luiz Augusto Gallego de Andrade, Claudio B. Cunha

In this paper, we address the problem of determining the optimal number and the location of ambulance stations, as well as the vehicle allocation and repositioning for the Mobile Emergency Care Service of Sao Paulo (SAMU-SP), in Brazil. This problem arises in the context of seeking to reduce expected ambulance response times, that was within 27 minutes in Sao Paulo for 98% of the requests. In order to bring total response times down closer to internationally acceptable standards, SAMU-SP devised the concept of moveable ambulance stations that can be installed in available public spaces such as squares and parks and also can be periodically relocated to ensure a good coverage at all times. This new concept, however, was not an easy sell. It was necessary to clearly demonstrate the benefits that such stations, properly located, could provide in the context of limited budgetary resources when compared to the traditional facilities in regular buildings. In this context, we propose an optimization-based decision support system to guide SAMU-SP in its strategic decisions involving their service network, as well in the allocation and repositioning of ambulances to each stand-by points in order to cope with varying demand on different time periods. The model was applied to analyze different scenarios, including one that was implemented in the short term and yielded an improvement in the expected coverage of over 40%.

2 - Modelling and Solutions of Slab Allocation and Reallocation Problems in Chinese Steel Industry
Lixin Tang, Gongshu Wang, Ying Meng, Jiyin Liu, Yuan Yuan

Over the last thirty years, China's steel industry, along with China's economy, has developed rapidly. However, in terms of operations management, most steel companies in China are still well behind those in developed countries and need significant improvements. We worked with China's leading steel company, Baosteel, and developed advanced OR modelling and solving techniques to solve two important operations decision problems on allocating and reallocating slabs to customer orders to improve resource utilization and customer satisfaction. The problems were formulated as an integer linear programming model and a mixed-integer second-order cone programming model, respectively. Column generation and Lagrangian relaxation techniques were used to solve the models. For large-scale instances of the slab allocation and reallocation problems, hybrid metaheuristic algorithms were proposed to obtain near-optimal solutions within a short computation time. The models and solution methods were successfully embedded into a computerized decision support system (DSS). The implementation of the DSS has brought a total direct economic benefit of $43.16 million USD to Baosteel and reduces carbon dioxide (CO_2) emissions by 238,883 tons annually.

3 - Water Allocation Modelling and Policy Simulation for the Min River Basin of China under Changing Climatic Conditions
Jiuping Xu, Zhineng Hu, Hong Yan, Liming Yao, Ziqiang Zeng, Mengxiang Zhang

The significant stress on development caused by unsustainable water resource allocation has been a perplexing problem for the Dujiangyan Administration Bureau of the Min River Basin, a tributary of the upper Yangtze River in China. To tackle these regional water resources allocation issues at Sancha Lake, an important area in the lower-right basin of the Dujiangyan Irrigation System, the local authority was seeking an optimum allocation strategy to ensure equitable and efficient water use for its subareas, from which the subareas would be able to provide reasonable reaction strategies. The authority dominates the water transactions between the subareas involved in water rights distribution, which shows a Stackelberg-Nash equilibrium, with the subareas playing a Cournot-Nash game to develop optimum strategies. Using a multi-objective multi-stage decision making process with an uncertain stream now, a multi-objective multi-stage Stackelberg-Nash-Cournot (m2SNC) game is modeled as a bi-level equilibrium optimization incorporating fuzzy random coefficients. An interactive-dynamic-programming-based genetic algorithm (IDP-GA) is designed to simulate the policies needed for the optimum allocation of water resources under various climatic scenarios. Specifically, a complete operationalized mechanism for the Sancha Lake area is presented to demonstrate the practicality and efficiency of the bi-level equilibrium model and the policy simulation procedure: (1) The bi-level equilibrium model, integrating the Stackelberg-Nash equilibrium and the Cournot-Nash equilibrium, is an efficient tool to determine optimum water resource allocation strategies. (2) Similar to the principles of an input-output system and the computable general equilibrium (CGE), the policy simulation system with an IDP-GA, an extension of principle of CGE, inputs scenario data and outputs an early-warning mechanism to inform the policy suggestions. (3) An emergency response cooperative mechanism based on allocation modes dominated by an authority is a relatively equitable and efficient method for developing countries which need to cope with uncertain situations under changing climatic conditions.

■ MB-21

Monday, 10:30-12:00 - Room 006

Optimization Modeling Software & Systems 2

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *Robert Fourer*

1 - Recent Developments in IBM ILOG CPLEX Optimizer

Xavier Nodet

Recently added features and performance enhancements will be presented. Particular emphasis will be given to distributed computing options available with the CPLEX Remote Object and the distributed parallel MIP algorithm as well as the solver for global solutions to nonconvex MIQP.

2 - Robust Problem Formulation Alternatives

Susanne Heipcke

Many optimization models include strategies for improving the model's robustness based on an intuitive definition of what is 'robust'. The first part of the talk reviews examples of such model formulation techniques. The second part presents cases that are not easily addressed this way with implementation examples using the new robust optimization framework of the FICO Xpress suite.

3 - Developments in the AMPL Ecosystem

Gautam Mitra, Christian Valente

For the AMPL modelling language ecosystem we report new developments which include: (i) AMPLDev, an advanced Integrated Development Environment for AMPL; (ii) SAMPL, a collection of extensions to AMPL for stochastic programming and robust optimisation models; and (iii) FortSP, a solver that processes stochastic programming problems and SOCP instances of robust optimization problems, using CPLEX or Gurobi as embedded solver and Benders decomposition with regularisation by the level method. We also describe AMPLDev cloud, which makes this software available via a cloud-based service.

4 - Optimizing a Manufacturing Process using JMP

Volker Kraft

This case study will demo JMP in capability analysis and process optimization, dramatically improving a manufacturing process. Dynamic visualization tools in JMP help to explore relationships between process factors and responses. As a next step various modeling techniques determine the most important factors and how they collectively impact process quality. Factor optimization will determine the best-case process capability, before finally simulating the process under real-world conditions. The live demo incorporates a wide range of tools for data exploration, modeling and simulation.

■ MB-22

Monday, 10:30-12:00 - Room 007

OR and Health Care Management

Stream: Health Care Data Analytics
Invited session
Chair:
Chair: *Janny Leung*

1 - The Impact of Directed Choice on the Design of Preventive Healthcare Facility Network Under Congestion

Navneet Vidyarthi, Onur Kuzgunkaya

Preventive healthcare (PH) programs and services aim at reducing the likelihood and severity of potentially life-threatening illness by early detection and prevention. The effectiveness of these programs depends on the participation level and the accessibility of the users to the facilities providing the services. In this talk, we study the impact of system-optimal directed choice on the design of the preventive healthcare facility under congestion. We present a model, solution approach, and insights using a case study that deals with locating mammography clinics in Montreal, Canada.

2 - Medical Decision Making in Resource Constrained Environments

Mariel Lavieri

I discuss ongoing work on allocating constrained resources across a panel of patients. This work is first applied to guide the sequential allocation of fixed screening capacity. The allocation of constrained treatment resources is then discussed. The models are calibrated using longitudinal clinical data from chronic disease patients.

3 - Using Simulation to Analyze Patient Flows in a Hospital Emergency Department in Hong Kong

Janny Leung, Yong Hong Kuo, Colin Graham, Omar Rado, Benedetta Lupia

This paper presents a case study of applying simulation to analyze patient flows in a hospital emergency department in Hong Kong. The purpose of our work is to analyze impact of the enhancements made to the system after the relocation of the department. We developed a simulation model to capture all the key relevant processes of the emergency department. Using the simulation model, we evaluated the impact of possible changes (such as, adjusting staffing levels or shift times) to the system by running different scenarios.

■ MB-23

Monday, 10:30-12:00 - Room 008

Behavioural Issues in Decision Making and Negotiation

Stream: Behavioural Operational Research
Invited session
Chair: *Etienne Rouwette*

1 - Decision Analysis in the Context of the Behavioural Reality in Organizations — An Empirically Supported Framework for Analysing Implementation Problems

Ana Barcus, Kai Helge Becker, Gilberto Montibeller

Decision analysts' experience shows that the practical implementation of their methods often turns out to be difficult. Our paper contends that these difficulties are the consequence of a gap between the prescriptive approach of decision analysis and the way in which unsupported decision making is typically carried out. We suggest an empirically supported framework that describes the nature of this gap and discuss its implications for the decision analysis practice, thereby offering a systematic way to reflect on the challenges that decision analysts encounter.

2 - Cognitive and Motivational Biases in Risk and Decision Analysis
Gilberto Montibeller, Detlof von Winterfeldt

Behavioral decision research has demonstrated that judgments and decisions of ordinary people and experts are subject to numerous biases. Decision analysts often face such biases when eliciting models and parameters from decision makers or experts. Some of them are due to faulty cognitive processes, some are due to motivations for preferred analysis outcomes. The purposes of this talk are to identify the cognitive and motivational biases that matter, as well as those that do not matter, show how they distort judgments involved in modeling, and to suggest effective debiasing techniques.

3 - The Impact of Need for Closure on Model-supported Group Conflict Management
Etienne Rouwette, L. Alberto Franco, Hubert Korzilius

Need for closure, the desire for definite knowledge on an issue, has important impacts on decision making. Decision makers that are high in need for closure seize on information and then freeze on early cues. We focus on the impact of need for closure on conflicts in decision making groups. The groups in our study use Value Focused Thinking to jointly develop a model. We compare MBA and MSc groups high and low in need for closure with regard to a) conflicts and how these are resolved and b) group outcomes such as consensus and satisfaction, using interaction/ phasic and multilevel analysis.

4 - Using Analytic Hierarchy Process to Enhance Consensus in Multi-agent Multi-issue Negotiation
Djamila Boukredera, Kamal Hariche, Maamri Ramdane, Rabah Kassa

This paper proposes to use the Analytic Hierarchy Process (AHP) to enhance consensus in bilateral multi-issue negotiation with incomplete information. We focus on mediated negotiation, where two agents try to reach an agreement over a range of qualitative and quantitative issues. We assume that the mediator agent adopts the AHP method to construct the ranking of the alternatives based on both agents' preferences defined beforehand. Based on a case study, we show how AHP can provide a simple and effective decision making leading to an efficient and timely conflict resolution.

■ MB-24

Monday, 10:30-12:00 - Room 212

Preference Learning II

Stream: Preference Learning
Invited session
Chair:
Chair: *Roman Slowinski*

1 - Descriptive Models of Deliberated Preferences
Olivier Cailloux

Prescriptive approaches to decision making aim at letting the decision maker (DM) think about, and possibly change, her preferences. This talk relates to validation of preference models obtained following such an approach. We propose to view the preference modeling task as aiming to describe the many possible views and arguments a DM can adhere to when facing a decision problem. By integrating elements from formal argumentation theory, we show how this view can render a preference model falsifiable, without having to adopt the belief that precise preferences pre-exist in the head of the DM.

2 - New Veto Rule for a Sorting Model
Olivier Sobrie, Marc Pirlot, Vincent Mousseau

In MCDA outranking methods, an alternative is considered at least as good as another one if a majority of criteria support this assertion and if there is no strong opposition, i.e., veto, among the minoritarian criteria. We give an overview of existing veto models in the literature. In the context of the sorting problematic, we introduce a new veto rule for a model based on ELECTRE-Tri in order to increase its descriptive ability. We present a Mixed-Integer Program and an heuristic that allow to learn the parameters of such a model on basis of assignment examples.

3 - Integrated Preference Disaggregation Framework for Value-Driven Multi-Criteria Sorting
Milosz Kadzinski, Krzysztof Ciomek, Roman Slowinski

We introduce a new preference disaggregation method for multi-criteria sorting. The preference information supplied by the Decision Maker is composed of (1) possibly imprecise assignment examples, (2) desired class cardinalities, and (3) assignment-based pairwise comparisons. The exploitation of all compatible value functions results in (1) necessary and possible assignments, (2) extreme class cardinalities, and (3) necessary and possible assignment-based preference relations. By exhibiting these outcomes, we provoke the DM in various ways to enrich her preference information interactively.

4 - Robust Ordinal Regression for Dominance-based Rough Set Approach to Decision under Risk
Roman Slowinski, Milosz Kadzinski, Salvatore Greco

We consider decision under risk where preference information provided by a decision maker is a classification of some reference acts described by outcomes to be gained with given probabilities. We structure the classification data using a variant of the dominance-based rough set concept. Then we induce all possible sets of minimal cover rules which correspond to all instances of the preference model compatible with the input preference information. We apply these instances on a set of unseen acts and draw robust conclusions about their quality using the robust ordinal regression paradigm.

■ MB-25

Monday, 10:30-12:00 - Room 009

Mathematical Economics and Optimal Control

Stream: Mathematical Economics
Invited session
Chair: *Alexander Zaslavski*

1 - Optimal Irrigation Scheduling for Wheat Production in Manitoba: A Simulation Study
Raphael Linker, Ilya Ioslovich

The current practice in Manitoba (Canada) is to grow wheat as a rainfed crop. We investigated whether applying supplemental irrigation could increase yield significantly. The optimization problem can be expressed as: Given weather and soil data, obtain maximum yield subject to irrigation water quota. Solving this problem for different values of the water quota allows creating an irrigation water use efficiency function which presents the yield as a function of the irrigation applied. This optimization problem was solved with the TOMLAB optimization library and the AquaCrop model

2 - Harvesting in an Age-Structured Population
Vladimir Veliov, Anton Belyakov

We investigate an age-structured infinite-horizon optimal control model of harvesting a biological resource, interpreted as fish. Time and age are considered as continuum variables. The main result shows that in case of selective fishing, where only fish of prescribed sizes is harvested, it may be advantageous in the log run to implement a periodic fishing effort, rather than constant (the latter suggested by single-fish models that disregard the age-heterogeneity). Thus taking into account the age-structure of the fish may qualitatively change the theoretically optimal fishing mode.

3 - Hierarchical Organizations
Zvi Winer, Benjamin Bental

This paper endogenizes the number of hierarchical layers, workers per layer, control spans of supervisors and the wage scale in hierarchical organizations. To monitor production workers' hidden effort the organization hires supervisors whose effectiveness also depends on hidden effort, and so on. The number of production workers and their induced effort is traded off against the overhead costs generated by the hierarchical structure needed to control the system. The latter limits the optimal size of the organization even if production is characterized by increasing returns to scale.

4 - Steady State Properties in a Class of Dynamic Models
Amos Zemel, Yacov Tsur

We characterize the location, stability and approach-time of optimal steady states in single-state, infinite-horizon, autonomous models by means of a simple function of the state variable, defined in terms of the model's primitives. The method does not require the solution of the underlying dynamic optimization problem. Its application is illustrated in the context of a generic class of resource management problems.

■ MB-26

Monday, 10:30-12:00 - Room 010

Fuzzy Multiobjective Programming

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Monga K Luhandjula*

1 - Approximation and Equivalence Approaches for Fuzzy Multiobjective Programming Problems
Monga K Luhandjula

In this paper, we present approximation and equivalence approaches for dealing with an optimization problem with several fuzzy objective functions. The first one is based on the Nearest Interval Approximation Operator for fuzzy numbers and the second is based on an Embedding Theorem for fuzzy numbers. Our approaches strike a balance between computational efficiency and effectiveness in representing the reality. Numerical examples are also provided for the sake of illustration.

2 - Mathematical Programming Problems with Several Fuzzy Objective Functions
Moeti Rangoaga

In this paper, we propose an approach for multiobjective programming problems with fuzzy number coefficients. The main idea behind our approach is to approximate involved fuzzy numbers by their respective nearest interval approximation counterparts. An algorithm that returns a nearest interval approximation to a given fuzzy number, plays a pivotal role in the proposed method. Our approach contrasts markedly with those based on deffuzification operators which replace a fuzzy set by a single real number leading to a loss of a lot of important information. A numerical example is also provided.

3 - Fuzzy Linear Programming Problems with Appropriate and Flexible Membership Functions
Takashi Hasuike, Hideki Katagiri, Hiroe Tsubaki

This paper considers a general fuzzy linear programming problem with flexibility of membership functions based on interval values involving ambiguity and decision maker's subjectivity. Since this proposed problem is not well-defined due to fuzziness, some fuzzy mean values and mathematical relations between two intervals are introduced. The main linear programming problem is transformed into a standard mathematical programming problem according to each fuzzy mean value and relation, and hence, each strict algorithm is developed.

4 - Fuzzy Scenario-based Multi-Criteria Optimisation of a Manufacturing Supply Chain
Jiabin Luo, Dobrila Petrovic

A real-world supply chain which consists of suppliers, a manufacturer and customers is considered. Raw materials are purchased in advance according to forecasted customer demand; customers can change their order at any time. In order to meet changed customer demand, raw material can be ordered from a standard supplier or a local supplier at different prices and lead times. A two-stage fuzzy scenario-based optimisation model is developed to determine the orders for a planning period, in such a way as to maximise the effectiveness, robustness and resilience of the supply chain.

■ MB-27

Monday, 10:30-12:00 - Room 213

OR in Quality Management II

Stream: OR in Quality Management
Invited session
Chair: *Aysun Kapucugil-Ikiz*

1 - The Factors to Affect Gap Between Exhibitors' Expectations and Visitors' Perceptive Satisfactions in Trade Shows
Kuochung Chang

Trade shows are always the excellent sources and opportunities for marketing programs. The study is purposed to verify the visitors' quality perspective of trade shows in 3C and design industries. Besides, the interaction quality is thought to be influenced by attitudes, behavior, and expertise of service personnel. Therefore, the study uses the analytic hierarchy process (AHP) to resolve the priorities of the influential dimensions in the trade show quality, and finds out the existed gap between exhibitors' expectations and visitors' perceptive satisfactions.

2 - Hybrid Quality Function Deployment for Tool Making
Cem Kayguluoglu, Gül Gökay Emel

Our study presents a Hybrid QFD for tool making; by integrating fuzzy app., Analytic Hierarchy Process and Axiomatic Design principles. AD independence axiom is used to check the dependency level of Customer Needs to have CNs which could be satisfied without affecting each other. Fuzzy AHP is used to define the degree of importance. After defining the absolute weight of CNs with QFD methodology; AD information axiom is used to define the final importance ranking of ECs by exploring the roof correlation. Aim of the study is to max. the efficiency of QFD by min. the effect of correlations.

3 - A Fuzzy-QFD Decision Model for Service Design
Aysun Kapucugil-Ikiz, Aşkın Özdağoğlu, Güzin Özdağoğlu

Quality Function Deployment (QFD), a well-known methodology, dedicated to translating customer needs (qualitative data) into technical characteristics (quantitative data) to develop products and services. Literature well defines some technical issues occurring in this transformation and also in determination of design targets in QFD methodology. As a solution to the technical issues, this study proposes a fuzzy optimization model which considers budget factors and uncertainties in order to balance between customer and organization satisfaction in service design.

■ MB-28

Monday, 10:30-12:00 - Room 130

Challenge ROADEF/EURO 2

Stream: Challenge ROADEF/EURO
Award Competition session
Chair: *Safia Kedad-Sidhoum*

1 - A Multi-stage Selection Hyper-heuristic for Rolling Stock Unit Management on Railway Sites
Ahmed Kheiri, Elsayed Elsayed

We propose an easy-to-implement, easy-to-maintain, yet an effective multi-stage selection hyperheuristic approach to solve the challenge problem. Selection hyper-heuristics, also known as 'heuristics to choose heuristics', are high level search methodologies which control and mix a fixed set of low level heuristics (neighbourhood operators) under an iterative framework. The proposed approach aims to exploit a large set of constructive and perturbative low level heuristics, each of which attempts to enhance an aspect of the quality of a solution in hand during the search process.

2 - Constructive and Heuristic Algorithms for a Rolling Stock Management Problem
Florence Thiard, Hugo Joudrier

We develop an algorithm to solve an industrial problem submitted by SNCF to the EURO/ROADEF Challenge 2014. The goal is to manage the traffic inside a railway station, under numerous constraints. In order to rapidly obtain initial feasible solutions, we develop a greedy constructive algorithm. These solutions are built by scheduling trains to storage units, then assigning departures when possible. To obtain relevant upper bounds and improve our initial solutions, we then move towards a metaheuristic approach.

3 - Local Search Algorithm for Trains Scheduling on Railways Sites
Szymon Wasik, Piotr Zurkowski, Wojciech Jaśkowski

The presented algorithm for solving the ROADEF Challenge 2014 problem consists of several phases. First, we use a heuristic based on network flow algorithms that determines the initial assignment of arriving trains to departure requests. Then, we use a simple construction heuristic on a resource-time graph to verify and improve the initial assignment. Finally, the solution is optimized using various local search techniques. A simplified version of this approach with much worse results was ranked on 6th place during the qualification phase.

■ MB-29

Monday, 10:30-12:00 - Room 011

Stochastic Models and Finance

Stream: Financial Optimization
Invited session
Chair: *Xiangwei Wan*

1 - Portfolio Decision under Loss Aversion Preference with Mean-reverting Returns
Jianjun Gao, Xiangyu Cui, Duan Li

The loss aversion, which describes the inconsistency of an investor's risk attitude for loss and gain, plays a central role in famous Prospect Theory in behavioral finance. On the other hand, there are abundant empirical studies which document the phenomena of the mean-reverting of the stock return. In this research, we propose a portfolio optimization model combining these two features. We develop the semi-analytical solution of such a problem by using the method of Inverse Fourier Transformation. The revealed portfolio policy exhibits different features compared to the classical policy.

2 - The Survival Distribution of SABR Model
Nian Yang

In this paper, we work out the asymptotic formulae for the rst passage time, the marginal and joint survival probability densities of the SABR model. To the best of the author's knowledge, this is the first time to obtain asymptotic solutions of problems with a lower absorbing boundary. These formulae have a wide range of applications such as the survival probability, pricing down-and-out barrier option under SABR model, etc. The numerical results show that our analytic formulae are accurate and efficient.

3 - Sensitivity Analysis of Nonlinear Behavior with Distorted Probability in an Incomplete Market
Xiangwei Wan, Xi-Ren Cao

The dynamic programming fails to work when a distortion in performance probability appears. In this talk, we use the sensitivity-based analysis to study this nonlinear behavior with probability distortion. We find a local linearity property of the distorted performance, which we call mono-linearity, and apply it to the portfolio management problem under distorted performance in an incomplete continuous market. The first-order condition for the optimal solution is presented, from which we obtain several characterizations of optimal solutions in the general market setting of incomplete markets.

■ MB-30

Monday, 10:30-12:00 - Room 012

Financial Mathematics and OR

Stream: Financial Mathematics and OR
Invited session
Chair: *Gordon Dash*
Chair:

1 - Hierarchical Neuro-Cybernetic Systemic Risk Factors for Multiobjective ESG Portfolio Optimization
Gordon Dash, Nina Kajiji

Investment approaches that embrace environmental, sustainability and governance (ESG) factors provide investors with long-term risk-mitigated performance gains. While ESG factors offer a wider view of the risk-return profile such factors are known to dampen short-run portfolio returns. This paper uses an artificial neural network (ANN) to capture ESG stylized effects from traded ETFs. The ANN linear weights are combined with a combinatorial nonlinear multiple objective portfolio optimization model to overcome the performance dampening effects observed in the traditional mean-variance approach.

2 - Entrepreneurial Decisions on Effort and Project with a Non-Concave Objective Function
Abel Cadenillas, Alain Bensoussan, Hyeng-Keun Koo

We solve an entrepreneurial/managerial decision making problem. We use a general expected utility function. We show that the optimization problem with the non-concave objective function has the same solution as the optimization problem when the objective function is replaced by its concave hull. We also show that the final wealth cannot take value in the region where the objective function is not concave. This implies that the risk taking explodes as time nears maturity if wealth is equal to the right end point of the non-concave region.

3 - Sustainability of the Japanese Pension System with the Automatic Balancing Mechanism
Masanori Ozawa, Tadashi Uratani

The Japanese pension system is a two-tier system which is composed of the employees' pension insurance and the national pension. There is a slowdown in economic growth in the recent decade. The population forecast shows a rapid growth of aged population and a low level in fertility. Therefore, the government introduced an automatic balancing mechanism for pension finance. We study the sustainability of the pension system with stochastic simulations under some scenarios.

4 - Optimal Investment Problem for Eco-Product
Masashi Toyoda, Katakai Takafumi, Katsunori Ano

We study the optimal stopping problem for the optimal investment problem of the eco-product company, such as energy supply with solar panel, in the real option framework, that is solved by the free-boundary problem approach to the corresponding optimal stopping problem. We naturally assume that the return of the investment depends on the remaining time to a certain finite time.

■ MB-31

Monday, 10:30-12:00 - Room 013

Decision Processes under a Life-cycle Perspective

Stream: Decision Processes
Invited session
Chair: *Luis C. Dias*

1 - Applying MCDA without Precise Weights to Life-Cycle Environmental Assessment of Vehicle Alternatives
Luis C. Dias, Ana Rita Domingues, Fausto Freire, Rita Garcia, Pedro Marques

Six technologies of compact passenger vehicles available in Portugal (internal combustion and electric) are evaluated by combining Life-Cycle Assessment (LCA) and Multi-Criteria Decision Analysis (MCDA). The evaluation is based on environmental indicators from Life-Cycle Impact Assessment and operation indicators. The ELECTRE TRI method (IRIS software) is used to sort the alternatives in performance classes, without requiring precise criteria weights. Combining ELECTRE TRI and LCA allows synthetizing the environmental assessment of the vehicles without requiring value trade-offs.

2 - Multi-Criteria Analysis of Low Voltage Grid Expansions
Tobias Lühn, Jutta Geldermann

Due to the increasing generation capacity of photovoltaics connected to the German low voltage grid, distribution system operators (DSOs) are challenged to prevent the overload of grid components and the violation of voltage range. Therefore, DSOs have to evaluate novel smart grid concepts leading to new types of structure, design and operation of distribution grids. These grid expansion concepts are analysed regarding environmental, economic, technological and social dimensions using the approach of multi-criteria decision making.

3 - Multicriteria Assessment of the Use of Renewable Resources under a Life-cycle Perspective
Jutta Geldermann, Meike Schmehl

Energy and material products based on renewable resources have different and partly opposing effects on sustainable development throughout their life-cycles. Based on one hectare agricultural land as common functional unit, four alternatives of use of renewable resources are assessed by a PROMETHEE-model. As the modeling of these different product systems requires heterogeneous kind of data sources, a pedigree matrix of data quality is implemented into the approach. Consequences for decision processes under a life-cycle perspective will be discussed.

4 - Incorporating Different Cognitive Styles into a DSS based on ILS Model
Ana Paula Costa, Levi Adelino Lima

This paper proposes to incorporate the cognitive style of different decision makers in a Decision Support System. In this research, an empirical study is performed to evaluate user satisfaction using a DSS which incorporate the learning style of the user based on Index Learning Style (ILS). The prototype developed offers different versions of DSS appropriate to each decision maker learning style, identified by the system through a questionnaire. The results of an experiment conducted with undergraduate and graduate students point differences in the levels of satisfaction in using the DSS.

■ MB-32

Monday, 10:30-12:00 - Room 014

Health Care Analytics

Stream: Humanitarian Operations Research
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair: *Maria Teresinha Arns Steiner*

1 - Discrete Event Simulation for Performance Modelling in an Outpatient Clinic
Aline Mendes, Paulo Rotela Junior, Luisa Moschioni

In an outpatient clinic the proper functioning of scheduled appointments is of paramount importance. The malfunction of this care leads to delayed diagnosis and treatment, causing high costs for the government as a consequence which justify the reason why optimization of this process is required. Applying Discrete Event Simulation, by using the IDEF-SIM technique and the ProModel software, this paper aims to analyze and optimize an outpatient clinic of a hospital located in Bragantina region of Sao Paulo state, demonstrating the applicability of Discrete Event Simulation in healthcare field.

2 - Developing and Validating Joint Dynamic Ambulance Relocation and Flexible Dispatching Strategies: A Simulation-Optimization Approach
Cem Saydam, Xun Li

We present a simulation embedded optimization approach for relocating ambulances and determining flexible dispatch policies for maximum performance. A realistic simulation model allows us to remove most of the simplifying assumptions which are required in analytical approaches. Using experimental and real data we show that this approach can provide a detailed output that can be used by EMS managers to estimate lives saved for multiple life threatening situations while providing a plethora statistics on important performance measures such as actual vehicle busy probabilities and response times.

3 - Analysis of the Dengue's Fever Care in a Basic Health Unit Using Discrete Event Simulation
Luisa Moschioni, Paulo Rotela Junior, Aline Mendes

Diseases outbreaks have different impacts in populations. In the Brazilian state of Goias, there have been many dengue's fever outbreaks, which have effects on society. Especially the financial effects concern particularly the municipal's governments. This current study uses the Promodel software, an discrete event simulation software, to analyze and optimize the costs for the official flowchart of dengue's fever care in the basic health unit of Ipora, in order to reduce them, however without losing process quality, helping the economy of the outbreak's area.

4 - Multi-Optimization in the Partitioning Healthcare System of Parana State, Brazil
Maria Teresinha Arns Steiner, Dilip Datta, Pedro Steiner Neto, Cassius Tadeu Scarpin, José Rui Figueira

Partitioning health services is a proposal to aggregate municipalities into microregions in a way to facilitate patients flow when in need for procedures not offered in their municipalities. This paper aims to "optimize" the division of Parana State, Brazil, into microregions through the use of a multi-objective genetic algorithm. Three objective functions (homogeneity its population; variety of medical procedures; distances), for defining the microregions, have been considered. The results may have a strong impact on the healthcare system management in Parana State.

■ MB-33

Monday, 10:30-12:00 - Room 015

Environmental Sustainability in Global Operations

Stream: Environmental Sustainability in Supply Chain
Invited session
Chair: *Emel Arikan*

1 - Investigating the Role of Electrified Vehicles for Automotive Industry Supply Chain and Fleet Sustainability
Matthias Kannegiesser, Hans-Otto Guenther, Niels Autenrieb

Electrified vehicle powertrains are perceived as key measures towards a zero emission and more sustainable automotive industry. We investigate how vehicle electrification may change end-to-end industry supply chain structures together with fleet powertrain mixes long-term towards 2030 and if these changes are sustainable with respect to costs, CO2 emissions and jobs created. We use a sustainability optimization framework applied to comprehensive industry data with a specific focus on supply chain steps and vehicle fleets in Germany and Europe vs. China.

2 - A Multi-Objective Modeling Approach for Intermodal Transport Planning with Environmental Aspects
Martin Hrusovsky, Emrah Demir, Wolfgang Burgholzer, Werner Jammernegg, Tom Van Woensel

Growing transport volumes induce new challenges for transport planners as increasing traffic congestion leads to more and more uncertainty and volatility of travel times as well as increased GHG emissions. Therefore, the need for new transport alternatives combining different transport modes is evolving. We propose a linear mathematical model in the form of a multi-commodity, capacitated network design formulation which considers time-dependent travel times and enables transport planning optimization according to costs, travel time and emissions.

■ MB-34

Monday, 10:30-12:00 - Room 016

Large-Scale Risk Systems

Stream: Data Mining in Finance and Commodities
Invited session
Chair: *Gegoire Caro*
Chair: *Dejan Stokic*

1 - Robust Multivariate Regression for Large Scale Risk Systems
Gegoire Caro

This study is focusing on the mapping of instrument returns on a set of market returns, as done for the CAPM model. The standard approaches implemented in the industry combine a set of heuristic rules based on the instrument meta-data with a univariate regression. The contribution of this work is a listing of the requirements of this mapping in the context of large scale risk systems, and a solution inspired from the LASSO regression to combine heuristic and statistics in a single optimization framework.

2 - Stress Testing Framework in a Large Scale Risk System
Paraskevi Papoula

This study focuses on hypothetical scenarios of market risk drivers. A way to translate the scenarios assumptions of a few risk drivers into the other risk factors via the covariance matrix is explained. One can also stress the covariance matrix or equivalently the correlation matrix through exposures to latent drivers of various risk driver groups. A solution using the latent factor theory is recommended to combine the historical correlations with a target/limit correlation matrix.

3 - Temporally Weighted Portfolio and Purchasing Sequences for Next-Purchase Prediction
Katerina Shapoval, Thomas Setzer

Although a customer's purchasing history might provide valuable information to better identify target customers, it is often considered in a very aggregated fashion, as such data would drive complexity due to an explosion of potential product sequences. We propose an approach to incorporate purchasing information by applying supervised clustering techniques on past purchases weighted nonlinearly, with more weight given to more recent purchases. Exploiting a unique set of empirical data of a large telecommunications provider, the experimental results on predictive accuracy are presented.

4 - Impact of Market Data Quality on Capital Requirements
Dejan Stokic

Data cleansing of financial time series is being established as a crucial part of risk management. We show how the different approaches in assessing the data quality of equity, interest rates and currency risk factors directly influence the estimated market risk, evaluated with different risk measures. The sensitivity of the historically simulated risk measures on the risk factor data quality impacts the capital adequacy of the financial institutions furthermore.

■ MB-35

Monday, 10:30-12:00 - Room 131

Stochastic Sports Analysis

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Norio Torigoe*

1 - Mathematical Modeling of Team Competition in Artistic Gymnastics
Nobuyoshi Hirotsu, Mutsumi Harada, Minoru Kano

We model men's team competition in artistic gymnastics of a 6-5-4 format, and propose a mathematical formulation for calculating a team score, considering each gymnast's score as a normal distribution. By setting the different mean and SD of the normal distributions, we calculate the distributions of the team score, and obtain the relationship between the mean and SD of the each gymnast and the expected number of the team score. Using this model, we demonstrate the method for selecting five gymnasts and analyze the sensitivity of an improvement of each gymnast's performance to the team score.

2 - Are Soccer Schedules Robust?
Dries Goossens, Fabrice Talla Nobibon

This talk focuses on the robustness of soccer schedules. We analyze the schedules of ten main European soccer leagues and we find that soccer seasons are hardly ever played as initially scheduled. This is due to disruptions, which require some games to be rescheduled. The data of the last ten seasons reveal that these disruptions have a profound impact on the quality of the final schedule, indicating that soccer schedules in Europe are computed without taking uncertainty into account.

3 - Figure Skating Scoring Optimization and Analysis
Kellie Keeling, Sydney Raith

In 2002, the International Skating Union scoring system was updated to make the system more objective, transparent, and fair to the competitors. In this study, we examine how the judging system has impacted the skater's strategy and their rankings. We use simulation to develop strategies to place elements of a program in or out of Bonus time.

■ MB-36

Monday, 10:30-12:00 - Room 132

Integrated Forest Planning

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Christian Rosset*

1 - Rethinking the Strategic Model
Eldon Gunn

If, in addition to its role in evaluating and planning landscape level ecosystem strategies, the strategic forest management modelling involves wood supply to the forest industry, then it seems obvious that it needs to include a reasonable representation of the industry capacity and how it might change over time. This paper discusses what this means for the mathematical structure for the model. We also raise questions about the appropriate time horizon for analysis. There are good reasons that this time horizon should be much shorter than it has been conventionally.

2 - Models and Mathematical Decomposition for Large-Scale Location Problems in the Forestry Sector
Bernard Gendron, Jean-François Cordeau, Sanjay Dominik Jena

We present mathematical models and algorithms for a complex location problem which is found in the forestry sector. Based on logging demands for the next five years, this problem investigates the optimal number, locations and sizes for new camps in order to host workers involved within logging activities and balance transportation, camp construction and camp relocation costs. The problem includes a very detailed cost structure. We compare different models and present heuristics based on two different Lagrangian decomposition approaches, capable to solve even very large instances.

3 - Integrated Planning and Control of Forest-based Supply Chains with Focus on Forest Management: Limitation and Potentialities

Christian Rosset, Germano Veiga, Alexandra Marques, Jussi Rasinmäki

Systematic planning and control of forest-based supply chain involving different actors is a key ingredient for overall sustainability and efficiency. The FOCUS project (focusnet.eu) aims to develop innovative solutions based on pilot study cases in several countries across Europe. The blend of operational planning with the concept of model-base control inspired in its use in industrial processes is a new and promising approach. This paper discusses the potentialities and limitations of such a concept and draws the outlines of a planning and control software focused on forest management.

4 - A Model for Optimal Crop Selection Based on Conditional Value-at-Risk

Carlo Filippi, Renata Mansini, Elisa Stevanato

Consider a farmer in a temperate zone who has to select crops to be cultivated on a piece of land in order to maximize the total expected profit on a given time horizon while considering: resource requests for each crop; machinery and manpower availability; timing of the operations required by each crop; market price and yield variability of harvested products. We propose a stochastic MILP model that allows to maximize the average expected return under a predefined quintile of worst realizations. We use the model to prove the advantages of resource aggregation among different farmers.

■ MB-37

Monday, 10:30-12:00 - Room 017

AHP Application

Stream: AHP (Analytic Hierarchy Process) /ANP (Analytical Network Process)
Invited session
Chair: *Yoichi Iida*

1 - The AHP Based on Weighted Sum

Yoichi Iida

I propose the AHP based on weighted sum. This method can restore the evaluation ratios of alternatives with respect to criteria in a meaning of weighted sum. The conventional AHP can often not restore such evaluation ratios of alternatives with real evaluation values. I think that this is a reason which users feel like it does not work well for such alternatives, although it is proper for intangible alternatives. The method has two versions. I also show the validity of this method mathematically. This is different from the ANP since it does not deal with dependence within or between clusters.

2 - Mapping Verbal AHP Scale to Numerical Scale for Cloud Computing Strategy Selection

Alessio Ishizaka

In Analytic Hierarchy Process (AHP), evaluations are given on a verbal scale and then converted into quantitative values for calculating the priorities. Several conversion scales have been proposed. In order to select the best matching scale according to the mental representation of each individual decision-maker, verbal scales are first used to compare alternatives with known measures, e.g., surface of figures. The best matching scale representing the real values is then selected. This AHP with individualised scales has been applied in a real case study to select cloud computing strategies.

3 - Strategic Customer type Segmentation by AHP Analysis

Masayo Morisada, Ning Li, Kutu Kei, Hong Seung Ko

Customer acquisition and retention are the very important issues for a company to survive in the global business environment with severe competitive change. Since current customer type category is complicated by the various classification bases, it is hard to draw up the efficient customer strategy. Therefore, we consider the segmentation with assigning various customer types to behavior pattern model proposed by Ko et al. through AHP analysis, in order to be able to draw the marketing strategy which results in the sales improvement and profits increase.

4 - Multi-Criteria Decision-Making Solution, Based on the ANP Approach, Applied to Maintenance's Supplier Selection Problem

Touhami Lalla Samira

Supplier selection is one of the most important decision problems in management. Achieving an accurate solution to this issue, the paper developes a model selection to enable managers of maintenance to different potential supplier selection in a multi-criteria decision making context. The contribution applies the ANP approach to the different supplier of the maintenance selection problem in order to help selecting the best compromise alternatives. Determining the selection criteria is the most important task of supplier selection.

■ MB-38

Monday, 10:30-12:00 - Room 214

Biomass-Based Supply Chains II

Stream: Biomass-Based Supply Chains
Invited session
Chair: *Frederic Lantz*

1 - Supply Chain Management for the Design of Future Biorefineries

Sara Giarola, Nilay Shah

This work proposes a multi-period spatially-explicit resource-technology network model to drive policies and investments on biorefineries. A MILP model is used to optimise an Organosolv-based biorefinery supply chain valorising all biomass fractions for the production of biofuels and biomaterials. It minimises the system cost accounting for seasonal biomass supply, geographical availability and competitive uses, transport logistics, densification technologies, biorefinery/storage capacity and location, product portfolio, biofuels mandates fulfilment. A real-world case study is proposed.

2 - Modelling the European Biofuel Supply Through a Mixed Integer Programme Linked with an Agricultural Model and a Refining Model

Frederic Lantz

The European Union has an 10% biofuel objective in the automotive fuel. In this context, we have developped an optimization model to assess the potential developement of biofuel supply according to the biomass supply and to the refining activity. Consequently the model is linked with the European biomass supply model AROPAJ (INRA) and with the European OURSE refining model (IFPEN). Because the local potential supply and the transportation costs are an important issue of this research, we use a disagregated approach. Through this modelling framework, several scenarios for 2030 are evaluated.

■ MB-39

Monday, 10:30-12:00 - Room 018

ORAHS V - Outpatient Scheduling

Stream: Health Care Applications
Invited session
Chair: *Sally Brailsford*
Chair: *Weifen Zhuang*

1 - Appointment Scheduling in Presence of Seasonal Demand

Evrim Didem Gunes, Tugba Cayirli, Pinar Dursun

This study investigates appointment systems, as combinations of access rules and appointment rules, that are explicitly designed for dealing with walk-in seasonality. We assume that a portion of capacity is reserved for walk-in demand while the rest is set as the booking limit for appointments. Simulation experiments are used to investigate the effects of environmental factors, such as demand load, probability of walk-ins and seasonality level. We use the efficient frontier method to explore the best appointment systems both in terms of micro-level and macro-level performance measures.

2 - Appointment Scheduling for Medical Diagnostic Facilities
Weifen Zhuang

This paper studies appointment scheduling for medical diagnostic facilities through a Markov Decision Processes (MDP) model. We derive structural properties of the value function and develop simple bounds to study the asymptotics. Using the empirical data from the hospital, we conduct numerical studies to exam the asymptotics and evaluate the performance of heuristics.

3 - An Adaptive Heuristic with Memory for Scheduling the Block Appointment System of an Eye Outpatient Clinic
Ka Yuk Carrie Lin

An eye clinic in a public hospital treats multiple patient classes with different flow sequences through the multi-phase-multi-server system. An adaptive scheduling heuristic with memory is proposed for the block appointment system. A mixed-integer programming model is formulated. The adaptive heuristic improves an initial schedule iteratively by identifying procedures with large average waiting times and reassigning their related patient classes to less congested time blocks probabilistically. The multiple objectives include patient system times, staff overtime and waiting room congestion.

4 - Case-based learnings for configuring custom packs
Brecht Cardoen, Jeroen Belien, Mario Vanhoucke

A custom pack combines medical disposable items into a single sterile package that is used for surgical procedures. In this paper we propose a mathematical programming approach to guide hospitals in developing or reconfiguring their custom packs. A computational experiment, based on real data of a medium-sized Belgian hospital, compares the optimized results with the performance of the hospital's current configuration settings and indicates how to improve future usage.

■ MB-40
Monday, 10:30-12:00 - Room 019

Production and Supply Chain Design

Stream: Production and the Link with Supply Chain
Invited session
Chair:
Chair:
Chair: *Nadezhda Kozlovskaia*

1 - On Supply Chain Network Re-Design after a Corporate Merger
Scott Mason, Mariah Magagnotti, Kelly Sullivan

When a corporate merger or acquisition occurs, it is often desirable to combine the companies' supply chains for increased efficiency. During this challenging task, decisions must be made as to what supply chain elements should be included in the combined network. We present a multi-objective model for supply chain network design problems that considers both cost and network connectivity. We argue that increased connectivity allows for increased supply chain reliability under uncertain future conditions and examine the cost and benefit of increased network connectivity in a supply chain.

2 - A Multi-objectives Facility Layout Design Problem for Thin-film Solar Power Plants
Mei-Shiang Chang, Shih-Ya Liu

A skeleton of designing thin-film solar power plants is a spine layout. A multi-objectives model is proposed to locate cells on an aisle. The first objective is to minimize material handling cost. The second one is to minimize unfitness of locating cells that is measured by weighted activity relationships. Weighting factors are distances between cells. Activity relationships are defined by the closeness rating system. A solar power plant is used to illustrate this model. It is solved by an immunized ant colony system. Compared with manual planning, our approach can obtain a dominated result.

3 - A Novel Mathematical Formulation for Minimizing the Makespan on a Single Batch Processing Machine
Mario Velez-Gallego

A batch processing machine (BPM) can process a set of jobs simultaneously as a batch as long as its capacity is not violated. This research was motivated by a practical application where a BPM is a bottleneck and consequently minimizing the makespan is the primary objective. We propose a novel mathematical formulation and compare its performance against one formulation that is commonly found in the literature. Extensive computational experiments showed that the proposed formulation performs considerably better that its counterpart with respect to solution quality and computational cost.

4 - Complete Solution of the Extended EOQ Repair and Waste Disposal Model with Switching Costs
Nadezhda Kozlovskaia, Nadezda Pakhomova, Knut Richter

The EOQ repair and waste disposal problem studied first by Richter, 1997, was extended by Saadany and Jaber, 2008, to the problem of minimizing the total cost of production, remanufacturing and inventory and, additional switching cost. However, in their paper the authors did not provide a complete solution to this complex problem. In our talk such a master solution will be provided. Furthermore, it will be illustrated how various other remanufacturing problems can be solved by specifying this master solution.

■ MB-41
Monday, 10:30-12:00 - Room 216

Lot-Sizing and Related Topics 2

Stream: Lot-Sizing and Related Topics
Invited session
Chair: *Mathieu Van Vyve*

1 - Computational Analysis of Lower Bounds for Economic Lot Sizing Problems with Remanufacturing
Sharifah Aishah Syed Ali, Kerem Akartunali, Robert Van der Meer

This talk evaluates different approaches to obtain better lower bounds for economic lot sizing problems with remanufacturing and separate setup (ELSRs) and joint setup (ELSRj), which are NP-hard in general. We propose several methods such as valid inequalities, a facility location reformulation and a shortest path reformulation for this, and study their theoretical strengths to understand the substructures of both problems. We also present computational results on a large number of test data sets available from the literature, and conclude with future research directions.

2 - Bounds for a Production-Inventory-Routing Problem
Cristina Requejo, Agostinho Agra

We consider a single item production-inventory-routing problem with a single producer/supplier and multiple retailers. Inventories are considered both at the producer and at the retailers following a vendor managed inventory approach, where the supplier monitors the inventory at retailers and decides on the replenishment policy for each retailer. We assume a constant production capacity and consider a single vehicle. Based on the mathematical formulation we discuss different relaxations and hybrid heuristics. A computational study is reported.

3 - Lagrangian Heuristic Applied to Lot Sizing Problems on Parallel Machines
Diego Fiorotto, Silvio de Araujo, Raf Jans

The lot-sizing problem is an optimization problem, where the objective is to plan the quantity of items to be produced in order to satisfy the known demand over the time horizon and minimize the total costs. This work addresses the problem that involves the production planning of multiple items in a single stage composed of distinct parallel machines and each item can be produced on any machine. We apply a Lagrangian heuristic within two hybrid methods to obtain upper and lower bounds of good quality for this problem.

4 - Efficient Approximation Algorithms for the Economic Lot-Sizing in Continuous Time
Mathieu Van Vyve, Claudio Telha

We consider the continuous-time variant of the classical Economic Lot-Sizing (ELS) problem. The setup cost, the demand and the holding cost are all continuous and integrable functions of time. The replenishment decisions are not restricted to be multiples of a base period. Starting from the assumption that certain operations involving the setup and holding cost functions can be carried out efficiently, we develop approximation scheme that are efficient under an oracle computational model.

■ MB-42

Monday, 10:30-12:00 - Room 215

Electric Vehicles

Stream: Green and Humanitarian Logistics
Invited session
Chair: *Jakob Puchinger*

1 - A Large Neighborhood Search for the Two-Echelon VRP: Extensions for Electric Vehicles
Richard Hartl, Ulrich Breunig

A two-tiered setup for the distribution of goods in cities can combine the advantages of small electric vehicles and conventional large trucks. In the classical 2EVRP first-level trucks are shipping goods to several satellites, located in the outskirts. From there smaller city freighters are used for inner-city deliveries. Keeping trucks out of the centre helps to reduce congestion and pollution - especially when replaced by electric vehicles. We show a simple LNS to find good solutions for the problem as well as specific extensions for implementing electric vehicles on the second level.

2 - Strategic Mixed Fleet Management with Electric Vehicles
Jakob Puchinger, Gerhard Hiermann, Pamela Nolz, Richard Hartl

Finding an optimal fleet mix of heterogeneous vehicles to fulfill a single-day demand is a hard problem for itself, which is further complicated by range-restrictions of electric vehicles. In real-world settings, changing the whole fleet layout each day is not an option, thus changes in the mix have to be planned over a longer period of time. In our work we present a mathematical model for the strategic problem. Furthermore we discuss methods to acquire useful approximations of tour costs for electric, plug-in hybrid and conventional vehicles which can be used in the strategic planning.

3 - A Heuristic for Locating Electric Vehicle Charging Stations for Trip Chains
Min Wen, Stefan Ropke

We present the problem of locating a limited number of electric vehicle charging stations for a given set of trip chains, each of which consists of a series of linked short trips and is represented by a sequence of intervening stops along the trip chain. The objective of this problem is to maximize the number of trip chains that can be completed by the electric vehicle without running out of battery. A mixed-integer programming formulation as well as a heuristic for solving this problem will be presented.

4 - Optimization Model and Algorithm for Wireless Charging Electric Vehicles
Young Jang, Ill Hoe Hwang

We introduce a new type of electric transportation system called the On-line Electric Vehicle. The battery in the OLEV is charged remotely from power transmitters installed under the road using the innovative wireless charging technology. The key design parameters of the OLEV are the battery size and the allocation of the power transmitters. We construct an optimization model for economically determining the key design parameters. The wireless-charging has been a big issue in a greener transportation. This paper introduces a new application of OR in this emerging technology.

■ MB-43

Monday, 10:30-12:00 - Room 217

Algorithms and Applications - 2

Stream: Algorithms and Computational Optimization
Invited session
Chair: *Gulser Koksal*

1 - A Coal Blending Problem Solved by Column Generation
Daniel De Wolf, Stephane Auray, Yves Smeers

We formulate and solve a real life coal blending problem using a column generation approach. The objective of the model is to prescribe optimal mixes of coal used to produce coke. The problem is formulated as a mixed integer program. It involves various types of constraints arising out of technical considerations of the blending process. The model also incorporates integer variables. Three heuristics based on column generation ideas are proposed to solve this problem. The heuristics are enabled by the use of dual variables related to the ratio amounts of each coal.

2 - Waste Sortation in Single Stream Recycling
Joshua Ignatius, Seyed Ahmad Hosseini, Mehdi Sepehri, Mark Goh

One way to generate a higher recycling rate is to handle materials recovery efficiently. Conventional recycling schemes require the recyclates to be "clean", i.e., separated prior to coming into the Material Recovery Facility (MRF). However, it is inconvenient to pre-sort their recyclates. To solve this problem, we propose multiple bins to be assigned to each personnel to maximize conveyor belt usage. We model the unload-and-switch cycle through a 2-nested routing problem. A numerical example validates the approach.

3 - In-Depth Features of the CPLEX Optimization Studio IDE
Frederic Delhoume

We will present many features that allow CPLEX Optimization Studio IDE users to accelerate their model development. Tips and tricks will be presented related to editing models, viewing results, debugging and writing custom scripting code and profiling. This presentation will also introduce the Eclipse environment that CPLEX Optimization Studio is based on.

4 - Product Mix Determination under Uncertainty for Effective Product Management
Gulser Koksal, Nilgun Fesel

In many real life problems, uncertainty is a major complexity for decision makers. A typical example to such a case is the product mix problem. In this study, we develop a methodology to aid the decision makers in product mix determination at the strategic level of product management under uncertainty. The methodology is based on a simulation optimization approach by which scenarios are generated using a statistical design of experiments approach. This methodology is a novel and original approach to the best of our knowledge.

■ MB-44

Monday, 10:30-12:00 - Room 218

Simulation in Management Accounting and Management Control II

Stream: Simulation in Management Accounting and Management Control
Invited session
Chair: *Stephan Leitner*

1 - A Comparative Study between Different Storage Assignment Policies in Automated Storage/Retrieval Systems

Amina Ouhoud, Amine Hakim Guezzen, Sari Zaki

Automated Storage and Retrieval Systems are warehousing systems that are used for the storage and retrieval of products in both distribution and production environments. This paper provides an overview of literature from the past. A comprehensive explanation of the current state of the art in AS/RS design is provided for a range of issues such as system configuration, storage assignment policies. Items need to be put into storage locations before they can be picked to fill customer orders. A storage assignment method is a set of rules which are used to assign items to storage locations.

2 - Bridging the Gap in Transport Project Evaluation: Accounting for the Inaccuracies in Demand Forecasts and Construction Costs Estimations

Kim Salling, Steen Leleur

For decades researchers have claimed that demand forecasts and construction costs estimations are assigned with large degrees of uncertainty, commonly referred to as Optimism Bias. A severe consequence is that ex-ante socio-economic evaluation of infrastructure projects becomes inaccurate and can lead to unsatisfactory investment decisions. Thus there is a need for better risk assessment and decision support, which is addressed by the recently developed UNITE-DSS model. It is argued that this simulation-based model can offer decision makers new and better ways to deal with risk assessment.

3 - Transfer Pricing - Impact of the Negotiation Duration

Arno Karrer

In this paper we analyze the impact of the negotiation duration on the consolidated profit and transfer price. A simulation is applied to show potential results implied by a reduced negotiation process. In particular, intracompany profit centers negotiate with each other or independent parties on an external market, which is technologically as well as demand independent. The identification of potential targets for business activities is affected by symmetric or asymmetric imperfect market information and the number of negotiation steps permitted to the parties.

4 - Does Collaboration Pay? An investigation for the Domain of Distributed Investment Decisions

Stephan Leitner, Alexander Brauneis, Alexandra Rausch

We implement a mechanism for coordinating investment decisions, which is inspired by the idea of the competitive hurdle rate (Baldenius et al., 2007). In addition to Baldenius et al., we add collaboration among departments, derive an optimal allocation rule for initial capital expenditures, and model departments as being incompetent to perfectly forecast measures associated with investment projects. We present results on the impact of the level of collaboration among departments and different levels of departmental competence in forecasting on our coordination mechanism's efficiency.

■ MB-45

Monday, 10:30-12:00 - Room 219

Stochastic Programming Models and Algorithms

Stream: Stochastic Programming

Invited session

Chair: *Unai Aldasoro*

1 - Stochastic Programs with Decision Dependent Probabilities

Lars Hellemo, Asgeir Tomasgard, Paul I. Barton

We present taxonomy of stochastic programming with decision dependent uncertainty and discuss modelling and applications in mathematical programming. Direct and indirect manipulations of probability distributions via decision variables are presented. We formulate two-stage models where prior probabilities are distorted through an affine transformation, or combined using a convex combination of several probability distributions. Additionally, we present models where the probability distributions are either incorporated using either the exact expression or a rational approximation.

2 - BFC-SDC Algorithm for Solving Multistage Mixed 0-1 Problems under Risk Averse Time Consistency Stochastic Dominance Constraints

María Merino, Laureano Fernando Escudero, María Araceli Garín, Gloria Perez

We extend to the multistage case a mixture of two recent risk averse measures for two-stage stochastic mixed 0-1 problems, such that an objective function is maximized in a feasible domain also constrained by time consistent first- and second-order Stochastic Dominance Constraints integer-recourse. We present the BFC-SDC decomposition algorithm, where a special treatment is given to cross scenario constraints. Computational experience is reported comparing risk neutral and averse strategies as well as the performance of the decomposition algorithm versus plain use of an MIP solver.

3 - BFC and other Decomposition Schemes in SMILPs

Gerardo Perez Valdes, Adela Pages Bernaus, Asgeir Tomasgard

We apply a Branch and Fix Coordination algorithm in a parallel setting to solve specially large Stochastic Mixed-Integer Programs in the context of energy infrastructure investment and operation. To handle large instances, we use the decomposition already required by the BFC into a few other schemes, like the L-shaped Method, to improve memory use, solve LPs faster, and improve the bounding throughout the BFC process. Preliminary results show that, with a careful selection of the subproblems, this can perform better when compared to solving the original SMILPs with commercial solvers.

4 - On Parallelizing Decomposition Algorithms for Solving Stochastic Multistage Mixed 0-1 Problems

Unai Aldasoro, Laureano Fernando Escudero, María Merino, Gloria Perez

Parallel versions of two risk-neutral serial decomposition algorithms for solving large-scale stochastic multistage mixed 0-1 problems are presented. The first, BFC (Branch-and-Fix Coordination), is an exact one and the second, SDP (Stochastic Dynamic Programming) is a metaheuristic intended for much larger instances (millions of constraints and variables). Two message passing parallelization paradigms are considered, namely inner and outer parallelization. Computational results show significant reductions in computing time by using the parallelization paradigms versus the serial versions.

Monday, 12:15-13:45

■ MC-50

Monday, 12:15-13:45 - Plenaries room

Plenary Session M. Brandeau

Stream: Plenary Sessions
Plenary session
Chair: *Elena Fernandez*

1 - Operations Research and Health Policy: Models that Can Make a Difference
Margaret L. Brandeau

When deciding which programs to invest in, public health decision makers face a number of challenges, including limited resources to invest among many potential programs, incomplete information about the potential effects of programs, and objectives that include not only health maximization but social, political, and cultural considerations. OR-based modeling can play a key role in informing such decisions: by providing a structured framework that uses the best available evidence, imperfect as it may be, and that captures relevant uncertainties, complexities, and interactions, OR-based models can be used to evaluate the potential impact of alternative public health programs. This talk describes modeling efforts in which OR has played and can play a role in informing public health decision making. We conclude with a discussion of useful lessons for OR modelers who wish to work on health-related and policy-related problems.

Monday, 14:00-15:30

■ MD-01

Monday, 14:00-15:30 - Room 118

Delays and Disruptions

Stream: Railway and Metro Transportation
Invited session
Chair: *Marie Schmidt*

1 - Modelling Delay Propagation in Railway Networks
Fabian Kirchhoff

We want to determine delay distribution functions analytically from given source delays. For this purpose, we consider a network that represents the relations between feeder and connection lines. Generally, the calculation of propagated delays requires a topological sorting of arrival and departure events and cannot be applied if the network contains cycles. We use an iterative method to approximate the long-run delay distributions in those cycles. The objective of this talk is to investigate the impact of this approach on the limiting distributions.

2 - An Iterative Framework for Railway Disruption Management
Twan Dollevoet

Railway systems face many unexpected events that render the planned timetable, rolling stock schedule, and crew schedule infeasible. Current scientific approaches to deal with such disruptions tend to focus on one of the resources individually. However, the resulting resource schedules are highly interdependent. Within the ON-TIME project, we developed an iterative framework that reschedules the three resources sequentially. We present results for several real-world instances from Netherlands Railways and show that feasible solutions can be obtained within minutes.

3 - OR Models for Disruption Management at Netherlands Railways
Dennis Huisman

Every day, there are several major disruptions on the Dutch railway network. During a major disruption, one or more railway lines are blocked for a few hours. In the coming years, Netherlands Railways (NS) will introduce advanced OR models and algorithms to reschedule the timetable, rolling stock, and crew in real-time. In this talk, we will discuss the first results, our implementation strategy and remaining challenges.

4 - Route Choice in Case of Disruptions
Paul Bouman, Marie Schmidt, Leo Kroon, Anita Schöbel

When passengers in a public transport system want to travel while there is a disruption, they face a dilemma: should they wait and hope that the disruption is over soon, or should they take a detour? Such a situation can be seen as a online decision problem, because as soon as the passengers know when the disruption is exactly over, the decision is trivial. We analyze this problem for a regular connection and a detour connection with a periodic timetable. We then compare the worst-case (robustness), competitiveness and expected values of arrival for different decision strategies.

■ MD-02

Monday, 14:00-15:30 - Room 111

Urban Logistics Problems

Stream: Vehicle Routing
Invited session
Chair: *Andrea Bettinelli*

1 - The Multi-Zone Multi-Trip Vehicle Routing Problem with Separate Delivery and Collection
Andrea Bettinelli, Teodor Crainic, Daniele Vigo

The multi-zone multi-trip VRP with separate delivery and collection (MTMZ-VRPPD) arises in the context of the planning operations of two-tiered City Logistics systems. It is an extension of the VRPTW involving both designing and assigning routes to vehicles within time synchronization restrictions. Each route is made up of a sequence of supply-point visits, each followed by a trip servicing first customer-delivery demands and then customer-pickup demands in the zones of the respective supply-points. We propose an exact branch-and-cut-and-price method to solve MTMZ-VRPPD to optimality.

2 - A GRASP Algorithm with Path Relinking for the Multi-depot Location Routing Problem with Stochastic Customers
Yannis Marinakis, Magdalene Marinaki

In this paper, a Stochastic Location Routing Problem is formulated using a number of capacitated depots, each one having one vehicle with no capacities restriction. We use a two phase algorithm based on GRASP for solving the problem. In the first phase, the open depots are determined and in the second phase, an a priori route is constructed for each one of the depots. The cost is the sum of the set up cost of the depots and the expected length of the routes. Different scenarios are examined in which each customer has either a homogeneous or a heterogeneous probability of requiring a visit.

3 - Waste Collection on Arcs — the Seixal Case Study
João Janela, Cândida Mourão, Leonor S.Pinto

The household waste collection problem in the Portuguese municipality of Seixal may be studied via an arc routing problem with some side constraints, which is known to be NP-hard. This work uses a GIS (Geographic Information System), available at the municipality, for the input/output phases and some heuristics specifically developed for the case study. Among the referred side constraints we try to find vehicle trips that are: balanced; connected and compact. This project was partially supported by National Funding from FCT (PTDC/ECE-GES/121406; PEsT-OE/EGE/UI0491; PEsT-OE/MAT/UI0152.

4 - Beyond Arc Routing
Dmitry Krushinsky, Tom Van Woensel

While the Arc Routing Problem (ARP) focuses on minimising the length (cost) of tours, several other goals take place in practice. Including them into the already complex ARP makes it unsolvable. Yet, the way of traversing a given ARP tour is often non-unique, which provides possibilities for optimisation. We show that such post-optimisation of ARP solutions is a non-trivial but practically tractable problem and consider several realistic objectives, such as serving prioritised arcs earlier or minimising the expected additional costs in case the (stochastic) demand exceeds the vehicle capacity.

■ MD-03

Monday, 14:00-15:30 - Room 001

Robust and Integrated Models for Airline Scheduling

Stream: Aviation
Invited session
Chair: *Luis Cadarso*

1 - Comparing Delay Prediction Models for Robust Airline Resource Scheduling and Optimization
Lucian Ionescu, Natalia Kliewer

Since cost-optimized airline resource schedules are not delay tolerant, sophisticated optimization techniques for robust scheduling have been developed in recent years. However, all these approaches depend on assumptions made concerning primary delay occurrences. In this context, we discuss different delay prediction models based on historical delay data analysis. Eventually, we measure the impact of competing prediction models on the scheduling process. The results show in how far assumptions on delay occurrences potentially determine subsequent scheduling decisions.

2 - A Heuristic Algorithm for Personalized Integrated Cockpit Scheduling
Atoosa Kasirzadeh, Mohammed Saddoune, Francois Soumis

We present a set-covering formulation and an iterative heuristic algorithm for personalized integrated cockpit pairing and assignment problems. The objective is to have as many similar pairings as possible between pilots and co-pilots to increase the schedules robustness, even if pilots and co-pilots schedules are different to satisfy their preferences. We use a solution approach based on column generation for this problem. The computational results provided are based on a major US carrier data set.

3 - A Bi-Dynamic Constraint Aggregation Based Solution Approach for Crew Pairing Problem
Mohammed Saddoune, Francois Soumis

The crew pairing problem consists of determining a minimum cost set of feasible pairings such that each flight is covered exactly once and side constraints are satisfied. Recently, Saddoune et al. (2013) showed that the rolling horizon approach produced better solutions compared to the three-phase approach. To improve the quality of the solutions, we develop, in this paper, a bi-dynamic constraint aggregation method that exploits a neighborhood structure when generating columns (pairings) in the column generation method. All tests are based on real data provided by a major airline.

4 - Integrated Airline Scheduling under Competition: the Entry of the High-speed Rail
Luis Cadarso, Vikrant Vaze, Cynthia Barnhart, Ángel Marín

Airlines and high-speed rail are increasingly competing for passengers, which affects the number of served passengers and revenues. We develop an approach that generates airline schedules capturing the impacts of airlines' decisions on passenger demand. We evaluate scenarios involving the entry of high-speed rail, and validate our results using out of sample data from a market that had an entry of high-speed rail in the past. Contingent on the offered attributes, the model predicts the optimal decisions to retain passengers and to maximize profits.

■ MD-04

Monday, 14:00-15:30 - Room 119

Supply Chain Design 1

Stream: Supply Chain Management
Invited session
Chair: *F. Tevhide Altekin*

1 - Design of a Collaborative Distribution Network
Xin Tang, Fabien Lehuédé, Olivier Péton

We present a case study of horizontal collaboration between several competing firms in the same geographic area. The companies have common customers and currently ship their products independently from each other. They aim at reducing their distribution costs by pooling shipments. A first phase of the project is to locate several distribution centers in the territory, define distribution rules with regards to flows, integrating their seasonality. We model this distribution network design problem with a linear integer program and present results obtained with a solver.

2 - Supply Chain Network Design with Uncertain Demand
Matias Schuster, Jean-Sébastien Tancrez

Demand uncertainty is a concern and difficulty of primary importance for companies. In particular, it has an important impact on the optimal design of a supply chain network. For example, demand uncertainty forces to store products in warehouses close to customers (safety stocks), in order to react quickly to variations and meet customer expectations. In this work, we integrate the impact of demand variability in a location-inventory model. Extending previous results, we propose a new mathematical formulation to consider safety stocks and study their impact on the supply chain network design.

3 - Mathematical Model Applied to Bio-Diesel Supply Chains in Colombia
Javier Arturo Orjuela Castro, Milton Herrera, Johan Alexander Aranda Pinilla

This paper presents a mathematical-programming model for structuring and integration of strategic decision-making in oil-palm bio-diesel production in Colombia. The model includes four stages of the supply chain (planting, extraction, bio-refining and mixing) and applies to four geographical areas. The model establishes a distribution plan for oil, bio-diesel and diesel along the supply chain. Production and inventory plans are included with an increase in the capacity of bio-refineries that minimizes total cost. Results show the potential behavior of the chain, particularly regarding soil.

4 - Post-Sales Network Design of a Household Appliances Manufacturer
F. Tevhide Altekin, Ezgi Ayli, Guvenc Sahin

In this paper, we analyze the post-sales network of a household appliances manufacturer providing repair and refurbishment services for its products. The post-sales network design problem under consideration involves determining the warehouse locations for the spare parts as well as their flows from manufacturing sites and to existing repair centers. A mixed-integer programming based solution method is proposed. The efficiency and effectiveness of the proposed approach is illustrated using a realistic case study from Turkey.

■ MD-05

Monday, 14:00-15:30 - Room 002

Supply Chain Management in Petroleum Industry

Stream: Petroleum Logistics
Invited session
Chair: *Anastasiya Karalkova*

1 - The Value of Strategic Flexibility in Gas Transport Infrastructure Investments
Katerina Shaton

Exploration interests of petroleum companies move further to the North of the Norwegian Sea and the Barents Sea. It raises a need for a gas transport solution in the area. In the paper, the choice between an LNG and a pipeline solution is discussed. A Real Options framework is used to analyse the trade-off between the destination flexibility of the LNG solution and strategic flexibility provided by the pre-investment in excess pipeline capacity. An approach to identify the value of strategic flexibility is proposed and the value is estimated for the case of a potential Barents Sea pipeline.

2 - Modal Split in Offshore Upstream Supply Chain under the Objective of Emissions Minimization
Ellen Karoline Norlund, Irina Gribkovskaia

We assess modal split in the offshore upstream supply chain of cargo from vendors to supply bases along the Norwegian coast under the objective of emissions minimization. To gain insight into drivers for modal split between road and sea transport from the shipper's perspective a multi-period mixed integer optimization model is formulated. The model is used to study how different demands, inventory policies at bases and shipper commitments to sea transport affect modal split. The results show that commitments and inventories are major drivers towards environmental friendly sea transport.

3 - Preparedness Logistics for Arctic Offshore Operations
Peter Schütz

One of the main challenges of industrial operations in Arctic waters is remoteness. The long distances to the supply bases not only affect regular operations, but also preparedness logistics are affected. We present a model for the problem of designing a preparedness logistics system for offshore operations. The solution to the problem aims at minimizing the cost of the resources assigned to the preparedness system while satisfying all preparedness requirements and accounting for resources that can be used to serve several preparedness tasks.

4 - Industry-wide Information Sharing in Oil and Gas Upstream Supply Chain: Analysis of Potential Impacts
Anastasiya Karalkova

Tightly interlinked activities, uncertainty and dynamic environment of upstream oil and gas supply chain raise the needs of information sharing among the companies. However, information sharing is a controversial issue. Available information may be beneficial for one of the parties, and at the same time it may benefit less or detriment another party in the supply chain. In this paper we use multi-stakeholder framework to analyze the potential impacts of industry-wide event information sharing hub in upstream oil and gas supply chain.

■ MD-06

Monday, 14:00-15:30 - Room 211

Behavioral Research on City Logistics

Stream: City Logistics and Freight Demand Modeling
Invited session
Chair: *Cara Wang*

1 - Freight Deliveries Directly Generated by Residential Units: An Analysis with the 2009 NHTS Data
Cara Wang, Yiwei Zhou

Using the 2009 U.S. National Household Travel Survey (NHTS) data, this paper studies truck deliveries generated by residential units. A count data model is used to identify the impacts of influential factors such as housing density, type of house and house ownership. A closer examination at the state level further discloses the spatial variation in their relationship. Such a study will supplement city logistics studies that traditionally focus on business behaviors, help reconstruct the complete picture of freight activities in urban areas.

2 - A Reference Model for Determining Road Toll Charges
Mario Dobrovnik, Sebastian Kummer

In recent years, numerous European countries have introduced tolls as a means of traffic guidance and control. These policy decisions have significantly affected entire economic regions as well as individual companies along the supply chain. For transport companies (especially for carriers), passing the additionally incurred cost to the (final) customer as reasonably as possible therefore is of utmost importance. We propose a reference model which involves solving a network problem based on effective toll distances that allows for determining the additional toll costs for individual shipments.

3 - Policy-Sensitive Vehicle Routing: An Optimization Approach for Evaluating Differentiated Transport Policy Measures
Gernot Liedtke, Stefan Schröder

We develop a carrier model and couple it with a transport simulation to analyze the impacts of congestion and differentiated policy measures. The model is formalized as rich vehicle routing problem and solved with a meta-heuristic based on a large neighborhood search and a time-dependent least cost path calculator. We benchmark the algorithm and conduct sensitivity studies varying attributes of the problem and the traffic system. In a case study, we show that the model reacts sensitively to congestion and fine-tuned policy measures differentiating between vehicle-type, area and time-of-day.

4 - Correlation Between Speeds in a Congested Road Network in the City of London
Saeideh D. Nasiri

This study uses real traffic data, from the City of London, to explore temporal and spatial correlations between travel speeds in a congested road network. It is shown that, in contrast with results found in other studies on non-congested networks, the first-order Markovian property does not hold for spatial correlations. Indeed, for our data set the spatial correlations are still significant for roads up to twenty links apart. If one analyses the correlations using principal component analysis, it turns out that only six components are needed to explain over 80% of the spatial variation.

■ MD-07

Monday, 14:00-15:30 - Room 003

Modelling the German "Energiewende" (Energy Transformation)

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Daniel Huppmann*

1 - How will Electric Vehicles Impact the Spot Market Prices for Electricity?
Philipp Hanemann, Thomas Bruckner

Depending on how electric vehicles are charged they can impede or support the integration of renewable energy resources into the energy system. For reducing CO2-emissions, the German government has set ambitious goals for increasing the share of electric vehicles up to 6 Mio in 2030. If all of them are charged uncontrolled, the peak load will increase. So will the prices. In contrast, controlled charging will smooth out price fluctuations. These will be further smoothed by vehicle to grid charging. Additionally, fossil fuelled power plants might be substituted.

2 - Carbon Emission Effects of the Power-to-Heat Technology in Germany
Diana Böttger

Power-to-heat plants could be used for the cost efficient provision of negative secondary control power. Their effects on carbon emissions of the German power system are evaluated with a power market model. The model is of mixed-integer type to account for techno-economic characteristics of thermal power plants. The quantification of carbon emissions in a German power system with and without power-to-heat plants shows that the technology could help to reduce carbon emissions in the power sector.

3 - Integrated Modelling of Reserve and Spot Electricity Markets in Systems with a Large Share of Variable Renewable Energy
André Ortner

In the light of an increased penetration of variable renewable electricity it is expected that due to forecast errors the amount of reserve capacity to be procured will increase as well. It is of interest how much costs could arise from this provision and how it translates into market prices given a certain market design. This paper presents a mixed complementary problem considering the economic equilibrium of spot and reserve markets under the market design implemented in Germany.

4 - National-Strategic Investment in European Electricity Transmission Capacity
Daniel Huppmann, Jonas Egerer

The transformation of the European energy system requires substantial investment in (cross-border) transmission capacity to efficiently integrate renewables. We investigate the impact of national regulators deciding on network expansion strategically, with the aim of maximizing welfare in their jurisdiction. Using a three-stage equilibrium model, we identify several Nash equilibria and quantify the welfare loss compared to the system-optimal investment. A compensation mechanism can partly alleviate the problem and yield a second-best equilibrium.

■ MD-08

Monday, 14:00-15:30 - Room 120

Sustainable Management and Climate Change

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session
Chair: *Marcus Brandenburg*

1 - Geoengineering: Is it a Valuable Option for Climate Policy?
Olivier Bahn, Marc Chesney, Jonathan Gheyssens, Anca Pana, Reto Knutti

We investigate geoengineering as a possible substitute for adaptation and mitigation to address climate change. With the help of an integrated assessment model, we distinguish between the effects of solar radiation management (SRM) on atmospheric temperature levels and its side-effects on ecosystems. To address the uncertainty regarding the magnitude of side-effects, we rely on a distributional analysis. Our results indicate that mitigation and adaptation are the preferred strategies. We then discuss additional concerns with SRM that further reduce its feasibility.

2 - Baseline Setting Problems of the Offset Mechanisms in the International Scheme for Climate Change
Haruo Imai

There are several offset schemes (both existing and proposed) in the international negotiation over climate change for which baseline emission level must be determined. The major obstacle for these is the uncertainty and asymmetric information inherent in the baseline levels, and the trade-off between environmental integrity and transaction costs involved. With a help of multi-objective optimization, we compare several proposals via generalized (self-selection) models and show that the standardization proposed could perform very well if the transaction costs are properly accounted for.

3 - Dynamic Capabilities and Policies for Sustainable Supply Chain Management — a System Dynamics Approach
Marcus Brandenburg, Daniel Thiel, Stefan Seuring

The link between sustainable supply chain management and dynamic capabilities has been conceptualized and operationalized by adequate policies. The proposed paper complements this conceptual and empirical research by quantitative modeling, which is based on the conceptual framework and related literature. A system dynamics model, which reflects the high complexity of different constructs and their dynamic interplay, is designed to assess the behavior of supply chains with regard to triggers and performance outcomes of sustainability. The poultry supply chain is chosen as application area.

4 - Lessons in Operations Management from State of Victoria's Department of Education Bushfire Infrastructure Improvement Program
Maria Cherilyn Marquez, Leorey Marquez

Following the devastation from Victoria's February 2009 bushfires, the state government issued directives requiring public buildings be designed and built so as to withstand the attack of a bushfire. This paper presents the multi-disciplinary approach to project management and decision-making processes that were applied to effectively deliver the Department of Education's bushfire program in 2011. It discusses the experiences and knowledge gained for future planning and design of schools and formulation of policies on risk mitigation and adaptation of schools in bushfire-prone areas.

■ MD-09

Monday, 14:00-15:30 - Room 121

Stochastic and Deterministic Dynamic Programming and its Applications 1

Stream: Dynamical Systems and Mathematical Modelling in OR
Invited session
Chair: *Yukihiro Maruyama*

1 - Strong Representation Theorems for Non-Deterministic Sequential Decision Processes
Yukihiro Maruyama

This paper proves the relation between a given non-deterministic discrete decision process (nd-ddp) and subclasses of non-deterministic monotone sequential decision process (nd-msdp) which is a finite automaton with a cost function. We show some strong representation theorems for the subclasses of the nd-msdp. Each strong representation theorem provides a necessary and sufficient condition for the existence of the subclass of nd-msdp with the same set of feasible policies and the same cost value for every feasible policy as the given process nd-ddp.

2 - Heuristics for the Optimal Routing of Customers in Queueing Systems with Heterogeneous Service Stations

Rob Shone, Vincent Knight, Paul Harper, Janet Williams

The problem of routing customers to parallel heterogeneous service stations in such a way as to optimise a queueing system's performance is known to be one for which optimal policies are difficult to characterise. The application of dynamic programming is impractical in problems of realistic size, and there is a need for effective heuristics to be developed. Some possible approaches to the problem include the development of indices for the stations similar to the Gittins indices for multi-armed bandit problems, and simulation-based methods including those based on artificial neural networks.

3 - Primal Function and Dual Function Through Conjugation

Yutaka Kimura, Seiichi Iwamoto

For a multi-stage division problem, we consider a duality between primal function and its dual function through conjugate function. We derive a duality between both the functions, which is called a primal-dual inequality. This is a dynamic generalization of Young's inequality. Moreover, both optimal values of (primal and dual) problems are characterized by the first element in the optimal solutions. In particular, for the multi-stage division problem with quadratic criterion, we show that the Fibonacci complementary equality holds.

4 - A Comparison of Methods to Evaluate the Probability of Excessive Waiting in the M(t)/G/s(t)+G queue

Stefan Creemers, Mieke Defraeye, Inneke Van Nieuwenhuyse

The M(t)/G/s(t)+G queue (with a time-varying arrival rate and general distributions for the service and abandonment processes) is highly relevant in practice, though it is notoriously difficult to analyze. Our computational experiment compares methods for determining the time-dependent probability of excessive waiting in an M(t)/G/s(t)+G queue with an exhaustive service discipline. The comparison includes two simulation-based approaches, the Modified Offered Load (MOL) approximation, and a randomization method. We investigate their accuracy and computational requirements.

■ MD-10

Monday, 14:00-15:30 - Room 122

Robust and Stochastic Models for Electricity Systems

Stream: Optimization Models and Algorithms in Energy Industry

Invited session

Chair: *Alexandre Street*

Chair: *Rodrigo Moreno*

1 - Contracting Strategies for Generation Companies with Ambiguity Aversion on Spot Price Distribution

Bruno Fanzeres, Alexandre Street, Luiz-Augusto Barroso

The typical approach to obtain contracting strategies for power companies is to simulate paths for the uncertainties and optimize the portfolio to maximize some measure of value. However, spot price simulation is a challenge due to its high dependence on parameters that are difficult to predict. Therefore, decisions are usually made under ambiguity, i.e., whenever the agent is aware that the scenarios represent only an approximation of the true underlying distribution. In this work, robust optimization is used to treat ambiguity in the optimal contracting strategy of renewable companies.

2 - Two-Stage Robust Optimization Models for Power System Operation and Planning under Joint Generation and Transmission Security Criteria

Alexandre Street, Alexandre Moreira, José Manuel Arroyo

Recent major blackouts have been a driving force to make power system reliability a subject of worldwide research. In this work, the main objective is to incorporate the joint generation and transmission general security criterion n-K in optimization models for power systems operation and planning. Our main contributions are: two-stage robust models to consider n-K security criteria and load variability in power systems operation and planning, solution methodologies that finitely converges to global optimal solution, and valid constraints to boost computational efficiency.

3 - CVaR Constrained Planning of Renewable Generation with Consideration of System Inertial Response, Reserve Services and Demand Participation

Rodrigo Moreno, Andres Inzunza, Alejandro Bernales, Hugh Rudnick

Although higher penetration of renewables may increase the mean cost of generation investment and operation, recent studies have demonstrated benefits of renewables in terms of the reduction in risks on system operation cost (e.g., less exposure to volatile fuel prices). In this context, we present an optimisation model that determines robust mix of generation technologies, including renewables, by minimising the mean cost of investment and operation while constraining risk exposure through CVaR. The model considers effects on system inertial response and reserves, and demand participation.

4 - Electricity Market Equilibrium Models — A Robust Solution Approach

Emre Çelebi

This presentation will examine the market equilibrium models for competitive electricity markets using a robust optimization approach. We cast our models as monotone and affine variational inequality problems where transmission network constraints and intermittent suppliers (e.g. wind) with uncertainty data sets are considered. For linear price-elastic demand response case, we have obtained a "robust" equilibrium solution. We have illustrated the models and solution approach using an electric power market model of Hobbs (2001) and realistic data from Turkish electricity market.

■ MD-11

Monday, 14:00-15:30 - Room 113

Impact of Combinatorial Optimization on Solving Challenging Applications

Stream: Combinatorial Optimization

Invited session

Chair: *Maria Grazia Scutellà*

1 - A Branch and Benders Cut Approach for Nonlinear Location-Design in Green Wireless Local Area Networks

Maria Grazia Scutellà, Bernard Gendron, Rosario G. Garroppo, Gianfranco Nencioni, Luca Tavanti

We study a problem arising in the design of Green (energy-saving) Wireless Local Area networks (GWLANs). Decisions on the location of access points, on the assignment of user terminals to the access points, and on the assignment of a power level to each opened access point, have to be taken simultaneously. The power level assigned to an access point affects, in a nonlinear way, the capacity of the connections between the access point and the user terminals assigned to it. We model the problem as an integer program with nonlinear constraints and solve it by a Branch and Benders Cut approach.

2 - Decomposition Approaches to Assignment and Routing Problems in Home Health Care Services
Paola Cappanera, Semih Yalcindag, Andrea Matta, Maria Grazia Scutellà, Evren Sahin

The design of efficient Home Care Services represents a societal and economic challenge. Home Care services play a crucial role in reducing the hospitalization costs due to the increase of chronic diseases of elderly people. At the same time they represent a means to improve the patients' quality of life. Recently, mathematical models that jointly address assignment, scheduling, and routing decisions have been proposed. However, their solution is not affordable for big instances. In this study, we propose a series of two-phase decomposition approaches and we test them on real instances.

3 - Network Design under Multi-Source Uncertainty
Martin Tieves

In the network power consumption problem, the size oft communication flows is determined by two factors: the initial traffic volume and a (potential) compression rate. Data on both factors is inherently uncertain in practice. We show how an extension of Gamma-Robustness, i.e., multi-source uncertainty, can be included in a MIP formulation of this problem, taking account of these uncertainties. We illustrate and evaluate the concept and the resulting solutions. A comparison with solutions obtained by the Gamma-Robustness concept concludes this talk.

4 - The Job-Scheduling and Tool Switching Problem
Martine Labbé, Daniele Catanzaro, Luís Gouveia

We investigate the Job Sequencing and Tool Switching Problem (JSTSP), a NP-hard combinatorial optimization problem arising from manufacturing systems. Starting from the results described in Tang and Denardo (1987), Crama et al. (1994) and Laporte et al. (2004), we develop three new integer linear programming formulations for the problem that are provably better than the alternative ones currently described in the literature. Our results suggest new insights on the combinatorics of the problem and provides new directions for the development of future exact solution approaches.

■ MD-12

Monday, 14:00-15:30 - Room 004

Graphs and Networks III

Stream: Graphs and Networks
Invited session
Chair: *Reinhardt Euler*

1 - Pareto-Optimal Many-to-Many-Matchings: Complexity and Integer Programs
Yiannis Mourtos, Katarina Cechlarova, Pavlos Eirinakis, Tamas Fleiner, Dimitrios Magos, Eva Potpinkova

We examine Pareto optimality in the context of a many-to-many matching market involving two finite sets A and C. Each member of A has preferences over a set of subsets of C that is downward closed and each member of C has a quota. We provide necessary and sufficient conditions for a such a matching to be Pareto optimal (POM) and a polytime recognition algorithm. A generalized version of serial dictatorship obtains any POM, whereas finding a minimum or a maximum cardinality POM is NP-complete. Last, we discuss integer programming formulations of POM along with its relation to matroid kernels.

2 - On the Polytope of Closed Subsets of Directed Graphs and its Extension to Ordinal Transportation
Pavlos Eirinakis, Dimitrios Magos, Yiannis Mourtos

For a directed acyclic graph G(V,A), a subset C of V is closed if A contains no arc from a node not in C to a node in C. We examine the polytope describing the set of closed subsets of such a graph. Specifically, we show that the polytope is full-dimensional and identify all families of facet-inducing constraints, hence providing a minimal linear description. Our analysis is then extended to non-acyclic graphs. Moreover, it is utilized in the context of the Stable Allocation (or Ordinal Transportation) and the Stable Flow problem to obtain their first linear description, which is also minimal.

3 - Hybrid Approaches for the Multi-Index Assignment Problem
Stathis Plitsos, Dimitrios Magos, Yiannis Mourtos

We study the (k,s)-assignment problem as a unified framework for the axial and planar assignment problems. The idea is to intensify the combined use of Integer and Constraint Programming methods, while also encompassing effective heuristics. In that direction, we propose an integrated solver that combines feasibility pump and tabu search with constraint propagation and problem-specific cutting planes. After employing these tools at several nodes of a Branch & Cut tree, while also using problem-specific branching schemes, we discuss computational findings on large-scale instances.

4 - Modeling the Geometry of the Endoplasmic Reticulum Network
Reinhardt Euler, Laurent Lemarchand, Imogen Sparkes, Congping Lin

We study the network geometry of the endoplasmic reticulum by graph theoretical and integer programming models. We determine plane graphs of minimal total edge length satisfying degree and angle constraints and we show that the optimal graphs are close to the ER network geometry. We use a binary linear program, that iteratively constructs an optimal solution, and a linear program, that iteratively exploits cutting planes. All formulations were tested on real-life and randomly generated cases. The cutting plane approach turns out to be particularly efficient for the real-life testcases.

■ MD-13

Monday, 14:00-15:30 - Room 123

Single Machine Scheduling

Stream: Scheduling
Invited session
Chair: *Zehra Duzgit*

1 - Minimization of the Tool Switches Problem - Polynomial Algorithm for a Special Case
Horacio Yanasse

The minimization of the tool switches problem consists in finding a sequence to process a set of jobs that minimizes the total number of required tool switches. Each job requires a set of tools to be in the machine in order to be processed. If a tool required to process a job is not in the machine, it must be placed in the tool magazine that has limited capacity. Therefore, tool switches must occur. The general case of MTSP is NP-Hard. We present a polynomial algorithm for a special case of the problem, where each one of the jobs requires at most two different tools.

2 - Due Date Quotation in Dynamic Single Machine Environment with Family Setups under Stochastic Job Characteristics
Zehra Duzgit, Ali Tamer Unal

We consider the due date quotation problem in dynamic single machine environment with family setups. A due date is to be assigned to jobs immediately at arrival. Two conflicting objectives are to be minimized: average quoted lead time and average tardiness. A two phase methodology is proposed. The first phase generates a batching configuration for families based on expected workload, before job arrivals. In the second phase, due dates are assigned. For each phase, an MIP model and a heuristic are constructed. The delivery performance and the competitive power of the system will be analyzed.

■ MD-14

Monday, 14:00-15:30 - Room 124

Other Real and General Problems in Production Scheduling

Stream: Realistic Production Scheduling
Invited session
Chair: *Jacques Teghem*

1 - A Branch and Bound Based Local Search for Consumable Resource-Constrained Single Machine Scheduling
Mehenni Tahar

Given the initial stock level of a consumable resource (e.g. raw materials, money, energy), a set of resource consuming jobs has to be scheduled on the machine such that there is enough quantity of the resource for starting each job, and the total completion times is minimized. We develop a local search method, based on the branch and bound algorithm to find the neighborhood, where its length is increased iteratively to avoid the local optima. We perform several tests on the algorithm, in order to evaluate the effectiveness of their main components.

2 - Iterated Local Search Algorithm for Flexible Job Shop Scheduling Problems with Resource Constraints
Dimitris Paraskevopoulos, Panagiotis Repoussis, Christos Tarantilis

This work presents an Iterated Local Search algorithm for flexible job shop scheduling problems with resource constraints. Focus is on production floors with unrelated parallel machines. Multiple consumption rates of renewable resources (e.g. energy, workforce) are considered per machine and production phase. The proposed approach consists of a local search, equipped with new compound moves, and an adaptive perturbation mechanism. A dual solution representation scheme is adopted that is based on the job permutation and the temporal ordering. Experiments on modified benchmark sets are reported.

3 - A Comparative Study of Evolutionary Algorithms in Two-Machine Flowshop Problem with Availability Constraints and Subject to Release Dates with Total Tardiness Criterion
Abdelaziz Berrais, Mohamed Ali Rakrouki, Talel Ladhari

In this work we consider minimizing the total tardiness in a two-machine flowshop problem with release date of jobs and with unavailability periods of machines. Despite its theoretical and practical importance, this NP-hard problem has not been investigated before. Five evolutionary algorithms are developed for the problem under consideration: Particle Swarm Optimization (PSO), Differential Evolution (DE), Genetic Algorithm (GA), Imperialist Competitive Algorithm (ICA), and Ant Colony Optimization (ACO). The computational experiments provide evidence that the ICA perform consistently well.

4 - Minimizing the Maximum Lead Time in a Three-Stage Supply Chain Scheduling Problem
Jacques Teghem, Walid Besbes, Taicir Loukil

A supply chain scheduling problem with three stages is analyzed with several actors at each stage. Three types of constraints are considered: each job is dedicated to only one path of the supply chain; there exist transportation times and batch deliveries between two successive stages. The maximum lead time minimization is the performance measure. Two approximate methods are proposed. The first one is inspired by the Johnson's algorithm whereas the second is a genetic algorithm. Additionally, a lower bound is proposed to evaluate the effectiveness of both algorithms.

■ MD-15

Monday, 14:00-15:30 - Room 125

Novel Models and Applications in Revenue Management

Stream: Revenue Management I
Invited session
Chair: *Timo P. Kunz*

1 - Optimal Keyword Bidding in Search-Based Advertising
Baris Selcuk

In search-based advertising, advertisers bid on keywords to have an impact on their ad's placement, which in turn affects the response from potential customers. An advertiser must choose the right keywords and then bid correctly for each keyword. We construct and examine a deterministic optimization model that maximizes total expected advertising revenue while keeping the total costs below a given advertising budget. We investigate the characteristics of the model and provide an exact solution. Numerical results are presented that give managerial insights on bidding strategies.

2 - Learning and Pricing for Substitutable Products
Yalin Bi

We consider a choice-based dynamic pricing problem with substitutable products. The company chooses a price policy that maximizes their expected total profit with a capacity constraint. A multinomial logit (MNL) choice model is used to describe the customer choice behavior. The parameters of the choice model are unknown and updated with Markov chain Monte Carlo (MCMC) method. We propose a scheme with Multi-armed bandit (MAB) to solve the trade-off between pricing to find a good estimation of customer behavior and pricing near the optimal price to obtain better revenue performance.

3 - The Use of Marginal Revenues in Revenue Optimization
Thomas Winter

Marginal revenues (MR) are often used in practical revenue management applications, e.g., in airline RM systems. MR offer the possibility to model and measure the inter-dependency between pricing and demand. Mathematically, they are defined as difference quotient of the revenue difference divided by the demand difference when offering/not offering a product. Hence, MR give indication about the benefit of a product. The drawback is that MR are numerically unstable, in particular for small demand values. We investigate the behavior of MR and discuss alternatives for more robust measures.

4 - The Value of Intra-Category Information in an LA-AIDS Based Retail Price Optimization System
Timo P. Kunz, Sven F. Crone

A key challenge in the application of Revenue Management to retail is the reliable estimation of a demand model that allows to individually price large amounts of products under the consideration of cross-price effects. We describe a price optimization system based on the Almost Ideal Demand System and evaluate a number of estimation methods that rely on, and combine information from different hierarchical levels of the category, including product attribute data. We use simulation to quantify the additional monetary value that the estimation procedures add to the optimized price sets.

■ MD-16

Monday, 14:00-15:30 - Room 127

Copositive and Polynomial Optimization III

Stream: Copositive and Polynomial Optimization
Invited session
Chair: *Luis Zuluaga*

1 - Tractable Relaxations of Polynomial Optimization Problems
Bissan Ghaddar, Martin Mevissen

This talk presents an inequality generation scheme to improve semidefinite relaxations of polynomial optimization problems. Contrary to the computationally expensive classical methods that build hierarchies of semidefinite-based relaxations to approximate polynomial programs, the proposed scheme improves the semidefinite relaxations without incurring exponential growth in their size. This approach combines techniques from real algebraic geometry and convex conic programming. Computational results on instances from water and energy distribution networks are presented.

2 - Appointment Sequencing: Moving Beyond The Smallest-Variance-First Rule
Qingxia Kong, Zhichao Zheng

We study the design of healthcare appointment system when patients' service durations are random. Numerous studies reported that sequencing patients in increasing order of variances of service durations (Smallest-Variance-First or SVF rule) performs extremely well in many environments. We propose in this paper a copositive program to model the appointment sequencing problem and obtain a general approach to construct interesting appointment sequencing rules that beat the SVF rule in numerical simulations.

3 - On New Classes of Nonnegative Forms
Zhening Li

In this paper we introduce three new classes of nonnegative forms (or equivalently, symmetric tensors) and their extensions. The newly identified nonnegative symmetric tensors constitute distinctive convex cones in the space of general symmetric tensors (order 6 or above). For the special case of quartic forms, they collapse into the set of convex quartic homogeneous polynomial functions. We discuss the properties and applications of the new classes of nonnegative symmetric tensors in the context of polynomial optimization.

4 - New Bounds for the cp-Rank in Copositive Optimization
Immanuel Bomze, Werner Schachinger, Reinhard Ullrich

In copositive optimization, it is essential to determine the minimal number of nonnegative vectors whose dyadic products form, summed up, a given completely positive matrix (indeed, one of these vectors necessarily must be a solution to the original problem). This matrix parameter is called cp-rank. Since long, it has been an open problem to determine the maximal possible cp-rank for any fixed order. Now we can refute a twenty years old conjecture and show that the known upper bounds are asymptotically equal to the lower ones.

■ MD-17

Monday, 14:00-15:30 - Room 005

Global Optimization and Applications in Development II

Stream: Global Optimization
Invited session
Chair: *Herman Mawengkang*
Chair: *Gerhard-Wilhelm Weber*

1 - A Nonlinear Stochastic Optimization Model for Water Distribution Network Problems with Reliability Consideration
Asrin Lubis, Herman Mawengkang, Herman Mawengkang

Water treatment and distribution is undoubtedly of high priority to ensure that communities could gain access to safe and affordable drinking water. Therefore the distribution network should be designed systematically. We propose a nonlinear stochastic optimization model for tackling this problem under the consideration of reliability in water flows. The nonlinearities arise through pressure drop equation. We adopt sampling and integer programming based approach for solving the model. A direct search algorithm is used to solve the integer part.

2 - Nonlinear Mixed-Integer Programming model for Sustainable Production Planning of Multi-Product Seafood Production
Tutiarny Naibaho, Herman Mawengkang

A multi-product fish production plant produces simultaneously multi fish products from several classes of raw resources. The sustainable production planning problem aims to meet customer demand subject to environmental restrictions. This paper considers the management which performs processing fish into several seafood products. The uncertainty of data together with the sequential evolution of data over time leads the sustainable production planning problem to nonlinear mixed-integer stochastic programming. Direct search is used for solving the deterministic equivalent model.

3 - Neighborhood Based Search Approach for Solving a Class of Mixed-Integer Nonlinear Programming Problems
Devy Mathelinea, Herman Mawengkang

Integer programming is not new subject in optimization. However, given its practical applicability, we face computational difficulties in solving the large scale problems. In this paper we solve a class of mixed-integer nonlinear programming problem by adopting a strategy of releasing nonbasic variables from their bounds found in the optimal continuous solution in such a way to force the appropriate non-integer basic variables to move to their neighbourhood integer points. Some computational experience are presented.

4 - An Improved Interactive Approach for Solving Sustainable Land Revitalization Planning Problems
Allysha Rahmi Darwin, Herman Mawengkang

Land revitalization refers to comprehensive renovation of farmland, waterways, roads, forest or villages to improve the quality of plantation, raise the productivity of the plantation area and improve agricultural production conditions and the environment. The objective of sustainable land revitalization planning is to facilitate environmentally, socially, and economically viable land use. Therefore we use participatory approach to fulfill the plan. This paper addresses a multicriteria decision aid to model such planning problem, then we develop an interactive approach for solving the problem.

■ MD-18

Monday, 14:00-15:30 - Room 112

Surrogate-Assisted Multiobjective Optimization I

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Markus Hartikainen*

1 - On the Validity of Replacing Upper Shells by Upper Approximations
Janusz Miroforidis, Ignacy Kaliszewski

In order to find discrete Pareto front approximations most algorithms exploit only feasible solutions, deriving feasible approximations (lower shells) of the Pareto set. We define an upper shell, a set of infeasible solutions, for which and for a given lower shell the Pareto front always lies "between" their objective mappings. The upper shell is not an operational construct whereas its relaxation (upper approximation) is. Therefore, in the presentation we investigate instances of multiobjective optimization problems in which an upper approximation is an upper shell.

2 - Computationally Expensive Multiobjective Optimization - Survey and New Method
Seyed Mohammad Mehdi Tabatabaei, Jussi Hakanen, Markus Hartikainen, Kaisa Miettinen, Karthik Sindhya

We first present a survey on surrogate-based methods to tackle computationally expensive multiobjective optimization problems. We split the surrogate-based methods into sampling-based and optimization-based ones. In particular, we focus on the capabilities of the methods in handling black-box functions and non-convex as well as disconnected Pareto optimal fronts. Secondly, based on the findings of the methods studied, we propose a new, general-purpose scalarization-based method. It handles computationally expensive multiobjective optimization problems in an effective and intelligent way.

3 - Pareto Set Identification for Expensive Multiobjective Optimization Problems
Ingrida Steponavice, Rob Hyndman, Laura Villanova, Kate Smith-Miles

We discuss strengths and weaknesses of a new method for identifying the Pareto optimal set: Efficient Pareto Iterative Classification (EPIC). The method classifies evaluated decision vectors into two classes - non-dominated and dominated - using machine learning, and then predicts the Pareto optimal set for unevaluated vectors. Different strategies for selecting the next decision vector to evaluate are developed to improve the approximation of the Pareto set while minimizing the number of evaluations. We test EPIC performance on benchmark problems and compare the results to existing methods.

4 - The Interactive HyperBox Exploration Method for Computationally Expensive Nonconvex Multiobjective Optimization Problems
Jussi Hakanen, Tomi Haanpaa, Kaisa Miettinen

We present a novel method for computationally expensive multiobjective optimization problems that the decision maker (DM) can use to explore Pareto optimal front. It uses an approximation of the Pareto front based on a surrogate function and pre-computed Pareto optimal objective vectors (POOVs). By specifying desirable upper and lower bounds for the objective vectors, the DM can investigate what kind of approximated POOVs exist for the problem. The method either presents the approximated POOVs satisfying the given bounds or helps the DM in adjusting the bounds if such POOVs could not be found.

■ MD-19

Monday, 14:00-15:30 - Room 128

Retail Labor Scheduling

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Armann Ingolfsson*

1 - Retail Labour Planning Considering Customer Impatience
Agust Thorbjornsson, Eyjolfur Asgeirsson, Armann Ingolfsson, Pall Jensson, Thorlakur Karlsson

We study impatience for retail customers and its implications for labour planning. Tracking customer behavior in retail is more difficult than in call centers. By comparing stated preferences (through surveys) to revealed preferences (through tracked behavior) for call center data, we hope to be able to extrapolate from data on retail customers collected through surveys to predict actual customer behavior in retail settings. We will work in close cooperation with three call centres and three retail chains, where we can conduct customer surveys and video recording.

2 - Retail Traffic: Arrivals, Labor Productivity and Staffing Decisions
Jayashankar Swaminathan, Saravanan Kesavan, Vidya Mani

In this talk, I will focus on the notion of conversion rates as an important measure of retail performance and then discuss the impact of retail labor on store productivity and discuss results on staffing decisions in retail store and how to quantify the impact of accurate staffing.

3 - Box Office Demand-driven Labour Scheduling at the Movies
Saeed Zolfaghari, Katherine Goff

New opportunities for operational efficiencies in movie exhibition exist as a result of the digital era and big data analytics. The scheduling problem has been addressed in the literature at a macro level, allocation of movies to cinemas, and at a micro level, allocation of movies to screens and times. This work extends the current research by addressing the labour scheduling problem and presenting opportunities to leverage big data analytics in the development of new demand driven decision support systems for optimizing theatre staff labour scheduling across networks of multiplex cinemas.

4 - Optimising and Testing Traffic-Based Staff Schedules for a Retail Chain
Armann Ingolfsson, Osman Alp, Ivor Cribben, Michele Samorani

We report progress on a project in which we use time series models to forecast retail store traffic, use predicted traffic and staffing levels to forecast sales, and use the resulting models to develop profit-maximizing staff schedules. A Canadian retail chain has agreed to test our schedules.

■ MD-20

Monday, 14:00-15:30 - Room 129

IFORS Prize for OR in Development 2014 - 3

Stream: IFORS Prize for OR in Development 2014
Award Competition session
Chair: *Andrés Weintraub*

1 - Measuring the Effectiveness of Development Programmes for Vulnerable Indigenous People in India
Bijaya Krushna Mangaraj, Upali Aparajita

This paper tries to measure as well as benchmark the effectiveness of development programmes meant for the vulnerable indigenous people of India. These people who live in different parts of the country are named as particularly vulnerable tribal groups (PTGs) by the Ministry of Tribal Affairs, Government of India. In this work, development effectiveness has been explained in a multi-dimensional framework and multi-criteria decision-making methodologies have been employed to measure it. The identification of the multiple criteria of the complex effectiveness construct has been done with the help of an ethnographic survey followed by a confirmatory analysis. The concept of relative effectiveness has been introduced to benchmark the effectiveness from that of the relatively ineffective ones. A twophase fuzzy goal programming methodology has been adopted to determine an effective portfolio for the purpose. Two case studies were also presented to demonstrate the measure of development effectiveness of the government sponsored development programme for the PTGs who are in the weakest section of the Indian society.

2 - Disaster Risk-Sensitive Shelter Plans from Community-Based Risk Analysis for Legazpi City, Philippines
Leorey Marquez, Sarah Redoblado, Maria Cheryl Prudente, Ernesto Serote, Nicasio Nicasio de Rosas, Myrna Llanes, Jenifer Belarmino, Evelyn Sierra, Bernard Apuli

Improving social protection and community-driven development (CDD) interventions and linking these mechanisms to disaster risk management (DRM) increases the effectiveness of DRM programs. This paper describes the implementation and impact of a CDD project aimed at creating Disaster Risk-Sensitive Shelter Plans (DR-SSP) for nine barangays in the city of Legazpi. The results show the importance of building capacity in civil society organizations and local government, and the effectiveness of the participatory approach in data collection, risk assessment, and disaster planning.

■ MD-21

Monday, 14:00-15:30 - Room 006

Optimization-Related Modeling & Software

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *József Smidla*
Chair: *Qi Huangfu*

1 - Adaptive Stable Additive Methods for Linear Algebraic Calculations
József Smidla, Péter Tar, István Maros

Operations with floating point numbers in linear algebraic calculations can cause numerical errors which can lead optimization algorithms to wrong directions. Numerical errors can be handled using relative and absolute tolerances with some overhead. A new method is proposed, which automatically recognizes the necessity of these tolerances using special SIMD instructions of the most recent CPU architectures in order to minimize overhead or even surpass standard implementations. "This publication has been supported by the project TÁMOP-4.2.2.C-11/1/KONV-2012-0004."

2 - Optimization Modeling in Heterogeneous Distributed Computing Infrastructure
Vladimir Voloshinov, Sergey Smirnov

We present an approach to deploy optimization systems in a heterogeneous distributed computing environment on the base of REST-services and coarse grain decomposition of the problem. These services provide remote access to state-of-the-art solvers and translators of AMPL (A Modeling Language for Mathematical Programming), e.g. it enables to run any AMPL-script in distributed mode, when all independent intermediate sub-problems are solved in parallel by remote optimization services. Implementations of Dantzig-Wolfe and coarse grain type of branch-and-bound algorithms are considered as examples.

3 - A Parallel Dual Simplex Method
Qi Huangfu

The dual simplex method is a fundamental and widely used technique for solving Linear Programming (LP) and Mixed Integer Programming (MIP) problems, yet has been remarkably difficult to parallelize efficiently. We present a new parallel dual simplex method that has been developed for the FICO Xpress Optimization Suite. We will also present benchmarks on large scale LP problems and the root solve (as a sequence of LP problems) of large and hard MIP problems, that show how such problems can often be solved twice as fast as with the traditional sequential dual simplex method.

4 - An Application of Queue Modelling to the Customers in a Gas Station
Abdullah Ozcil, Irfan Ertugrul

In this work, the service process of a gas station having heavy customer traffic in Denizli (Turkey) is simulated through a review of the available literature related to queue modelling and is determined by process efficiency and performance level. The queue modelling is identified related to waiting in the queue of gas station, customers and optimal service levels and service needs are tried to be determined. The data related to the gas station queue problems are evaluated using Microsoft Excel and WinQSB software packages for planning the capacity, increasing the productivity.

■ MD-22

Monday, 14:00-15:30 - Room 007

DEA, AHP and Statistical Analysis

Stream: Health Care Data Analytics
Invited session
Chair: *Kwok Leung Tsui*
Chair: *Simone Angelo*

1 - Case-Mix Adjusted Efficiency Score: the Case of the South African Private Hospital Industry
Shivani Ramjee, Kathryn Dreyer

We examine the impact of risk adjusting a DEA hospital model for the mix of clinical cases, and find that ignoring case mix can distort the efficiency scores of individual hospitals. On comparison of three different techniques for case-mix adjustment, it is evident that if there is sufficient data to construct a case-mix adjustment factor, adjusted admissions should be used, rather than using the factor as an additional output. In the case where insufficient data is available, disaggregating admissions captures some of the differences in case mix but substantial power is lost.

2 - Efficiency and Quality implications in Health Care Management
Ioannis Mitropoulos, Panagiotis Mitropoulos

Efficiency and quality constitute the fundamental goals of any contemporary Health Care system. Especially nowadays where the economic pressures impose major restrictions in fiscal policy, this study investigates the implication of efficiency and quality in primary healthcare centers. Cluster analysis of patient satisfaction and bootstrapped DEA analysis scores are performed. Implications are examined by regressing these scores with variables that represent clusters from alternative dimensions of patient satisfaction. Significant interactions of efficiency with quality are apparent.

3 - Demand Forecast and Optimal Allocation of ICU Beds: A Case Study in Rio de Janeiro
Simone Angelo, André Salles, Edilson Arruda, Miranda Albino Martins Muaualo

Determining the optimal number of ICU beds in a given neighborhood is essential due to both the expensive cost of these beds and the ever increasing demand for them. This paper is concerned with finding the optimal number or ICU beds in the metropolitan region of Rio de Janeiro, making use of information on the daily requests for ICU beds in a set of selected hospitals in 2010 and 2011. This information is used to obtain a demand forecast by means of exponential smoothing and Box-Jenkins models, which is the input of the queueing model whose output is the optimal number of ICU beds.

■ MD-23

Monday, 14:00-15:30 - Room 008

Emotions and Human Behaviour in Interactions

Stream: Behavioural Operational Research
Invited session
Chair: *Raimo P. Hämäläinen*

1 - PoSITeams - Positive Systems Intelligent Teams, an Agent Based Simulator for Studying Group Behaviour
Juha Törmänen, Raimo P. Hämäläinen, Esa Saarinen

The agent based simulator analyses the effects of positive interaction in groups with different organisational and interaction structures. The ideas in the model draw from our work in human systems intelligence and broaden and build the theory of positivity by Barbara Fredrickson. The software is used to explore structures that generate and support positivity in teams. We have planned to allow the customization of the reactions of the agents. Then PoSITeams could be used in self development by allowing a member agent to analyze the effects of his/her behavioural changes on the whole team.

2 - An Affective Model for an Autonomous Decision Agent
Pablo Gómez Esteban, David Rios-Insua

We provide a decision making model which includes four basic emotions and mood as affective elements, dynamically influencing the weights in a multiobjective expected utility model. We also incorporate the possibility of triggering impulsive behavior when sufficiently high intensities of certain emotions are reached. Our motivation for this is the development of algorithms that control the behavior of autonomous robots, aiming at improving interactions. We present some simulations in which our agent faces differently behaving users and compare its performance with an emotionless agent.

3 - Why Emotional Behaviors Matter for the Design of Decision Support Systems (DSSs): Evidence from Text-based Electronic Negotiations
Patrick Hippmann

Emotional behaviors shape the progression of negotiation processes and can steer negotiations toward success or failure. The present work shows that DSSs impact emotional behaviors throughout the negotiation process, and explains why the research on and design of DSSs should incorporate this interconnection. We elicitate emotional behaviors from the communication process by using multidimensional scaling, and analyze emotional behaviors in line with a multi-level research framework, which addresses behavioral (i.e., intra- and inter-personal) and procedural (i.e., temporal) dynamics.

4 - Emotions in a Repeated Cournot Duopoly: A Psychophysiological Experiment

Ilkka Leppänen, Raimo P. Hämäläinen

We study emotions in a Cournot duopoly, where experimental subjects often cooperate but also reciprocate. We measure psychophysiological reactions that include the skin conductance response (SCR) and facial electromyography (EMG) on three muscle regions. We find that choices that would lead to higher own payoffs are accompanied by higher SCR than choices that lead to lower own payoffs. The SCR is also increasing in own payoffs. We also find that low own payoffs are accompanied by negative emotions in EMG. Our research provides a method of observing directly emotions in strategic interactions.

■ MD-24

Monday, 14:00-15:30 - Room 212

Preference Learning III

Stream: Preference Learning
Invited session
Chair: *Krzysztof Dembczynski*

1 - Preference Learning from Managerial versus Data Mining Point of View

Peter Vojtas, Ladislav Peska

We consider the CRISP-DM process for preference learning for an e-shop. We discuss the problem along several dimensions: # users; # items; complexity of items; explicit-implicit user feedback; registered-anonymous user; frequent-rare visit repetition; data sparsity (user x item matrix); data real-artificial. We focus specially on relation between measuring quality of offline data mining and MCDA for the manager deciding deployment (online A/B testing). We illustrate it on real implicit behavior data from an e-shop travel agency (content based recommendation with collaborative aspect).

2 - Improve Infrastructure Stakeholder Collaboration through e-Participation: A Strategic Analytics Planning Approach

Xiaojun Wang, Isabella Lami, Leroy White

This research describes a Strategic Infrastructure Analytics Planning approach that is internet/cloud based and seeks to foster collaboration amongst infrastructure providers and the public. The approach provides a highly beneficial means for organisations to manage their own infrastructure delivery programmes and share high-level information with stakeholders in an efficient manner. The approach will facilitate greater sharing, analysis and action upon infrastructure 'big' data, and combines e-participation with MCDA to ensure community consultation and participation in decision-making.

3 - Regional Anti-Desertification Management with a Multi-Criteria Inference Approach: A Study of the Khorasan Razavi Province in Iran

Tommi Tervonen, Adel Sepehr, Milosz Kadzinski

We apply a multi-criteria inference approach for classifying 28 administrative zones of the Khorasan Razavi province in Iran into three equilibrium classes which indicate the zones' susceptibilities for desertification (collapsed, transition or sustainable). The model is parameterized with enhanced vegetation index measurements from 2005 and 2012, and 7 other indicators measured in 2012. Results indicate that the resulting model is underdefined in terms of attributes, but the approach is promising in providing usable decision support for managing anti-desertification efforts.

4 - How German Parties Learn the Electorate's Preferences

Andranik Tangian

The goals of the paper are empirically finding the political preferences of the German electorate at the moment of the 2013 Bundestag election and evaluating the representative capacity of the political parties and that of the Bundestag. The 2013 election winner, the CDU/CSU, is shown to be the least representative among the 28 parties considered. The representativeness of the Bundestag is about 50%, not much surpassing the decision results when on every policy issue a coin is tossed.

■ MD-25

Monday, 14:00-15:30 - Room 009

Mathematical Methods of the Economic Theory

Stream: Mathematical Economics
Invited session
Chair: *Alexander Zaslavski*

1 - A Theory for Estimating Consumer's Preference from Demand

Yuhki Hosoya

This study shows that if the estimate error of the demand function is sufficiently small with respect to local C1 topology, then the estimate error of the corresponding preference relation is also sufficiently small. Furthermore, this study shows that if the estimate error of the inverse demand function is sufficiently small with respect to local uniform topology, then the estimate error of the corresponding preference relation is also sufficiently small.

2 - Transboundary pollution control and environmental absorption efficiency management

Fouad El Ouardighi, Konstantin Kogan

In this paper, we suggest a two-player differential game model of pollution that accounts for a time-dependent environmental absorption efficiency that allows for the possibility of a switching of the biosphere from a carbon sink to a source. We investigate the impact of negative externalities resulting from the transboundary pollution non-cooperative game wherein countries are dynamically involved. To do so, we assess differences related to both transient path and steady state between cooperative, open-loop and Markov perfect Nash equilibria. The results suggest unexpected contrasts in terms

3 - Locally Robust Mechanism Design

Chaowen Yu

The purpose of this paper is to investigate locally robust implementability of a social choice function. Locally robust implementation captures the idea that the social planner knows the agents' believes well, but not exactly. It is known that in many economic models, almost all social choice functions are not locally robust implementable. However, by considering the replica economy, we show that, asymptotically, well-known mild conditions are sufficient for a social choice function to be locally robust implementable.

4 - Proportional Coalitional Values for Monotonic Games on Convex Geometries with a Coalition Structure

Qiang Zhang

A new model called games on convex geometries with a coalition structure is proposed where the player set and the coalition structure both form a convex geometry. A value called the proportional coalitional solidarity value is defined. From the expression of this value, we know that any union's proportional coalitional solidarity value coincides with the solidarity value of the union in the quotient game and the players in a union share this amount proportionally to their solidarity values in the original game on convex geometries (i.e., without unions).

■ MD-26

Monday, 14:00-15:30 - Room 010

Neural Networks and Applications

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Hans-Jörg von Mettenheim*
Chair: *Georgios Sermpinis*

1 - Towards a Better Explanation of Asset Pricing Puzzles in Emerging Markets
Leoni Eleni Oikonomikou

The aim of this presentation is to test the existence of asset pricing puzzles in BRICS equity markets and to quantify them. The empirically tested model is the Long-Run Risks model developed by Bansal and Yaron (2004) and this is the first study that uses this model with BRICS equity markets data. In this model, the consumption and dividend growth rates contain a small long-run component and fluctuating economic uncertainty. The performance of the model is tested using Epstein-Zin and external habit preferences. The empirical results for BRICS are compared with US data for the last 20 years.

2 - Rolling Genetic Support Vector Regressions: An Inflation and Unemployment Forecasting Application in EMU
Georgios Sermpinis, Andreas Karathanasopoulos, Charalampos Stasinakis, Konstantinos A. Theofilatos

In this paper a hybrid Rolling Genetic — Support Vector Regression (RG-SVR) model is introduced in economic forecasting and macroeconomic variable selection. The proposed algorithm is applied in a monthly rolling forecasting task of inflation and unemployment in eight EMU countries. The RG-SVR genetically optimizes the SVR parameters and adapts to the optimal feature subset from a feature space of potential inputs. The feature space includes a wide pool of macroeconomic variables that might affect the two series under study of every country.

3 - High-Order Multivariate Neural Network Based Fuzzy Time Series Model for Car Road Accidents
Ozer Ozdemir, Memmedaga Memmedli

Multivariate and high order neural network based fuzzy time series approach might obtain better forecast results than other approaches for fuzzy time series. So, we used a new high order multivariate neural network based fuzzy time series model for forecasting. We used various degrees of membership in establishing fuzzy relationships with various numbers of hidden nodes. The time series data of the total number of annual car road accidents casualties in Belgium from 1974 to 2004 are used for the proposed method and other methods in the literature. All results are compared with each other.

■ MD-27

Monday, 14:00-15:30 - Room 213

OR in Quality Management III

Stream: OR in Quality Management
Invited session

Chair: *Chien-Wei Wu*

1 - Process Yield Assessment for Processes with Multiple Manufacturing Lines
Yu-Ting Tai, Huei Chun Wang

Process yield assessment is critical since it could provide feedback on what actions need to be taken for yield control. Process capability indices have been widely applied in quality assurance since some manufacturing processes require very low fraction of defectives. Due to economic scale considerations, multiple manufacturing lines are common. However, existing research works only deal with processes with a single manufacturing line extensively. In this paper, we provide a new and effective index method for assessing the process yield for those processes with multiple manufacturing lines.

2 - Skewed Correction Average Control Chart Based on Sample Standard Deviation
Shih-Chou Kao, Yi-Chuan Huang

This study proposes an average control chart with the skewed correction and the standard deviation (SCS) based on the generalized lambda distribution (GLD). Constants of SCS average control chart are calculated in accordance with the GLD and the method of moments by using Monte-Carlo simulation. This study also compares type I risks and type II risks among control charts, including skewed correction based on range and weighted variance control charts. The average control chart with the SCS gives good effectiveness for monitoring the both type I risks and type II risks.

3 - A Variable Quick Switching Sampling System for Controlling Lot Fraction Nonconforming
Shih-Wen Liu, Chien-Wei Wu

In this paper, a new variable quick switching sampling system based on process yield is developed for lot sentencing when the quality characteristic follows a normal distribution and has bilateral specification limits. The operating characteristic (OC) function of the proposed sampling system is derived based on the sampling distribution of process yield index and the OC curve is required to pass through two designed points for satisfying business contract. The computation result shows that the proposed plan is more economic in terms of needing fewer required sample size for inspection.

4 - A New Sampling Plan by Variables Inspection for Product Acceptance Determination
Chien-Wei Wu, Shih-Wen Liu

Acceptance sampling plans provide the producer and the consumer a general rule for lot sentencing to satisfy the desired quality requirements and protections. In this paper, a new concept of sampling strategy is applied to develop a sampling plan by variables inspection based on process yield for product acceptance determination. The results show that the proposed sampling plan requires smaller sample size for inspection while providing the same projection to the producer and the consumer.

■ MD-28

Monday, 14:00-15:30 - Room 130

Optimal Project Investment Sequencing (Palisade)

Stream: Sponsored Sessions
Sponsored session

Chair: *Manuel Carmona*

1 - Using genetic optimization algorithms for optimal project investment sequencing. How to evaluate project risks using Monte Carlo simulation.
Manuel Carmona

@RISK performs risk analysis using Monte Carlo simulation to show outcomes in your spreadsheet, and their likelihood of occurrence. @RISK also helps you plan the best risk management strategies through the integration of RISKOptimizer, combining Monte Carlo simulation with the latest solving technology. We will demonstrate a number models such as; how to plan a capital investment considering probabilistic variables and strategic risks. We will also optimize a portfolio of projects, considering probabilistic returns and capital inflow rates.

■ MD-29

Monday, 14:00-15:30 - Room 011

Volatility Modeling and Investment Strategies

Stream: Financial Optimization
Invited session

Chair: *Qi Wu*
Chair:

1 - Mean-Field Formulations for Optimal Multi-period Mean-Variance Portfolio Selection
Xun Li

When a dynamic optimization problem is not decomposable by a stage-wise backward recursion, it is nonseparable in the sense of dynamic programming. The classical dynamic programming-based optimal stochastic control methods would fail in such nonseparable situations as the principle of optimality no longer applies. Among these notorious nonseparable problems, the dynamic mean-variance portfolio selection had posed a great challenge to our research community until recently. We propose a novel mean-field framework that offers a more efficient modeling tool and a more accurate solution scheme.

2 - Multi-curve Term Structure Modeling with Low-dimensional Differing Short Rates
Qi Wu

We approach the joint modeling of discount curve and forward curve using short rates based on the premise that low-dimensional quasi-Gaussian short rate models can be as effective as a full-blown LIBOR market model. In our specificaiton, the discount curve stems from the yields of the posted collateral and the forward curve is associated with the usual LIBOR forwards. The joint dynamics of differing short rates are modeled in the collateralized martingale measure with time-dependent volatility and correlation to generate flexible swaption skew. Analytical formulas of swaption vol are derived.

3 - Capturing the Term Structure of FX Smile
Pui Yin Chan

The term structure of volatility smile is the aggregated market expression of forward implied vol at a series of future horizons, yet retrieving them asks for a model that calibrates the non-ATM maturity curves well besides the ATM term structure. In this paper, we focus on the FX vol market and propose a dynamic SABR model with deterministic volatility shift functions and contrast it with the better known lambda-SABR model that uses mean-reversion in vol drifts. Our extensive numerics suggest that the vol-shifted SABR, although structurally different, is as competitive as the lambda-SABR.

■ MD-30

Monday, 14:00-15:30 - Room 012

Financial Mathematics 1

Stream: Financial Mathematics and OR
Invited session
Chair: *Masamitsu Ohnishi*

1 - Regime Switching among Several Short Rate Models
Keiichi Tanaka

We study the evaluation of contingent claims under a regime switching environment where either the dynamics or the level of the short rate is switched among ones of several short rate models. This paper decomposes the solution to the system of partial differential equations with terms represented by recursive integrals in a meaningful way by making use of the homotopy perturbation method. Some examples of the bond price decomposition and the derived term structure of yield curve are presented and discussed. The greeks of the contingent claim price is also derived in the same form.

2 - Equilibrium Relationship between the Performance and the Information Ratio with Transaction Costs
Shingo Nakanishi, Masamitsu Ohnishi

We study that both the potential loss of performance and its information ratio which is a risk-adjusted measure of active management make the equilibrium relationship. At the same time, we consider it with transaction costs. That is, it is considered that the decision-making measure for active investment that is the probability based on financial mathematics indicates the ratio of important investment in the equilibrium relationship when we think of the information ratio. Moreover, we clarify that the other equilibrium relationship is shown mathematically to explain above mentioned.

3 - Limit Order Book Dynamics and Optimal Execution Strategy
Seiya Kuno, Masamitsu Ohnishi

In this study we consider the resilience effect on optimal execution strategy by the institutional trader taking the Limit Order Book (LOB) into account. Under the assumption of linear market impact, we specify how the new orders from the noise traders are provided in the LOB, then derive the optimal execution strategy for the institutional trader focusing mainly on the resilience. By analyzing a price model from the LOB in which the liquidity is provided by many noise traders, the optimal execution strategy is varied by the characteristic of the noise traders, in particular the patience.

4 - Free Boundary Problem for Double Stopping Russian Option
Kyohei Tomita, Tomatsu Takumi, Katsunori Ano

We study the double exercise Russian option. For two times exercise chances, the system of the corresponding free-boundary problem (FBP) are derived and the optimal stopping strategy are studied in details. Then all componets in the free-boundary problem such as the smooth-fit condition are proved. The verification theorem of the FBP for the pair of the optimal price and the optimal stopping boundaries are proved.

■ MD-31

Monday, 14:00-15:30 - Room 013

Public Sector Networks and Applications

Stream: Decision Processes
Invited session
Chair: *Zhili Zhou*

1 - Risk-Averse Network for Disaster Preparedness
Miguel Lejeune, Nilay Noyan, Xing Hong

We propose a new risk-averse stochastic modeling approach for the design of a pre-disaster relief network. We introduce a probabilistic constraint on the existence of a feasible flow to ensure that the demand for relief supplies across the network is met with high probability. Local chance constraints ensure the responsiveness and self-sufficiency of each region. The Gale-Hoffman inequalities represent the conditions on the existence of a feasible network flow. The solution method rests on a preprocessing algorithm and on a Boolean reformulation method for chance constraints.

2 - ICT and Humanitarian Supply Chains
Ioanna Falagara Sigala, Tina Wakolbinger, William Kettinger

This paper aims to explore the role of information systems in supporting humanitarian organizations in efficiently and effectively delivering essential medicines. The study deploys both qualitative and quantitative methods. First, we look at the current implementation of an ERP at a medical humanitarian organization's missions. Second, we use agent-based modeling and simulation to highlight how the technology adoption will spread throughout the organization, where points of resistance might exist.

3 - Allocation Models for Shared Ambulance Services
Lavanya Marla

We consider the setting where multiple ambulance services compete to serve a population. Such settings have been observed in emerging economies where 911-type services are just being set up, and they compete with existing ad-hoc services; as well as in cities like New York, where multiple EMS companies exist. First we show, using existing data from a densely populated city, that this can have high opportunity costs due to phenomena like abandonment. Second, we discuss game-theoretic models that can facilitate better ambulance utilization and improve service levels for the population.

4 - Incident Response Bus Routes Planning and Management for Public Transit Networks
Zhili Zhou

In this paper, we study the subway system incident response in public transit networks by utilizing both existing public bus service and express bridging bus service. We design the express bridging bus routes and frequencies and rearrange the existing bus stops and frequencies to minimize the waiting time of impacted passengers. We propose a column generation based method to select bridging bus routing, rearrange existing bus stops, and determine bus frequencies in a time-space network. We implement solution approaches for incident cases in Singapore MRT system and demonstrate results.

■ MD-32

Monday, 14:00-15:30 - Room 014

Humanitarian Operations Research for Developing Countries

Stream: Humanitarian Operations Research
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Joao Neiva de Figueiredo*

1 - An Objective Methodology to Measure Corruption Levels and Institutional Maturity in Developing Countries
Joao Neiva de Figueiredo

Corruption intensity across countries is mostly gauged through rankings based on surveys which often render subjective results. We suggest an objective methodology to evaluate corruption levels and institutional maturity in different jurisdictions which takes into account local cultural values and attitudes towards corruption and is based on operations research and industrial engineering statistical quality control sampling techniques. The conceptual framework is developed, theoretical backing is provided, and an illustrative example of corruption levels in Brazil is presented.

2 - Better Queue Management Using Data Envelopment Analysis: An Application in a Large Public Hospital of a Developing Country
Komal Aqeel Safdar, Ali Emrouznejad, Prasanta Kumar Dey

Queuing is considered as a key efficiency criterion in any service industry, including healthcare. Despite numerous healthcare applications, Data Envelopment Analysis (DEA) has not been used before for evaluating queuing systems. In developing countries, overloaded health systems and absence of appointment systems result in extensive waiting times. This paper aims at employing DEA to assess the queuing system of a large and busy public hospital in Pakistan, where all patients are walk-ins. Hence the objective is to develop a framework for improving the patient flow at the designated hospital.

3 - Multi-Objective Decision Analysis for Force Analysis of Conventional Forces Problem
Mehmet Durkan

One of the most important problems in Defense and Operation Planning is being able to make a detailed force analysis and then make force comparisons. This research approaches the problem statically. It considers air power as an example of a force and uses conventional air force specifications to see how to analyze a force statically. This research identifies the analysis of an air force as a decision analysis problem and applies the Value Focused Thinking method to build a decision model. It is recommended to future operation planners to use this model in operation planning processes.

4 - A Stakeholder-based Approach for Assessing the Effects of Land Use Scenarios on Ecosystem Services: Cases of Bolgatanga and Bongo Districts in Upper East Region, Ghana
Hongmi Koo, Christine Fürst

In Ghana where most inhabitants rely on utilizing natural resources, agricultural land uses faced with unfavorable climate condition affect the ecosystem services (ESS). Our study suggests a stakeholder-based assessment and scenario modeling framework for estimating the potential capacity of land use to provide ESS. ESS to interpret the regional conditions, relations between ESS and land-use types, and eligible land use scenarios are determined based on opinions of stakeholders. The GISCAME platform is used to balance place-specific/overall targets for developing successful planning scenarios.

■ MD-33

Monday, 14:00-15:30 - Room 015

Closed-loop Supply Chains and Reverse Logistics

Stream: Environmental Sustainability in Supply Chain
Invited session
Chair: *Fuminori Toyasaki*

1 - The Redesign of Extended Producer Responsibility and its Impact on a Producer's Recovery Strategies
Wenyi Chen, Beste Kucukyazici, Maria Jesus Saenz

This research investigates the economic and environmental impacts of potential legislative changes on consumers and producers. The model consists of a regulator and an OEM engaged in a Stackelberg game with perfect information. We use CED (cumulative energy demand), toxic waste and virgin material usage as our measures of environmental impact. A frontier of efficient policies is developed for the regulator to balance the economic and environmental impacts. The proposed methodology is illustrated using a case based on a German company.

2 - Accurate Response with Refurbished Consumer Returns
Marc Reimann

In this paper we study a retailers' optimal accurate response policy under consumer returns that can be refurbished and resold on the primary market. Using a newsvendor-type formulation, we analyze the impact of the optimal reaction including the refurbishing option on the anticipative supply decision taken under uncertainty. We then extend the model by including partial backlogging, where some of the demand may be lost when shortages occur. For both, the basic model and its extension we provide analytical and numerical insights into the retailers' optimal behavior.

3 - Reverse Logistics Decision Making for Modular Products
Thomas Nowak, Fuminori Toyasaki, Tina Wakolbinger

Product design issues play a crucial role in determining a product's life-cycle duration, costs and environmental impacts. In this paper, we study how supply chain strategies and reverse logistics activities influence a product's level of modularity. We develop inter-temporal optimization problems for companies following a push and a pull supply chain strategy. The model analysis provides insights concerning product design and reverse logistics decisions.

4 - When and for Whom Would e-Waste be a Treasure Trove? Insights from a Network Equilibrium Model of e-Waste Flows
Fuminori Toyasaki, Tina Wakolbinger, Thomas Nowak, Anna Nagurney

One of the major concerns of many electrical and electronic equipment waste (WEEE) take-back schemes is whether adequate amounts of WEEE flow into the designed recycling systems. We analyze how technical, market, and legislative factors influence the total amount of e-waste that is collected, recycled, exported and disposed of. The results of the numerical examples highlight the importance of considering the interaction between the supply and the demand side for precious materials in policy-decisions. Furthermore, the results emphasize the need for cooperation between recyclers.

■ MD-34

Monday, 14:00-15:30 - Room 016

Energy Analytics

Stream: Data Mining in Finance and Commodities
Invited session
Chair: *Marcus Hildmann*

1 - Review of Day-ahead Planning Models for Electricity Trading
Minja Marinovic, Milena Popovic, Uros Sosevic

Since the nineties, electricity markets have been deregulated, allowing customers to choose their providers. This situation opened new optimization problems in electricity trading. The literature on different aspects on this subject is extensive and gives a variety of different approaches and solutions. The aim of this paper is to present various models for solving a problem of day-ahead planning in electricity trading. Day-ahead planning refers to finding an optimal plan, which will maximize the daily profit considering demands, supply and the available transmission capacities.

2 - Application of Modern Portfolio Theory for the Evaluation of Onshore Wind Power Investments in EU Countries
Dimitrios Angelopoulos, Konstantinos Milios, Haris Doukas, John Psarras

Onshore wind power currently is one of the most competitive renewable energy technologies. In this study, the problem of optimal geographic distribution of new onshore wind power plants is examined from the investor's perspective. This methodology focuses on technical and economic parameters of different EU countries to extract the efficient portfolios that maximize the inverse levelized cost of electricity generation and minimize its volatility. An illustrative example is provided to evaluate this methodology and sensitivity analysis of the key input variables of the model is performed.

3 - Apply Genetic Algorithms to Estimate Wind Energy Function Parameters
Sheu-Hua Chen, Hong Tau Lee

Wind power is one of the green energies. Theoretically, a wind turbine is expected to produce a certain amount of energy given a specific wind speed. Based on the analysis of historical data of wind turbines, it revealed that the corresponding power curve is similar to a logit function. We used the least squares method to construct the logit function with four parameters. The models are solved by a designed GA. The calculated parameters are used in the power function for monitoring the effectiveness and efficiency of the wind turbine.

4 - A MINLP Model for the Bidding Design Problem of a Hydroelectric Producer: The Case of a Head-Dependent Cascaded Reservoir System in Spain
Javier Diaz, Luis Moreno

It is presented a large-scale mixed-integer non-linear programming (MINLP) model to maximize the day-ahead profit of a hydroelectric generation company (H-GENCO) in a pool-based electricity market. Incorporating some variants to the basic model it can be used for decision making about questions associated with three classical problems: when to generate?, the Unit Commitment Problem; how much to generate?, the Economic Dispatch Problem; how to offer?, the Bidding Design Problem. Price scenarios are considered. Results of the case study are discussed.

■ MD-35

Monday, 14:00-15:30 - Room 131

Stochastic Models

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Koichi Nakade*

1 - System Failure Probability of a k-out-of-n System Considering Common-Cause Failures
Tetsushi Yuge, Shigeru Yanagi

This paper discusses the system failure probability of a k-out-of-n system considering the common-cause failures. The conventional implicit technique is introduced at first using the failure probabilities of common-cause basic events. Then the system failure probabilities are formulated when the symmetry assumptions, i.e., all components have the same failure probabilities, are introduced. We also provide algorithms to enumerate minimal cut sets and to calculate the system failure probability. These methods can apply to the systems with non-identical components.

2 - Advertisement on Social Network
Hiroshi Toyoizumi

Many companies are starting to rely on marketing activities on social networks. Main marketing method on social network is advertisement by word of mouth (WOM). On the other hand, it is known that large-degree nodes can become the bottleneck of spreading information on complex networks. In this research we will analyse the spread process of WOM advertisement on social network by using extended heterogeneous SIR (Susceptible-Infectious-Recoverd) model. Further, we will discuss the possible improvement of WOM advertisement.

3 - Optimal Control Problems in a Closed Loop Manufacturing System with Stochastic Variability
Kenichi Nakashima

This paper deals with a closed loop manufacturing system problem with stochastic variability such as the demand. The system is formulated into a Markov decision process (MDP) that gives us the optimal control policy that minimizes the expected average cost per period. We define the state of the system by some kinds of inventory levels and the cost function is composed of various cost factors such as holding, backlog and some kinds of production costs etc. We obtain the optimal production policy using policy iteration method. Numerical results show the properties of the optimal policy.

4 - Optimal Maintenance Policy of Multiple Parts with Repair-Dependent Operating Cost
Koichi Nakade

A machine is assumed to consist of multiple identical main parts. During operation, parts are periodically inspected and if a part has a crack below the threshold level then it is either repaired or replaced with a new one. If the crack of a part is above the threshold then it must be replaced. The part which is repaired is used with operating cost, which is not incurred to a new part. Repair and replacement costs are also needed for maintenance. An optimal parts repair and maintenance policy is developed theoretically and numerically by using a Markov decision process.

■ MD-36

Monday, 14:00-15:30 - Room 132

Forestry Industry Production Planning and Management

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Ola Eriksson*

1 - Designing Value Chains in the Forest Sector
Sophie D'Amours, Mikael Rönnqvist, Marc-André Carle

Over the years, models and solution methods have been proposed to design value chains in the forest sector. The strategic design is viewed as a combination of assets (including timber licences) and coordination mechanisms (including partnership contracts and policies), to meet the goals of the stakeholders within a highly regulated social, environmental and economic environment. A review with focus on the challenges face by the forest industry is presented. Issues are linking forest and industry, considering uncertainties, ramp-up investment strategies and coordination mechanisms.

2 - Optimizing the Log Yard Assignment Problem given Different Diameter Distributions and Volumes
Maria Anna Huka, Manfred Gronalt

We present an optimization approach to minimize the log yard round wood transportation time for a medium sized hardwood sawmill. Simultaneously taking into account the log transportation time, storage capacity, and yard crane deployment an optimal assignment of ejection boxes, storage boxes and feeding carriages can be found. Furthermore, several diameter distributions and the stepwise increase of the overall volume are investigated. The solutions of an optimization model and a partition model are compared to heuristic approaches with and without the partition of assortments.

3 - Tactical Planning as the Focal Point of Forest Company Planning: A Suggestion
Ola Eriksson, Malin Nilsson, Olof Wahlberg

The forest planning system followed by Swedish forest companies is sequential (longer-term plans form the framework for shorter-term plans) and hierarchical (top-level management prepare the long range plans and the lower management plans with shorter horizons). This approach tends to uncoordinated planning activities and unused knowledge at lower levels of the organizational ladder. Here, an alternative, bottom-up oriented, approach is demonstrated that illustrates potential advantages and drawbacks of the approach and its viability in perspective of new market and technical developments.

■ MD-37

Monday, 14:00-15:30 - Room 017

Fuzzy AHP and ANP

Stream: AHP (Analytic Hierarchy Process) /ANP (Analytical Network Process)
Invited session
Chair: *Maznah Mat Kasim*
Chair: *Amy H. I. Lee*

1 - Decision Making for the Type of Wind Turbines by DEMATEL and FANP
Meng-Chan Hung, Amy H. I. Lee, W. L. Pearn, He-Yau Kang

Wind energy production is a fast growing renewable energy source in the world, and an effective use of wind turbines can enhance the long-term energy production. In this study, a comprehensive evaluation model, which incorporates decision making trial and evaluation laboratory (DEMATEL) and fuzzy analytic network process (FANP), is developed to evaluate various types of wind turbines. Interactive relationships among criteria are considered by the experts, and recommendations are provided for constructing a wind farm. A case study implemented to examine the practicality of the model.

2 - A Multi-Criteria Decision Making Model for Developing Solar Cells
Amy H. I. Lee, He-Yau Kang, Chun Yu Lin, Jian-Shun Chen

New product development (NPD) is an important source of competitive advantage for solar firms. Literature review and interviews with domain experts are done first to construct a house of quality (HOQ) for quality function deployment (QFD). Fuzzy interpretive structural modeling (FISM) is applied next to determine the relationships among the factors, and the results are input to the HOQ. Fuzzy analytic network process (FANP) is then used to generate the outcome for the HOQ. The proposed model can provide a framework for helping designers to systematically consider relevant NPD information.

3 - Combining Fuzzy Integral and DANP Model to Improve Transportation Service Quality
James Liou, Chao-Che Hsu

In this study, we propose a novel, fuzzy integral-based model to evaluate and improve the service quality of transport systems. The relations structure between the criteria and the influential weights of the criteria is constructed with the aid of the DEMATEL and a basic form of the ANP method called DANP. A fuzzy integral is used to aggregate the gaps with influential weights modeled by DANP. The hybrid model remedies prior shortcomings and should be more applicable to real-world situations. Data from Taipei city bus companies are used to demonstrate this method.

■ MD-38

Monday, 14:00-15:30 - Room 214

Biomass-Based Supply Chains III

Stream: Biomass-Based Supply Chains
Invited session
Chair: *Taraneh Sowlati*

1 - An Optimization and Stochastic Simulation Approach for Economic Feasibility Analysis of Biofuel Supply Chains
Jörn C. Meyer, Philip A. Hobson, Magnus Fröhling, Frank Schultmann

Economic feasibility of fuel production from biomass depends on regional factors and on the choice of feedstocks and conversion technologies. The objective of this contribution is to demonstrate how strategic planning and uncertainty analysis can be integrated with techno-economic modelling to support biofuel investment and commercialisation decisions. A three step approach that includes techno-economic modelling of supply chain elements, strategic supply chain design and uncertainty and variability analysis is developed and applied to a case study for biofuel production in Australia.

2 - RDEA Heuristic Algorithm for the Optimal Design of Biomass Supply Chain Networks
Konstantinos Petridis, Evangelos Grigoroudis, Garyfallos Arabatzis

In the world literature, biomass supply chain network (BSCN) design is based on economic (cost/profit) or other objectives. Yet, most of the models and algorithms tend to leave out the efficiency of the solutions. In this work we present a recursive DEA heuristic algorithm for the optimal design of BSCN. An application of the algorithm is shown on the optimal installation of biomass facilities problem where each facility is treated as a DMU, determining a-priori the inputs and outputs based on which the efficiency measurement will be performed, selecting only those DMUs with higher efficiency.

3 - Uncertainties in Forest Biomass Supply Chain for Electricity Generation
Taraneh Sowlati

In this work, the supply chain of a typical forest biomass power plant is optimized considering the uncertainties in different parameters. The optimization model includes biomass procurement, storage, electricity production and ash management in an integrated framework at the tactical level. It is applied to a real biomass power plant in Canada. Monte-Carlo simulation, stochastic programming, robust optimization and a hybrid model are used to consider uncertainties in the amount of biomass supply, its quality and cost, and electricity price in the modeling and incorporate them in the decision.

■ MD-39

Monday, 14:00-15:30 - Room 018

ORAHS II - Quality Improvement

Stream: Health Care Applications
Invited session
Chair: *Sally Brailsford*
Chair: *Turgay Ayer*

1 - Routing and Scheduling of Urban Home Health Care Transport Systems
Christian Fikar, Patrick Hirsch

We provide a solution procedure for a real-world routing and scheduling problem in home health care motivated by challenges caused by urbanization (e.g. congestions, limited parking spaces, staff without driver's permits). A transport service delivers nurses to clients and picks them up after completion of their services. Furthermore, nurses can also walk to their next clients. Different objective functions for real-world instances of three Austrian cities are investigated to discuss trade-offs and benefits of the concept.

2 - Competing on Quality: Evidence from Award Winning Hospitals in California
Bogdan Bichescu, Wei Wu, Randy Bradley

Healthcare is a highly competitive environment in which hospitals compete against one another to both provide services to patients and attract indispensable resources (i.e., nurses and physicians) to deliver their services. We investigate the marketing, operational, and financial benefits associated with winning quality awards, by performing a matching study that compares quality award-winning hospitals from the state of California to comparable hospitals without quality awards during the period of our study.

3 - Simulation of an Elevator Bank
Preston White

The University of Virginia Children's Hospital is constructing a 200,000-square-foot, seven-story complex to consolidate pediatric outpatient services in a central hub for interdisciplinary care. In order to resolve facility layout and scheduling issues prior to occupancy, we developed a discrete-event simulation to analyze the flow of patients, staff, and material within the complex. Central to this simulation is a sub-model of the main transportation system—a bank of four elevators. In this paper we describe the design and implementation of the elevator simulation.

■ MD-40
Monday, 14:00-15:30 - Room 019

Supply Chain Optimization

Stream: Production and the Link with Supply Chain
Invited session
Chair: *Lionel Amodeo*
Chair: *Jonathan Oesterle*

1 - Investigating the Relation between Product Modularity and Supply Chain Decoupling Level through Multi-Objective Optimization
Metehan Feridun Sorkun, Ozgur Ozpeynirci

This study investigates the relationship between the product modularity (PM) and the organizational decoupling. Proponents of this link assume high PM leads to less coordination cost, shorter product development, and higher flexibility. The opponents list strategic and logistics concerns; so assert the necessity of integral supply chain (SC) in spite of high PM. These views motivate us to investigate the main explanatory of SC integration level. We develop a multi-objective MILP program and analyze the optimal solutions at different PM levels, with distinct supplier and module peculiarities.

2 - Bi-Objective Algorithm for Unidirectional Flow Path Design
Julie Rubaszewski, Alice Yalaoui, Lionel Amodeo

The flow path design is the determination of each segment direction and the paths that will be used by vehicles in production units. Important points when designing a new network are construction costs and the cost of its utilization. An efficient optimization method based on ant colony optimization is developed in order to solve the case of minimizing the total travel distance considering both loaded and empty travels and the construction costs. These two objectives are not dependent. To ensure the efficiency of the proposed optimization method, computational experiments are carried out.

3 - Implementing Decomposition Approaches in Multi-Period, Multi-Stage Supply Chain
Amirhossein Sadoghi, Helene Lidestam

We model the capacitated, multi-commodity, multi-period, multi-stage facility location problem. The literature on such problem is still sparse. However there is still room for improvement of the algorithms or finding the initial solutions for exact ones. We proposed an effective heuristic approach based on the primal and dual and hybrid decomposition methods to solve the Large-scale linear programming. Results show that our approach significantly improves solvability of the problem. We exemplified the supply chain of distribution and production of forest residues are to be converted into fuel.

4 - Option Contract Performance in a Supply Chain
Alejandra Gomez Padilla, Tsutomu Mishina

This document studies a bi-directional option contract. In an option contract a retailer may order a number of units and modify the ordered quantity as he receives more accurate information on demand. The modification may go in both directions, that is, it may be higher or lower than the initial order. The purpose of this research is to analyze the performance of this contract for the retailer, the supplier and the chain as a unit, when it is used under several demand patterns. We conclude on the coordination of this contract for different demand patterns and the best parameter combination.

■ MD-41
Monday, 14:00-15:30 - Room 216

Lot-Sizing and Related Topics 3

Stream: Lot-Sizing and Related Topics
Invited session
Chair: *Masood Fathi*

1 - Product Assortment and Production Planning
Luis Guimarães, Diego Klabjan, Herbert Meyr, Bernardo Almada-Lobo

The intense competition in consumer packaged goods industry has motivated companies to expand their product lines. A wider variety tends to satisfy more customers and attract variety-seeking shoppers. On the other hand, the manufacturing complexity increases lead to extra changeovers, lower productivity, higher safety stocks and more frequent stockouts. This talk considers the problem faced by a manufacturer that simultaneously makes product assortment and production planning decisions. The goal is to analyze the trade-off between sales revenue and its consequences in operational costs.

2 - Operations Planning in Dynamic Production Networks
Atour Taghipour

A production network includes ensemble of organizations connected by information, financial and physical flows. When these networks involve independent entities without any central control unit, it is difficult to provide a near optimal plan for global system. The difficulty increases when production planning problem is considered in a dynamic context in which information change and it is necessary to re-plan the production of all independent companies. This research addresses the problem of dynamic planning of production networks using a heuristic search and linear programming.

3 - Numerical Analysis of Flow Time Oriented Lot Sizing Models: A Simulation Study of a Serial Production System
Simon Jutz, Hubert Missbauer

Lot sizes for multi-stage production traditionally are determined based on the trade-off between setup and inventory holding costs. Incorporating the impact of lot sizing on manufacturing flow times has been performed for single-stage production. The resulting decision rules for standard lot sizes are difficult to integrate into a multi-stage environment and seem to change certain structural insights from inventory theory. Motivated by a practical case, we investigate this issue for a two-stage production system by means of a simulation model with different lot sizes for the operations.

4 - A Discrete Particle Swarm Algorithm for Solving the JIT Part-Supplying Problem at Mixed-model Assembly Lines
Masood Fathi, María Jesús Alvarez, Victoria Rodriguez

The assembly line part-supplying problem can be defined as mixed scheduling and decision problem so that for having a reliable part delivery schedule a number of decisions should be made. In this study a mathematical model for the JIT part-supplying problem at mixed-model assembly lines is introduced and due to the complexity of the problem a discrete particle swarm algorithm is also suggested. A set of computational experiments is carried out and the result of comparisons reveals that the proposed algorithm is efficient in term of both provided solution and computational time.

■ MD-42

Monday, 14:00-15:30 - Room 215

Green Freight Transportation 2

Stream: Green and Humanitarian Logistics
Invited session
Chair: *Emrah Demir*

1 - A New Mathematical Formulation to Support Fleet Management Decisions
Emrah Demir, Efstathios Dimarelis, Tom Van Woensel

The assignment of vehicles to freight shipments is investigated to propose better allocation decisions to the planners so that both operational costs and carbon dioxide equivalent emissions can be reduced. This approach facilitates planners to define different scenarios and compare decisions to select the most economical fleet schedule including using their own and chartered vehicles. We show that this approach remarkably helps logistics service providers improve their planning processes.

2 - CO2 Reduction by Using Inhomogeneous Fleets
Herbert Kopfer, Jörn Schönberger

The proposed approach aims at minimizing CO2 emissions caused by transportation. Based on the observation that vehicles of different sizes have different payload-dependent CO2 emission characteristics, the option of choosing different vehicle types is added to vehicle routing problems. Then, the total amount of fuel consumption is minimized in dependence of the types of the used vehicles and their payload during route fulfillment. The quantity of fuel needed to serve a given request portfolio can be reduced tremendously by using an inhomogeneous fleet with vehicles of different size.

3 - Modal Shift and Sustainable Network Design for Municipal Solid Waste Transport Routing
Dirk Inghels, Wout Dullaert

A modal shift from road transport towards vessel or train transport can increase the sustainability of the municipal solid waste management process if it shows to be beneficial. The main challenge is to minimize transport costs using vessels or trains on distances shorter than 100 km. This problem is modeled as a Service Network Design Planning problem. We present an MILP model to solve the transport mode allocation problem. Preliminary results show that using vessels can be beneficial if external costs are taken into account and shipped volumes can be increased.

4 - Critical Review of CSR Indicators on Extended Producer Responsibility
Cristobal Miralles

After some years of evolution, Reverse logistics systems are considered quite important, becoming crucial to design business processes through a closed loop perspective that aims to restore as much value as possible to the system. However, the clear link between Planned obsolescence of products and Extended producer responsibility should be carefully analyzed. This contribution makes a critical review of the CSR indicators on this issue, proposing some useful indirect indicators that can provide a better tracking on the environmental performance of companies.

■ MD-43

Monday, 14:00-15:30 - Room 217

Algorithms and Applications - 3

Stream: Algorithms and Computational Optimization
Invited session
Chair: *Edilaine Soler*

1 - Controlling Dynamical Systems with Branch-and-Bound
Ingmar Vierhaus, Armin Fügenschuh

We consider the optimal control of dynamical systems, given in terms of a set of ordinary differential equations. We allow non-smooth functions in the model equation. In order to solve these problems, we reformulate the problem into a mixed-integer nonlinear optimization problem and apply a tailored branch-and-bound approach which employs an extensive presolving bound propagation technique. This approach has the advantage of potentially finding a proven globally optimal solution. The talk will present the approach as well as numerical results for test instances.

2 - Interior Point Method for Solving the Maximum Loading Problem with Discrete Control Variables
Edilaine Soler, Edmea Cássia Baptista, Vanusa Sousa, Geraldo R. M. da Costa

The problem of finding the maximum loading of a power system can be formulated as a mixed integer nonlinear programming problem. In this work, a function that penalizes the objective function when the integer variables assume non-integer values is proposed. Thus, a sequence of nonlinear programming problems with only continuous variables is obtained and the solutions of these problems converge to the solution of the mixed integer nonlinear programming problem. The nonlinear programming problems are solved by an interior point method. Numerical tests with the IEEE test systems are presented.

3 - Impact of Sovereign Rating Actions on Holdings of Government Debt in Developed and Emerging Economies
Tomasz Orpiszewski

Using a new broad dataset on holdings of government bonds in 30 countries, this article investigates the impact of sovereign rating actions on changes in bondholding positions for different investors types. A paradox emerges with regards to investors' risk aversion, as initial downgrades in the Peripheral Eurozone and Safe Haven countries were followed by a rise in demand by both foreign institutional investors and non-resident central banks. Surprisingly, rating actions can trigger significant changes in bondholdings that are not necessarily coupled with a change in yields and vice versa.

4 - A Mathematical Formulation for Data Mule Scheduling in Sensor Networks
Pablo Luiz Araujo Munhoz, Philippe Michelon, Lucia Drummond, Luiz Satoru Ochi

The Data Mule Scheduling Problem is a special case of a wireless sensor network where a special sensor (mule) is responsible for collecting the data from other sensors. This can be applied in critical areas such as disaster relief and military communications. The objective is minimizing the travel time while solving 3 steps of the problem: define the path of the mule, management of speed of the mule through this path and finally the communication scheduling between the mule and sensors. We propose a mathematical formulation and use adapted instances of Close-Enough TSP to validate the model.

■ MD-44

Monday, 14:00-15:30 - Room 218

Simulation in Management Accounting and Management Control III

Stream: Simulation in Management Accounting and Management Control
Invited session
Chair: *Cristián Cortés*

1 - Metaheuristic to Improve Career Progression in an Organization with N Functional Careers
João Barata, Rui Deus

The matrix Q establishes the number of individuals in each functional career and competence level in a certain organization. Q is determined every year in order to satisfy the organization needs and provide an equal flow of promotions in each career. N careers are evaluated by a set of indicators using a career simulator. We use the Hellinger distance to compare two different careers and a genetic algorithm to search the optimal transfer of vacancies in Q within a 40 year time frame that minimizes the overall difference in k careers intended to have similar progression velocities.

2 - Modeling Innovation Resistance in Technology Diffusion: An Agent-Based Approach
Martin Zsifkovits, Markus Günther

Several innovation resistances influence or even hinder the adoption process. Although widely accepted, previous models on the diffusion of new technologies have either reduced those multiple dimensions to only one parameter or neglected them completely. This might lead to a pro-innovation bias. Therefore we present an Agent-Based model considering a multi-generation and a multi-technology environment with various market players that allows for analyzing possible influences arising from multiple innovation resistances and discuss possible strategies and measurements for these challenges.

3 - Simulation Approach for the Distribution Strategy and Fleet Design of a Major e-Commerce Provider in Santiago-Chile
Cristián Cortés, Jaime Miranda, Cristobal Pineda, Pablo A. Rey

We develop a simulation scheme to provide insights for distribution strategy and fleet design of a major e-commerce provider, in which customers can choose composition and delivery TW of their food and general merchandise orders. The approach comprises 4 steps: demand generation, VRPTW, fleet design and execution of routes with uncertainty in both travel and delivery times. The scheme allows computing performance indicators in terms of costs and level of service of various scenarios of operation, including reduction of delivery TW, opening a storage center different from the original CD, etc..

■ MD-45

Monday, 14:00-15:30 - Room 219

Stochastic Programming in Logistics and Transportation

Stream: Stochastic Programming
Invited session
Chair: *Patrizia Beraldi*

1 - Robust Constrained Shortest Path Problems under Budgeted Uncertainty
Luigi Di Puglia Pugliese, Francesca Guerriero, Michael Poss

Bertsimas and Sim (2003) showed how to efficiently solve combinatorial optimization problems under cost uncertainty, characterized by the budgeted uncertainty set. Unfortunately, their approach does not extend to problems with uncertain constraints, which still need specific algorithms to be handled efficiently. In this talk, we study the constrained shortest path problems under budgeted (variable or not) uncertainty. We discuss some differences between capacity and time window constraints, propose dynamic programming-based algorithms for the problems, and present computational results.

2 - A Progressive Hedging Method for the Multi-Path Traveling Salesman Problem with Stochastic Travel Times
Francesca Maggioni, Luca Gobbato, Guido Perboli

In this talk we propose a two stage stochastic programming model for multi-path Traveling Salesman Problem with stochastic travel costs. Tour design makes up the first stage decision, while recourse actions select the best paths, minimizing the total traveling cost. To solve the problem, we propose a heuristic method inspired by the Progressive Hedging algorithm. New instances representing a medium-sized city derived from the speed sensor network of Turin are introduced. The impact of the stochastic travel time costs on the problem solution is examined showing the benefits in solution quality.

3 - The Traveling Repairman Problem with Stochastic Profits
Maria Elena Bruni, Patrizia Beraldi, Demetrio Laganà, Roberto Musmanno, Francesca Vocaturo

We deal with a vehicle routing problem arising in situations where a server visits nodes of a graph in order to collect time-dependent profits that depend on the arrival time to nodes. Not all nodes need to be visited and the aim is to maximize the total revenue. We propose an extension of the traveling repairman problem in which the travel times are stochastic and the profit collected at each node depends on the uncertain arrival time. We describe a heuristic solution approach and we present preliminary computational results.

4 - Mixed-Integer and Continuous Constrained Optimisation via Simulation
Felisa Vazquez-Abad

The problem is motivated by the optimisation a local public transportation system subject to a chance constraint. Scheduling is parametrised by a continuous random variable. We use local gradient information and Lagrange multipliers in combination with random (integer) search methods in order to obtain the optimal fleet size and scheduling. The large number of function evaluations makes Monte-Carlo simulations impractical. We use the ghost method that combines discrete event simulation max/plus modelling and Monte-Carlo filtering to do retrospective estimation of the chance constraint.

Monday, 16:00-17:30

■ ME-01

Monday, 16:00-17:30 - Room 118

Delays and Disruptions II

Stream: Railway and Metro Transportation
Invited session
Chair: *Leo Kroon*

1 - Simultaneous Train Rerouting and Rescheduling on an N-track Network: A Model Reformulation with Network-based Cumulative Flow Variables
Lingyun Meng, Xuesong Zhou

This paper develops integer programming models for the train dispatching problem. The track occupancy is reformulated using cumulative flow variables. This technique can provide an efficient decomposition mechanism through modeling track capacities as side constraints which are dualized through a Lagrangian relaxation solution framework. We further decompose the original complex rerouting and rescheduling problem into a sequence of single train optimization subproblems. We present a set of numerical experiments to demonstrate the system-wide performance benefits of the proposed models.

2 - Optimization for the Real-Time Railway Traffic Management: Case Studies in European Networks
Paola Pellegrini, Grégory Marlière, Sonia Sobieraj Richard, Joaquin Rodriguez

Railway operations management must cope with system failures and external disturbances that may cause delays. In heavy traffic areas, these delays can quickly propagate. This study details the results of a railway traffic optimization tool based on a MILP formulation. The case studies tackled represent different European locations. These experiments are part of a task the European FP7 project ON-TIME. The project aims to develop a prototype for a new generation of railway traffic management systems which will increase capacity and decrease delays for railway customers' satisfaction.

3 - Disruption Management for High Speed Trains
Leo Kroon, Lucas Veelenturf, Joris Wagenaar, Shuguang Zhan

In this presentation we describe a macroscopic rescheduling model for dealing with a temporary blockage of a railway line, thereby also considering the station capacities. One important aspect to be handled in such a situation is the uncertainty about the duration of the disruption. Main decisions to be taken then are: which trains are to be cancelled, in which stations trains must wait until the disruption is over, and in which order the trains are leaving there once the disruption is over. The model is tested on the High Speed railway line between Beijing and Sjanghai in China.

4 - Rapid Transit Rail Systems: A Robust Design Model with Consistent Disruption Probabilities
Ángel Marín, Esteve Codina, Luis Cadarso

A robust network design may be expensive for daily basis train operations. In practice, a) only the most likely disruptions are taken into account and b) the fail probability depends on the train unit characteristics and the infrastructure usage level. We propose a recoverable robust network design model as a two recourse stochastic programming problem. The proposed model has a bilevel programming structure and it is solved by a heuristic method. Computational experiments are conducted using data drawn from RENFE (the major Spanish train operator).

■ ME-02

Monday, 16:00-17:30 - Room 111

Maps, Zones and Routing

Stream: Vehicle Routing
Invited session
Chair: *Marco Colombi*

1 - Map Matching and Route Optimization
Kaj Holmberg

When optimizing routes for snow removal, the problem of map matching appears when evaluating GPS-tracks recorded by vehicles, and utilizing GPS-information in graphs suitable for route optimization. The task is to associate sequences of GPS-points to links in a graph, suitable for optimization, and thereby obtain paths or tours in the graph. Difficulties are errors in the GPS-coordinates and possible lack of GPS-points on short street segments. We discuss several possible methods for off-line solution of this problem, based on heuristics, shortest paths and rural postman problems, etc..

2 - The Hierarchical Mixed Rural Postman Problem
Marco Colombi, Angel Corberan, Renata Mansini, Isaac Plana, Jose Maria Sanchis

We introduce the Hierarchical Mixed Rural Postman Problem where required arcs and edges are partitioned into hierarchies. The problem looks for a minimum cost tour starting and ending at the depot and serving all the required edges and arcs in the predefined hierarchical order. We propose a mathematical formulation to the problem and introduce several valid inequalities. We develop a branch and cut algorithm as well as a Tabu Search meta-heuristic. All the proposed algorithms have been tested on existing instances for the Mixed Rural Postman Problem suitably modified.

3 - Using Cluster Analysis to Identify STops in GPS Data
Hannelie Nel, Stephan Krygsman

The focus of transport modelling is on trips between home and work. Employees at a university took part in a GPS tracking study, and completed a corresponding travel diary and a household travel questionnaire. A procedure, using cluster analysis, was developed to convert the GPS records of each participant into an activity diary and a travel diary. Trip statistics and activity statistics were compared with actual values extracted from the completed travel diary. Home and work locations were identified without the use of additional sources and compared favourably.

4 - An Iterative Cluster-First Route-Second Approach for a Sales Territory Design Problem with Balanced Workload Requirements
Matthias Bender, Anne Meyer, Stefan Nickel

We consider a territory design problem in which customers are assigned to salesmen with fixed sites in a way that workload is balanced. Since workload contains travel times, it is variable. We decompose the problem by an iterative cluster-first route-second approach: (1) The assignment problem is solved using estimated proportionate travel times for each customer. (2) For each territory a TSP is solved, and the results are communicated to (1) through adapted travel times. The good estimation of travel times is an important task in practice. We evaluate the approach on real-world instances.

■ ME-03

Monday, 16:00-17:30 - Room 001

Addressing Uncertainty in Passenger Aviation

Stream: Aviation
Invited session
Chair: *Amy Cohn*

1 - Mechanism Design for Setting the Parameters of Traffic Management Initiatives
Vikrant Vaze, Michael Ball, Cynthia Barnhart, Prem Swaroop, Chiwei Yan

A traffic management authority is expected to take airline preferences into account when setting parameters of traffic management initiatives. We propose and evaluate a Majority Judgment-based mechanism to replace the existing ad-hoc methods. It captures airline preferences via airline-submitted grades for candidate parameter vectors. Several important sub-problems are formulated and solved, e.g., 1) optimal candidate vector generation problem, 2) optimal strategic voting problem for the airlines, and 3) optimal airline recovery problem to evaluate true costs of a chosen vector.

2 - Minimizing Aircraft Lost Time on Tarmac
Gregoire Spiers, Olivier Ratier

Actual trips include a significant amount of time lost on the tarmac waiting for a free departure slot on the runway, representing both an inconvenience for passengers and a cost for airlines.

It is possible to support departure managers at the airport to make the best out of their resources by optimizing the departure sequence based on the list of flights and their forecast take-off time. With past data analysis, this optimization can be improved to take into account the variability of the processes and to become less sensitive to perturbations.

3 - Can Planned Time Buffers Result in Delays?
Milind Sohoni

Given an aircraft rotation schedule, the airline builds tactical schedules that determine the resources available to complete the various tasks during the scheduled ground-time. While the planned aircraft rotation lays out the scheduled time buffers, the actual arrival time of the aircraft is uncertain. Thus, the actual ground-time available could be different from the scheduled ground-time. We address the question of how the actual and scheduled ground-times affect the operational performance. Specifically, and intriguingly, we show that delays increase with planned scheduled buffers.

4 - True Demand Estimation – A Novel Approach
Cheng-Lung Wu, Tomasz Drabas

In Revenue Management, a fundamental concept of true demand is defined as a set of passengers that would book a flight if there was no capacity constraint. Traditionally, statistical methods were used to unconstrain the demand for a single booking class at a time. In this paper we present an unconstraining model that simultaneously estimates true demand for all the booking classes in a given market. We use Segment Specific Cross-Nested Logit model to manage spill and recapture rates between each booking class. Our approach significantly reduces the error of true demand estimates.

■ ME-04
Monday, 16:00-17:30 - Room 119

Supply Chain Design 2

Stream: Supply Chain Management
Invited session
Chair: *Mehmet Akif Sahman*

1 - Using Integrated Location Routing Approach to Study the Effect of Vehicle Mix Strategies on Cost of a Milk Collection Network
Mohammad Mumtaz, Muhammad Naiman Jalil, Kamran Chatha

Previous work on milk collection network has considered the development of vehicle routing models and heuristics to design routes that minimize collection cost. However, there has been no effort to understand the impact of system design and operational strategies on performance of the network. We use integrated location-routing approach to investigate the effect of various vehicle fleet mix strategies on milk collection cost of a general milk collection network. Results show how different vehicle mix strategies affect cost under various conditions prevalent in dairy sector.

2 - A Location-Routing Problem for Waste Oil Collection
Fahriye Karabak, Burcu Balcik

We consider a biodiesel production company which collects waste cooking oil from various sources, e.g., households. The company is interested in placing collection bins to a set of community centers (CCs) where people can bring their waste oil. We develop a mathematical model to simultaneously determine the locations of the CCs, the number of bins to assign to each CC and the collection routes for vehicles. We develop a simulated annealing heuristic, perform computational experiments to evaluate the performance of our heuristic, and illustrate our model using real-world data from the company.

3 - A Lagrangian Relaxation Heuristic to Determine the Methods for used-Product Return
Jiyin Liu, Hendrik Lamsali

We consider a nonlinear integer programming model for locating used-product collection centres, assigning incentives for users to return their used products, and selecting the return methods for customer zones. A Lagrangian Relaxation (LR) heuristic is proposed to solve this complex model. While the general LR procedure is followed, the steps for solving the relaxed problem and generating feasible solutions are carefully designed considering the problem structure. Computational tests show that the algorithm can generate reasonably good solutions within a relatively short computation time.

4 - The Implementation of the Discrete Artificial Bee Colony Algorithm on a Real Facility Layout Problem
Mehmet Akif Sahman, Abdullah Oktay Dundar, Ali Alagoz

Locating machines, workstations and other elements in production facilities in a proper way is an important and complicated problem. Parameters such as material handling and movement of workers are affected as a result of layout planning as well as spaces to be utilized. Improper applications can result in complexity and difficulty in controlling layout operations. In this paper, a layout problem of a production facility is discussed and solved by the discrete artificial bee colony algorithm. The differences between the current layout and the proposed layout are compared.

■ ME-05
Monday, 16:00-17:30 - Room 002

Fuel Logistics

Stream: Petroleum Logistics
Invited session
Chair: *Rapik Saat*

1 - Sufficient Density of Refueling Stations for Alternative Fuel Vehicles
Masashi Miyagawa

This paper develops an analytical model for determining sufficient density of alternative fuel stations required to achieve a certain level of service. The service level is represented as the probability that the vehicle can make the repeated round trip between randomly selected origin and destination. Distance is measured as the Euclidean distance. The probability is obtained for regular and random patterns of stations. The result demonstrates how the vehicle range, the trip length, and the refueling availability at origin and destination affect the sufficient density.

2 - Measuring the Availability of Fuelling Solutions
Emőke Ila Baladincz, Péter Bajor

There is a strong need to provide alternative fuel for the transportation industry, but the structure of the infrastructure is still problematic. First of all we have to be clear with the current retail network - what are the characteristics of the network, how long the fuelling procedure takes, and how to define the density of available refuelling stations. In order to obtain the most accurate data we developed a measurement system and exact measurement protocol. With the consideration of the measurement results about the existing system it is possible to develop the alternative fuel network.

3 - Risk Management of Rail Transport of Petroleum Crude Oil
Rapik Saat, Xiang Liu

The interest in the safety of rail transport of crude oil has intensified in the wake of several recent severe crude oil train accidents. We develop a generalized risk analysis model to estimate railroad crude oil transportation risk accounting for a series of principal risk factors. The model is used to estimate nationwide crude oil transportation risk by rail. Some results of this research have been used in evaluating the safety effectiveness of more robust tank car designs.

■ ME-06

Monday, 16:00-17:30 - Room 211

Passenger Transportation in Cities

Stream: City Logistics and Freight Demand Modeling
Invited session
Chair: *Alok Choudhary*
Chair: *Letitia Pohl*

1 - A Survey of Travel Times at Shinjuku Skyscraper District in Tokyo
Takeshi Koshizuka

The author has been studying many urban spaces by distance distribution method which is based on the measure of the point pairs whose distance are less than any value at all points of a given space. We can obtain the theoretical result about low buildings, but we cannot derive the theoretical distribution about skyscrapers. So we made a survey about the travel times of 523 point pairs at allthe real floors in Shinjuku. Finally, with respect to travel time we conclude that Shinjuku district is almost equivalent to the set of low buildings which have the same total floor area as Shinjuku.

2 - A Simulation Framework for the Operational Problem of One-Way Car Sharing Systems
Burak Boyaci, Martin Repoux, Nikolas Geroliminis

Electric vehicle sharing systems have been introduced to a number of cities as a means of increasing mobility, reducing congestion, and pollution. One-way systems provide more flexibility to users since they can be dropped-off at any station. However, their operation involves a number of complexities arising from asymmetric demand. In this paper we develop a simulation framework associated with efficient heuristics for relocation to investigate the performance of one-way systems for different levels of flexibility and types of services (with or without reservations) to the users.

3 - Public Transit Network Optimization and Stop Configuration
Michael Klier

Deciding on lines and frequencies is essential for planning public transit networks. In addition, the configuration of stops can also be part of this strategic decision. Empirical studies suggest that real-time displays at stops reduce the perceived waiting time (PWT). On account of the crucial role of PWT for mode choice, one could expect to increase the number of transit passengers when displays at stops are available. A model for line optimization and stop configuration is presented. It can be used to derive an optimal configuration of stops regarding the equipment with real-time displays.

4 - Optimizing the Shape of Rectangular Parking Lots Based on Lot Capacity and Door Location
Letitia Pohl

Large retail supercenters provide one-stop shopping, with a huge variety of products. The convenience of parking is an important aspect of the shopping experience. However, the volume of business dictates a large parking lot, which translates into long walking distances. The typical customer seeks to minimize their walking distance, often willing to spend longer driving (and possibly waiting), to achieve a slightly closer parking spot. This paper investigates parking lot designs that minimize walking distance by using techniques developed for designing warehouse layouts.

■ ME-07

Monday, 16:00-17:30 - Room 003

Multi-Level Programming and Equilibrium Models in Electricity Markets

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Juan Miguel Morales*

1 - Integrating Intermittent Renewable Energy Sources in Electricity Markets
Cristian Pelizzari, Giorgia Oggioni

The increased penetration of unpredictable renewable energy sources, due to the 20-20-20 European targets, has significantly affected the dynamics of electricity markets. In this paper, we investigate the effects of wind energy penetration through generation capacity expansion models. The equilibrium of the electricity market is determined assuming that agents can be either risk-neutral or risk-averse. Models are formulated as complementarity problems and are implemented in GAMS. The analysis is performed on a prototype electricity market.

2 - Modeling the Impact of Imbalance Costs and Market Design on Generating Expansion of Stochastic Units
Salvador Pineda Morente, Juan Miguel Morales

Imbalance costs of stochastic power producers due to forecast errors have a high impact on their total profit and thus, they need to be accounted for when making investment decisions. We present a mathematical program with equilibrium constraints that incorporates both the day-ahead and balancing markets to determine the optimal generating expansion of stochastic units. This model allows us to investigate the effect of both imbalance costs and market design on such investment decisions. The main features and results of the models are discussed using a 2-node example and a 24-bus case study.

3 - Transmission Expansion Planning in Electricity Markets: A Bilevel Multi-Objective Framework
Raquel García-Bertrand, Natalia Alguacil-Conde

This paper presents a multi-objective model for transmission expansion planning in electricity markets. The model simultaneously minimizes investment and congestion costs. We present a novel bilevel programming approach in which prices associated with congestion costs are explicitly characterized as decision variables of the optimization. Thus, expansion plans are determined by the upper-level problem with the goal of minimizing both objective functions through the augmented epsilon-constrained method while prices are obtained by an optimal power flow in the lower level.

4 - A Method to Identify Competitive Wind Locations
Juan Miguel Morales, Henrik Madsen

New transmission investments are required to integrate wind resources that are far away from the large power loads. If wind power producers are, however, made to bear the investment costs, they may see their competitiveness seriously impaired. Taking this potential conflict as starting point, we present a model to decide the amount of wind resources that are economically exploitable at a given location from a transmission-cost perspective. This model builds on stochastic optimization to account for the uncertain character of wind and has a bilevel structure to simulate market competition.

■ ME-08

Monday, 16:00-17:30 - Room 120

Optimal Design in Environmental Management

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session
Chair: *Eleni Zografidou*
Chair: *Konstantinos Petridis*

1 - Optimal Design of the Renewable Energy Production Map of Greece using a Multi-Period Goal Programming Model
Eleni Zografidou, Konstantinos Petridis, Garyfallos Arabatzis

Renewable energy sources are considered to be a clean energy form due to the low levels of hazardous and GHG gas emissions. Nowadays, there is a noticeable switch to electrical energy production from renewable power plants, taking into account specific environmental directives. Considering the energy needs of Greece, we suggest a mix of different renewable energy plants and their locations in Greek Prefectures, applying a 0-1 weighted goal programming model. Finally, an optimal design of the present and future renewable energy production map of Greece is presented.

2 - Optimal Design of Capacity Market with Startup Costs and Capacity Constraints
Marina Dolmatova, Alexander Vasin

We consider a model of electric capacity market, where demand is given by a load duration curve and capacity constrained suppliers are characterized by their fixed, variable, startup and shutdown plant costs. We provide an algorithm that finds an optimal capacity structure satisfying the demand with minimal costs. We formulate sufficient conditions for perfect competition and suggest an auction design such that there exist a dominating strategy for each supplier, and the outcome corresponds to the optimal capacity structure.

3 - Probabilistic Pricing for Wind Farms
Natália Addas Porto, Regiane Silva de Barros, Paulo Correia

Auctions are procedures for disclosure of the market price where the bidding strategy seeks to balance the expected benefit and the probability of winning the auction. Therefore it is necessary to express the expected benefit and the probability of winning the auction as a continuous function of the bid, taking as starting point the probability distribution of the net present value of the object that will be sold which involves algebraic operations with random variables. The paper shows the results for the wind power farm pricing.

■ ME-09
Monday, 16:00-17:30 - Room 121

Stochastic and Deterministic Dynamic Programming and its Applications 2

Stream: Dynamical Systems and Mathematical Modelling in OR
Invited session
Chair: *Tomomi Matsui*

1 - Dynamic Linear Bayesian Model for Inventory Optimization with Demand Forecasting
Marisol Valencia Cárdenas, Javier Diaz, Juan Carlos Correa Morales

Inventory models including all the fixed factors are not robust to uncertainty in variables. Classical models do not have adequate structures helping to deal with drastic changes or no data. Dynamic inventory models are necessary to afford changes that affect planning of sales and production. The Dynamic Linear Bayesian Model is a system which can be used to forecast when there are few or no data or with changes mentioned. In this work, we develop an optimal inventory model with Bayesian demand forecasts, using probability distributions which permits finding optimal production quantities.

2 - Markov Decision Processes with Static Hidden States and Observations
Takayuki Osogami

We study partially observable Markov decision processes (POMDPs) with a particular structure where only a part of the state is hidden, and the hidden part stays unchanged. We show that this structure allows us to make the standard algorithms for POMDPs significantly more efficient. We then discuss applications of these particular POMDPs to the scenarios where machines estimate characteristics of humans while providing services to those humans. A part of this research was supported by JST, CREST.

3 - An Analysis of Deterministic Random Walks on Hypercubes using the Krawtchouk Polynomial
Takeharu Shiraga, Yukiko Yamauchi, Shuji Kijima, Masafumi Yamashita

The rotor-router model is a deterministic process in analogy with a random walk. It is also known by the name of deterministic random walk, implying a deterministic version of random walk. Discrepancy between a deterministic random walk and a random walk is intensively investigated, recently. This paper is concerned with a generalized model of the rotor-router model, which we call functional router model, and investigates single-vertex discrepancy of the number of tokens between a functional-router model and a random walk on a hypercube, using the Krawtchouk polynomial.

4 - Compare the Ratio of Symmetric Polynomials of Odds to One and Stop
Tomomi Matsui, Katsunori Ano

We deal with an optimal stopping problem that maximizes the probability of selecting k out of the last L successes, given a finite sequence of independent Bernoulli trials. This problem includes some natural problems as special cases, e.g. Bruss' odds problem, Bruss and Paindaveine's problem of selecting the last L successes, and Tamaki's problem for stopping at any of the last k successes. We show that a threshold strategy gives an optimal stopping rule and present a tight lower bound of the probability of winning. Our approach is based on Newton's inequalities and optimization.

■ ME-10
Monday, 16:00-17:30 - Room 122

Optimization Methods for Offshore and Onshore Wind Farms

Stream: Optimization Models and Algorithms in Energy Industry
Invited session
Chair:
Chair: *Cristina Corchero*

1 - Optimal Power Flow Tool for Mixed HVAC and HVDC Systems for Grid Integration of Large Wind Power Plants
Mònica Aragüés, Oriol Gomis

The parallel advances in High Voltage Direct Current (HVDC) and High Voltage Alternating Current (HVAC) technologies are leading to electrical systems based on AC and DC transmission. A scenario with mixed DC and AC interconnected networks is then feasible. Specially, if HVDC multiterminal is built for delivering the offshore power to the AC grids. To ensure an efficient power transmission, a tool that solves mixed optimal power flows is developed, knowing the power available on the wind farms, the demand on the AC grids and the electrical characteristics of the network.

2 - Optimal Offshore Wind Power Plant (OWPP) Design based on a Hybrid AC-DC Configuration
Mikel De Prada Gil, Lucia Igualada, Cristina Corchero, Oriol Gomis, Andreas Sumper

The aim of this paper is to optimize a proposed OWPP design based on a hybrid AC-DC topology in order to minimize its total cost. This optimal design consists in determining the optimum number and location of AC/DC converters and collector platforms to be installed between the AC wind turbine array and the single HVDC platform. Likewise, the cable route connecting the WTs between each other is also optimized. Each converter is directly connected to a cluster of WTs providing a centralized control. Thereby, the individual converters of each turbine are not required implying cost savings.

3 - Techno-Economic Optimization of Offshore Grids
Hakan Ergun

In this presentation, two optimization techniques will be shown. The first methodology optimizes the connection of multiple offshore wind farms to the main electricity grid. The method optimizes the system layout for the wind farms, transmission technology and the transmission system voltage. The second optimization methodology is based on iterative combination of linear integer programming and Dijkstra's shortest path algorithm. Transmission layout, cable routes and transmission technology are optimized considering the spatial aspects of the area of focus.

4 - Effects of Optimal Grouping of Wind Farms in Day-Ahead Markets Through an External Agent
Victoria Guerrero, Agustín Alejandro Sánchez de la Nieta López, Javier Contreras

This paper models the optimal joint offer of several wind farms in day-ahead market grouped through an external agent considering the imbalance penalty market. This problem is modeled as a stochastic mixed integer linear one and the objective function maximizes the expected profit of the daily operation with two kinds of offers: i) Separate wind farm offers and ii) A coordinated wind farm offer through an external agent. A risk-hedging measure is used and a case study will be analyzed comparing imbalances and expected profits.

■ ME-11

Monday, 16:00-17:30 - Room 113

Miscellaneous Topics in Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Michele Monaci*

1 - Self-Splitting Tree Search in a Parallel Environment
Matteo Fischetti, Michele Monaci, Domenico Salvagnin

Parallel computation requires splitting a job among a set of processing units called workers. Tree search algorithms are particularly suited for being applied in a parallel fashion, as different nodes can be processed by different workers in parallel. We propose a simple mechanism to convert a sequential tree-search code into a parallel one. In the new paradigm, called SelfSplit, each worker is able to autonomously determine, without any communication with the other workers, the job parts he has to process. Computational results are reported.

2 - The Split Delivery Vehicle Routing Problem
Hande Yaman

The split delivery vehicle routing problem is a relaxation of the classical capacitated vehicle routing problem where the demand of a customer can be split and delivered using multiple vehicles. We try to solve this problem with a formulation using variables that do not carry a vehicle index. This formulation may have solutions where customer nodes act like depots at which several vehicles arrive and exchange loads. We try to avoid these solutions using cutting planes or by extending the formulation locally with vehicle indexed variables. We report some preliminary computational results.

3 - On Two-Branch Split Cuts
Sanjeeb Dash, Oktay Gunluk, Diego Moran

In this talk, we present some properties of two-branch split cuts, which generalize the split cuts of Cook, Kannan and Schrijver, and were studied by Li and Richard (2008). In particular, we show that the closure of a polyhedral set with respect to two-branch split cuts is a polyhedron. Furthermore, we use this result to show that the quadrilateral closure of the two-row continuous group relaxation – the set of points satisfying all cutting planes obtained from maximal lattice-free quadrilaterals – is a polyhedron.

4 - A Divide-and-Conquer Heuristic for the Minimal Steiner Tree Problem
Badri Toppur

We seek the Steiner Minimal Tree on the Euclidean plane using a divide-and-conquer principle. After a lexicographic sort, the set of terminal sites is divided into subsets using recursive division. These subsets contain three, four or five vertices in each set. The optimal Steiner tree length and topology for each subset are calculated using an exponential time exact algorithm that now takes constant time. All the primary bridges between the small trees have been tried to find the best ones. The search for the best secondary bridges is in progress. The cycles will lead to the best topology.

■ ME-12

Monday, 16:00-17:30 - Room 004

Graphs and Networks IV

Stream: Graphs and Networks
Invited session
Chair: *Chunhui Lai*

1 - Calculating the Network Complexity Index in Directed Acyclic Networks
Bajis Dodin

Directed Acyclic Networks (DANs), known also as diagrams, such as project networks, are useful models for many decision problems. Analysis and optimization methods of these models require the determination of the number of paths, criticality of the activities/links, and complexity index of such DANs. In this paper, procedures are developed to calculate these quantities for any DAN in a linear order of the number of nodes, O(N), where N is the number of nodes in an Activity-on-Arc representation of the DAN. Computational work is provided to illustrate the proposed procedure.

2 - A New Technique of Embedding of Binary Trees into Hypercubes
Kamal Kabyl, Abdelhafid Berrachedi

The study of embedding of trees in the hypercube has received much interest these later years. The problem consists of giving the smallest dimension of the hypercube in which a given tree T is embeddable. In this paper, we derive a new technique for the determination of the cubical dimension of several families of binary trees. Furthermore, by using this technique we prove that several balanced binary trees satisfy the conjecture of Havel which states that every balanced binary tree with 2 to the power of n vertices is embeddable in the hypercube of dimension n.

3 - Chordal-(k,l) and Strongly Chordal-(k,l) Graph Sandwich Problems
Sulamita Klein, Fernanda Couto, Luerbio Faria, Sylvain Gravier

In this paper we classify the complexity of graph sandwich problems when property phi is to be a (strongly) chordal-(k,l)-graph, for all k, l. We prove that strongly chordal-(0,k), k at least 3 and strongly chordal-(k,l), for k, l at least 1, graph sandwich problems are NP-complete. We also prove the NP-completeness for chordal-(0,k), k at least 3 and chordal-(k,l), k at least 1,l at least 2 and for k at least 2, l at least 1 graph sandwich problems. Moreover, we prove in P: chordal-(0,k), chordal-(k,0), strongly chordal-(0,k) and strongly chordal-(k,0) graph sandwich problems for k=1,2.

4 - Some Problems on Paths and Cycles
Chunhui Lai

In 1976, Thomassen conjectured that every longest cycle in a 3-connected graph has a chord. In 1979, Kotzig conjectured that there exists no graph in which each pair of vertices is connected by a unique path of length k (larger than or equal to 3). In this talk, some results on these problems and related conjectures are summarized.

■ ME-13

Monday, 16:00-17:30 - Room 123

Project Scheduling 1

Stream: Scheduling
Invited session
Chair: *Carlos Cardonha*

1 - Project Scheduling using Buffers under Consideration of Psychological Effects of Cutting Down the Original Estimations
Dorota Kuchta

Each time we are dealing with project scheduling we are facing psychological problems with time estimations and their relevance to future actual activity realization times. Sometimes the estimations given by future activity executors are cut down by project managers, sometime left unchanged. The advocators of cutting them down attach a importance to the so-called student effect, causing that the work is delayed until the activity completion deadline is very close, independently of how far in time this deadline has been set. In this paper the estimations of activities duration are modeled.

2 - Robust Project Scheduling at a Large IT Services Delivery Organization
Elvin Coban, Aliza R. Heching, John N. Hooker, Alan Scheller-Wolf

We consider a practical project scheduling problem at a large IT services delivery organization with cross-trained employees, heterogeneous projects, schedule disruptions, and service quality guarantees. Durations of subtasks, disruptions, and project arrival times are uncertain. Our goal is to identify an effective scheduling of project subtasks and assignments to each employee. We capture uncertainties in a robust scheduling model by uncertainty sets using logic-based Benders decomposition.

3 - A Framework of Project Management Methods to use the Resource-Constrained Project Scheduling Problem
Shruthi S Kumar

The resource-constrained project scheduling problem (RCPSP) has been studied and improved for decades now. Nevertheless, applied resource scheduling has still been identified as one of the most occurred planning problems in project management. In this talk we will present a framework of management methods for a structured determination of the formal optimization model parameters out of unstructured management information. Based on a case study we will show how this framework can be extended to support also a more advanced versions of the RCPSP with flexible resource profiles.

4 - The Online Resource Constrained Project Scheduling Problem with Bounded Multitasking
Carlos Cardonha, Ricardo Herrmann, Victor Cavalcante

The Resource Constrained Project Scheduling Problem with Bounded Multitasking (RCPSPBM) is about the assignment of service requests to analysts with varying levels of expertise and bounded multitasking capacity. An optimal scheduling plan minimizes penalties originated from due dates violations and cognitive overheads, which occur whenever analysts work on two or more requests simultaneously. We propose a MILP-based algorithm for the online version of the RCPSPBM and show with the support of computational experiments on real-world scenarios that it outperforms algorithms currently in use.

■ ME-14
Monday, 16:00-17:30 - Room 124

DEA in Health and Education

Stream: DEA Applications
Contributed session
Chair: *Carla Amado*

1 - Analysis of Technical Efficiency and Scale using Time Series in Higher Education Institutions by Means of Window Analysis DEA
Gonzalo Eduardo Campos Hernández, Marcela Gonzalez-Araya

Today the concern of most advanced countries to improve the efficiency and effectiveness of the Universities is evident. In Chile, this topic is not properly studied. This paper develops a new method that assesses the evolution of technical efficiency and scale of a Chilean university, through a time series (nine years). Three methods for selecting variables over time, which led to better discriminate the DMUs in the study period were created. Then DEA Window Analysis models, CCR and BCC, were applied, both with output, considering the efficiencies of scale and technological change (IPM).

2 - A Comparative Analysis of the Treatment of Chronic Obstructive Pulmonary Disease Episodes
Maria Portela, Emmanuel Thanassoulis, Mike Graveney, Mike Graveney

Chronic obstructive pulmonary disease (COPD) is characterized by a largely irreversible obstruction of the airways, and is one of the leading causes of chronic morbidity and mortality worldwide. This paper investigates the efficiency of hospitals in handling this disease, through an analysis of 900 episodes pertaining to 500 patients. This analysis compares the length of stay of episodes, when the medical conditions of the patient are accounted for through some surrogate measures. DEA is used in this comparison exercise, through a non-oriented model.

3 - Assessing the Effectiveness of Noncommunicable Diseases Prevention and Control Using Data Envelopment Analysis: An International Comparison
Carla Amado, Sérgio Santos, Ana Cristina Nascimento

Noncommunicable diseases (NCDs) are leading causes of death worldwide. For policymakers the prevention and control of these diseases is fundamental to ensure an effective management of healthcare systems. The main purpose of this paper is to explore the potential of using Data Envelopment Analysis (DEA) to assess the effectiveness of healthcare systems in preventing and controlling NCDs. To this purpose, data from 27 OECD countries has been used. Our results demonstrate the potential strategic role of DEA for an effective use of the available resources in NCDs prevention and control.

4 - Benchmarking Portuguese Hospitals through a web based Platform (HOBE)
Ana Camanho, Maria Portela, Diogo Borges, Luiz Lopes, Sofia Silva, Ricardo A. S. Castro

This paper describes an internet platform, called HOBE, which compares public hospitals in Portugal. The platform allows benchmarking hospital services from a managerial perspective. Aggregate performance indicators are constructed for hospital services based on Data Envelopment Analysis cost models. Aggregate hospital efficiency is also addressed, where we propose a model to aggregate the performance of a set of hospital services into a single performance measure at the hospital level. Some results are presented for the trial years of 2008 and 2009.

■ ME-15
Monday, 16:00-17:30 - Room 125

Pricing and Strategic Consumer Behavior in Revenue Management

Stream: Revenue Management II
Invited session
Chair: *Rachel Zhang*
Chair: *Shining Wu*

1 - Pricing of Conditional Upgrades in the Presence of Strategic Consumers
Izak Duenyas, Yao Cui, Ozge Sahin

In this paper, we study a conditional upgrade strategy that has recently become very common in the travel industry. After a consumer makes a reservation for a product (e.g. a hotel room), she is asked whether she would like to upgrade her product to a more expensive one at a discounted price. We analytically analyze this policy and identify when offering such conditional upgrades can be beneficial for the firm and how to set prices for the conditional upgrade. Our results indicate offering conditional upgrades can compensate for a firm's lack of ability to set its prices optimally.

2 - Price Drop Guarantee in the Context of Limited Inventory
Dinah Cohen-Vernik, Amit Pazgal

Have you ever purchased an item only to notice a short while later that its priced has dropped? Many retailers (e.g. Amazon, Best Buy, Neiman Marcus) offer customers to refund the price difference if the price drop occurs within a specified period of time. Despite the popularity of such policy, the scope of existing research is surprisingly limited. In this paper we develop analytical multi-period model to analyze price drop guarantee policy in the context of limited inventory, and allow the retailers to choose the optimal percentage of refund, contrary to a common assumption of a full refund.

3 - The Reference Effects on a Firm's Dynamic Pricing and Inventory Strategies with Strategic Consumers
Shining Wu, Rachel Zhang, Qian Liu

We consider a retailer that sells the same or different versions of the product season after season. At the beginning of each season (stage 1), the firm places an order and sells the product at the full price. As the sales unfold, the firm has an opportunity to mark down the price (stage 2) to match supply with demand. However, the retailer's markdown strategies in past seasons give strategic consumers an incentive to time their purchases in future seasons. We characterize the properties of the optimal ordering and markdown decisions and show some interesting properties of the decisions.

■ ME-16

Monday, 16:00-17:30 - Room 127

Copositive and Polynomial Optimization IV

Stream: Copositive and Polynomial Optimization
Invited session
Chair: *Cordian Riener*

1 - A Semidefinite Hierarchy for Containment of Spectrahedra
Kai Kellner, Thorsten Theobald, Christian Trabandt

We study the computational question of whether a given spectrahedron (or polytope) is contained in another one. To overcome the situation that the containment problem for spectrahedra is co-NP-hard, relaxation techniques are of particular interest. Based on a reformulation as a polynomial optimization problem, we provide a hierarchy of sufficient semidefinite criteria for the containment problem. The hierarchy is at least as powerful as existing criteria for containment. Finally, we demonstrate the effectiveness of the approach by providing numerical results.

2 - Counting Arithmetic Progressions using Semidefinite Programming
Erik Sjöland

One of the most challenging problems in Ramsey theory is to count the minimal number of monochromatic arithmetic progressions in a group colored in c colors. Based on Putinar's positivstellensatz it is possible to rewrite the problem as a semidefinite program. Inspired by methods developed by Klerk, Pasechnik and Schrijver we reduce the size of the problem by understanding its symmetries. The approach is applicable for any group, including non-abelian groups. We present novel results for several infinite families of groups.

3 - Linear Matrix Inequalities and Spectrahedra in the Plane
Daniel Plaumann

We study the problem of characterising the plane spectrahedra, which are the convex semialgebraic subsets of the real plane described by linear matrix inequalities and therefore the two-dimensional domains of semidefinite programs. We present an approach to compute such descriptions numerically via polynomial homotopy continuation methods. (Based on joint work with Anton Leykin)

■ ME-17

Monday, 16:00-17:30 - Room 005

Global Optimization and Applications in Development III

Stream: Global Optimization
Invited session
Chair: *Herman Mawengkang*
Chair: *Gerhard-Wilhelm Weber*

1 - An Interactive Approach for Solving Sustainable Production Planning Model of Crude Palm Oil Industry
Hendaru Sadyadharma, Herman Mawengkang

Despite obvious benefits of crude palm oil industry for economic development, it contributes to environmental degredation. This paper addresses a multi-objective stochastic programming model of the sustainable production planning of crude palm oil. The model takes into account conflicting goals such as return, financial risk and environmental costs. The uncertainty comes from the price of crude palm oil. At the start, two single objective models are formulated: a maximum expected return model and a minimum financial risk (pollution penalties) model.

2 - An Optimization Model for River Water Quality Problem
Syafari Syafari

Rivers water quality is increasingly under threat from different pollutants, which include conventional pollutants (organic matter and inorganic nutrients) and hazardous substances (organic contaminants and heavy metals). In this paper dynamic integrated modelling of basic water quality and organic contaminant fate and effect in rivers are explored. A basic river water quality model and organic contaminant submodel were developed as an optimization problem and then linked in order to estimate the wastewater removal efficiencies for discharge site.

3 - An Improved Iterative Approach for Incomplete Dependent Variables
Sampe Simangunsong, Herman Mawengkang

It is common in some applications that we encounter missing data problems. Standard ad hoc missing value imputation methods invariably fail to deliver efficient and unbiased parameter estimates. The typical imputation approach is to assume the blank fields take some ad hoc (subjective) value. However, this approach fails to deliver efficient and unbiased parameter estimates. This paper proposes an improved iterative maximum likelihood based procedure to impute 'most likely' values for the missing data. This approach could generate fitted values for the missing data.

4 - An Improved Direct Search Method for Solving Land use Management Problems
Suryati Sitepu, Siti Rusdiana, Herman Mawengkang

Land is used to meet a multiplicity and variety of human needs and to serve numerous, diverse purposes. Our study is focused finding an optimal land/resources portfolio composition through time, in the presence of future market uncertainty. In this paper we formulate a mixed-integer nonlinear programming model, which takes into account the market value of revenues accruing from the land in different states. In order to take into account the non-constant incremental benefits accruing from different land allocations. This model is applied to land management problem in Banda Aceh, Indonesia.

■ ME-18

Monday, 16:00-17:30 - Room 112

Surrogate-Assisted Multiobjective Optimization II

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Jussi Hakanen*

1 - Parallel Hybrid Multiobjective Derivative-Free Optimization in SAS
Steven Gardner, Joshua Griffin

We present enhancements to a SAS high performance procedure for solving multiobjective optimization problems in a parallel environment. The procedure, originally designed as a derivative-free solver for mixed-integer nonlinear black-box single objective optimization, has now been extended for multiobjective problems. In the multiobjective case the procedure returns an approximate Pareto-optimal set of nondominated solutions to the user. We will discuss the software architecture and algorithmic changes made to support multiobjective optimization and provide numerical results.

2 - A Simple Framework for Parallel Multi-Objective Optimization using JAVA
F. Antonio Medrano, Richard Church

Solving multi-objective combinatorial optimization problems can quickly become computationally intractable when applied to big data. Top MIP solvers have parallelism built-in, but specialized solution algorithms are typically programmed serially. Java 7 provides a new concurrency package that allows for simple conversion of a serial algorithm to parallel, which is particularly well suited to approaches for finding the supported Pareto front of a multi-objective optimization problem. These methods, along with extensions for also finding unsupported Pareto solutions, are discussed.

3 - Multiobjective Emergency Room Capacity Planning using Simulation Goal Programming and Response Surface Methodology
Felipe Baesler, Oscar Cornejo

This paper presents the results of a real life emergency room case study in Chile that was modelled using discrete event simulation. The objective was to find the best combination of human and physical resources that are necessary for an expansion of 40% in demand, maintaining the current patient's waiting time. Four different objectives were considered in the analysis using a goal programming optimization model. This model was used in combination with response surface methodology to perform an optimization iterative process and determine the best combination of resources.

4 - A Globally Convergent Method for Approximating the Pareto Critical Set of a Multiobjective Optimization Problem with any Number of Objectives
Markus Hartikainen, Alberto Lovison

In the 1970s, Prof. S. Smale combined dynamical systems and multiobjective optimization to define the Pareto critical set (a generalization of the critical point in calculus) and to extend the Morse's theory to vector functions. Using these ideas, a global convergence criterion based on the Hausdorff distance for approximation of the Pareto critical set was proposed in 2013 along with a globally convergent method for bi-objective optimization problems. Now, we present a new globally convergent method for multiobjective optimization problems under a suitable Lipschitz condition.

■ ME-19

Monday, 16:00-17:30 - Room 128

Retail Distribution and Replenishment

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Thomas Wensing*

1 - Multi-product Joint Replenishment Model with Substitution
Mohamed Kharbeche, Bacel Maddah, Shaligram Pokharel, Ahmed Ghoniem

We propose a novel model for the joint replenishment model with substitution for multiple products. For fast moving consumer goods that have a relatively deterministic demand, we determine the ordering quantities for each product taking into consideration substitution between them. In particular, once the demand is partially met and the total cost associated with the delivery, holding, and shortage of the products is minimized, we show that substitution between products saves in the fixed ordering cost and the holding cost. (Acknowledgement: Qatar/QNRF/NPRP Project: NPRP 5-591-5-082)

2 - Impact of Case Pack Sizes on Retail Instore Logistics Systems
Heinrich Kuhn, Michael Sternbeck, Thomas Wensing

Case pack sizes influence the performance of retail instore logistics systems in several ways: They put a constraint on the possible replenishment doctrine and thus pre-determine inventory levels and order quantities, they cause efforts for searching and picking when the shelf is stocked, and finally, they may cause additional handling efforts if there are excess items that do not fit onto the shelf. We present a Markov chain model to analyze the impact of case pack sizes on the performance of instore logistics. We illustrate scope and benefits on basis of a real world data set.

3 - Assignment of Transport Jobs to Multiple Contract Carriers
Thomas Wensing

A manufacturing company employs multiple carriers to ship their goods from storage points to the customers. Each carrier is contracted to handle a certain percentage of the total transport volume within a larger time span, e.g., a month. We examine the problem of assigning transport jobs on a daily basis so that the long-term percentages are satisfied as good as possible in various dimensions, e.g. revenue, mileage, number of stops. The problem is closely related to the agent bottleneck generalized assignment problem. We examine runtimes and solution quality on basis of real-world data sets.

■ ME-20

Monday, 16:00-17:30 - Room 129

Managing Risk in Energy Storage and Trading

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Nils Löhndorf*

1 - Risk-Sensitive Gas Storage Valuation under a Price Process with Long and Short term Dynamics
Nils Löhndorf, David Wozabal

We consider the problem of gas storage valuation under a Schwartz-Smith two-factor gas price process where risk is controlled by the conditional value at risk (CVaR). To solve the stochastic-dynamic decision problem, we propose an approach based on approximate dual dynamic programming that combines efficient discretization of the price process with learning the optimal policy. We then compare the stochastic value of storage with the (rolling) intrinsic value, study the influence of the CVaR on profit distribution and policy, and discuss the effect of time granularity on the value of storage.

2 - Quantile Optimization in Electricity Trading in the Presence of Storage with Heavy-Tailed Prices
Ricardo Collado, Warren Powell, Jae Ho Kim

We consider the problem of electricity trading in the presence of storage, where electricity prices are heavy-tailed with infinite variance. In this case traditional stochastic dynamic models relying on optimizing the expectation fail. Instead, we propose a quantile optimization model that avoids many of the pitfalls of expectations in a heavy-tailed environment. To cope with this, we develop a provably convergent algorithm for computing the quantile of a continuous random variable that does not require the existence of expectation or storing all of the sample realizations.

3 - Bidding Strategies in Electricity Markets with Long and Short Term Objectives
Enrique Munoz de Cote

We present ColdPower, an autonomous energy retailer (broker agent) in a smart grid environment whose task is to provide energy to consumers through tariff offerings, and then manage its consumer portfolio loads by trading in a wholesale market. The main focus of this work is on the broker's bidding strategy in the day-ahead (wholesale) market. In particular, we formulate the problem as a Markov decision process with a three-fold objective: i) to buy energy in the wholesale market at low prices (long-term objective), ii) satisfy energy demands (short-term objective) and iii) balance supply.

4 - Models for Optimizing Market Bids from Hydroelectric River Chains
Faisal Wahid, J. Frederic Bonnans, Andy Philpott

We consider the problem of offering energy to an electricity market from a chain of hydroelectric generation plants with a single operator, but situated on a cascaded river system. In each trading period, the offers with prices below the market clearing price are dispatched and paid at that clearing price. We consider the multiple period and plant problem in uncertain reservoir inflows and prices. This can be approximated as a linear stochastic control problem and solved through ADP and SDDP methods. We will present some simple models with examples of how these can be applied.

■ ME-21

Monday, 16:00-17:30 - Room 006

Optimization Modeling Applications in Air Transportation

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *Kaan Aliefendioğlu*

1 - Operations Research Air Traffic Management (ATM) of the Future: A Support System for Free Flight Concept
Charis Ntakolia, John Coletsos

We transform the ATM system from 'airport' to 'airplane' centered by developing a mathematical model in order to: (i) support free flight concept, (ii) prioritize airline preferences, (iii) distribute fairly groundholdings and air delays, (iv) relax the existing distance limits between airplanes since the human factor has been annihilated, (v) increase air sectors' capacity, (vi) avoid congestions and adverse weather, and (vii) increase safety and efficiency. The formulation aids to decrease computational efforts and problem's complexity, and to increase decision making flexibility.

2 - Robust Operation Model for Airline Ticket Distribution Channels with Uncertian Market Demands
Rong HU

Airlines are attempting to shift consumers from traditional booking channels to more cost-effictive online channel. The paper develops a robust operation model of airline ticket distribution channels with uncertain market demands in traditional and online channels. What airlines pursue is to minimize the total channels cost. Uncertain demands are expressed as a scenario set with given probability, and the robust operation model is set up by using the robust optimization based on scenario analysis. The results showed that the model proposed is robust to uncertain demands by a numerical example.

3 - A Mathematical Programming Approach to Aircraft Maintenance Scheduling
Kaan Aliefendioğlu, Fadime Üney-Yüksektepe

Aircraft maintenance scheduling is a complex problem with hard restrictions and a changeable environment. In this study, a mathematical programming based approach is proposed to solve a real-life problem of Turkish Technic. Using past data, different scenario analyses are performed to test the accuracy and applicability of the developed model. In conclusion, a convenient method will be suggested to the companies to efficiently plan their aircraft maintenance.

■ ME-22

Monday, 16:00-17:30 - Room 007

Machine Learning in Healthcare

Stream: Health Care Data Analytics
Invited session
Chair: *Samuel Buttrey*

1 - Application of an HIV Risk Scorecard Model to Track Changes in Risk Profile of Demographic Characteristics using Antenatal HIV Seroprevalence from 2001 to 2010
Wilbert Sibanda, Philip Pretorius

A thorough understanding of causal relations based on antenatal HIV seroprevalence data is paramount to the elucidation of HIV/AIDS mechanism and disease etiologies. The antenatal data obtained from each pregnant woman contains a number of demographic characteristics. In this research we aim to develop HIV risk scorecards for each year from 2001 to 2010 to investigate the changes in weights-of-evidence and information values as measures of risk of acquiring an HIV infection. This work is based on the research supported by the National Research Foundation of South Africa (Grant no. 86946).

2 - Data Mining Application for Blood Consumption Forecasting in a Private Hospital
Saliha Karadayı, Aydın Tanrıverdi

Both the available huge amount of data and the urgent need of extracting a meaningful knowledge have increased the data mining's importance. In the recent studies, the data mining healthcare applications have become more of an issue owing to the healthcare activities' own vital significance such as immediate blood inventory requirements in hospitals. In this study, we investigated the hospitals' blood bank demands in order to forecast the successor blood consumptions. According to this blood consumption prediction, we generated three and six months plans by using dynamic programming.

3 - Correlating Influenza Prevalence with Twitter Mentions of Flu
Samuel Buttrey

The Twitter micro-blogging service generates hundreds of millions of messages a day. In this paper, we examine a 1% sample of Twitter messages for incidence of the words "flu" or "influenza" in English-language messages originating in the United States. This incidence rate is compared to the actual prevalence of flu as reported by the Centers for Disease Control.

Our sample of about 18 months of data occupies thousands of files and requires on the order of 10TB of disk space. Some of the practical difficulties associated with handling and analyzing data of this magnitude are addressed.

4 - Precipitation Prediction by Hidden Markov Models
Inci Batmaz, Nevin Sivrikaya, Ceyda Yazici, Ceylan Yozgatligil

Recently, we have been experiencing extreme weather events such as floods or droughts frequently because the climate change is in effect. As a result, precipitation forecasting has become important matter for both managing water resources efficiently and preventing disasters beforehand. There exist several forecasting methods used for this purpose such as regression models, time series models, neural networks and MARS. In this study, we propose to use Hidden Markov Models (HMMs) to developed precipitation models for the case of Turkish data.

■ ME-23

Monday, 16:00-17:30 - Room 008

Behavioural Issues in Modeling and Simulation

Stream: Behavioural Operational Research
Invited session
Chair: *Stewart Robinson*

1 - Models, Optimality, Experts and Alternatives
Julian Scott Yeomans

Optimization models remain a core tenet of "hard" OR. In real-world mathematical programming applications, some researchers point to expert modellers' innate feel in solving problems, while others highlight that modellers are frequently ignorant of their own ignorance. Can these diametrically competing perspectives be effectively reconciled so that OR modelling can remain central to supporting the decision-making process? One practical approach is modelling-to-generate-alternatives (MGA). In MGA, numerous alternatives that provide very disparate perspectives to the problem are created.

2 - Learning from Discrete-Event Simulation: Exploring the High Involvement Hypothesis
Tom Monks, Stewart Robinson, Kathy Kotiadis

We detail a laboratory experiment to test learning in discrete-event simulation studies, identify mechanisms that explain how involvement in model building or model reuse affect learning and explore the factors that inhibit learning from models. Measurement of learning focuses on the management of resource utilisation in a case study of a hospital emergency department and through the choice of scenarios during experimentation. Findings suggest that there may be a learning trade-off between model reuse and model building when simulation projects have a fixed budget of time.

3 - Generating Insights: Experimental Study on the Effectiveness of Simulation Models in Creative Problem Solving
Anastasia Gogi, Antuela Tako, Stewart Robinson

There is no empirical evidence to support claims that simulation models are beneficial in generating insight. A laboratory experiment is designed to examine which features of Visual Interactive Modelling and Simulation, animation, statistics or none, support insight generation. The task requires participants to find solutions to a model of the UK's NHS111 service, a telephone service for urgent health care. Performance is measured based on whether insights occurs and the time taken. This research contributes towards a better understanding of how simulation models support decision-making.

4 - Impacts of Mobile Internet on Customer Behavior
Yubo Chen, Liu Yang

In this paper we study how mobile internet affects customer behavior. The fast growing mobile internet is becoming a driving force to shift the marketplace. Based on the data from a leading Chinese online retailer, we investigate how mobile internet influences customer engagement and purchase behaviors in the online markets.

■ ME-24

Monday, 16:00-17:30 - Room 212

Preference Learning IV

Stream: Preference Learning
Invited session
Chair:
Chair: *Michael Rademaker*

1 - Checking Classifiers Sensitivity to Non-Monotone Noise
Irena Milstein, Arie Ben David, Rob Potharst

Dealing with noisy data sets is a major concern in data mining, and monotone classifiers are no exception. Since there have been no comprehensive reports so far about the sensitivity of monotone and non-monotone classifiers to non-monotone noise, we have developed a novel algorithm which generates monotone data sets with varying levels of non-monotone noise. Using these data sets we check the effects of this type of noise on the accuracy of several well known classifiers. The accuracy is measured by different metrics, like accuracy, Cohen's Kappa, and the area under the ROC curve.

2 - Alternative Decomposition Techniques for Label Ranking
Massimo Gurrieri, Philippe Fortemps, Xavier Siebert

In this work we propose some alternative reduction techniques for label ranking that, similarly to the standard reduction technique, decompose the original problem into binary classification related to pairs of labels. The proposed reductions aim at taking into account label correlations during the learning process to improve the classification performance, while limiting computational complexity.

3 - Efficient Label Tree Structures for Top-k Classification
Krzysztof Dembczynski, Arkadiusz Jachnik

In many multi-class classification problems we are interested not only in the most probable class, but also in the list of top k classes. For example, the information or image retrieval systems usually present a list of the most relevant documents or images. Since many of the modern classification applications concern thousands or even hundred thousands of classes, we need to rely on fast algorithms for these problems. Label tree classifiers belong to the most efficient approaches. We discuss in the talk how this approach can be used for delivering the top-k class predictions.

4 - Looking for the Right Noise: A Decision Rule as a Maximum Likelihood Estimator.
Michael Rademaker, Bernard De Baets

More than 200 years ago, Condorcet examined voting rules as maximum likelihood estimators, for a specific noise function in the setting of a limited number of candidates. Almost 20 years ago, Young extended his work to an arbitrary number of candidates, identifying Kemeny's method as the solution. We will examine a voting rule based on stochastic dominance from this perspective. This will be done by attempting to construct a noise model for which the rule is a maximum likelihood estimator. If such a noise model can be constructed, we will assess whether it can be considered reasonable.

■ ME-25

Monday, 16:00-17:30 - Room 009

Optimization and Mathematical Economics

Stream: Mathematical Economics
Invited session
Chair: *Maria Carmela Ceparano*

1 - Methods of the Parametric Control Theory for Testing Mathematical Models of Macroeconomic Systems
Abdykappar Ashimov, Yuriy Borovskiy

Within the framework of solving the problem of verification of mathematical models the paper for the first time proposes an algorithm for testing macroeconomic models for the possibility of their practical application including methods for estimating: (i) structural stability of dynamical model, (ii) values of stability indicators of the mapping defined by model & (iii) stability of the differentiable mapping defined by model. There are presented examples of testing of (econometric, computable general equilibrium, dynamic stochastic general equilibrium) models based on proposed algorithm.

2 - On Vertical Separated Equilibrium for Two-Stage possibly Discontinuous Games
Maria Carmela Ceparano

We consider a multi-leader multi-follower game in which the strategy of each leader is not common knowledge among all agents, for instance when leader manufacturers delegate the sale through exclusive retailers. A selection of Nash equilibria, based on a belief (passive belief) that each follower has about the strategy of the other leaders, is investigated. Properties of the equilibria are presented under conditions of minimal character, in particular results of existence and stability under perturbations on the data, both in uncoupled and coupled constraint cases.

3 - An Interior-Point Path-Following Method for Computing Perfect d-Proper Equilibria for Strategic Games
Chuangyin Dang

The perfect d-proper equilibrium is a strict refinement of perfect equilibrium for strategic games, whose degree of properness is controlled by d. To determine such an equilbrium, an interior-point path-following method is developed in this paper. The method is derived from a close approximation to a perturbed game through an appropriate convex combination of payoff function and a barrier term. It is shown that there exists a smooth path starting from a totally mixed startegy profile and ending at a perfect d-proper equibrium. Numerical results show that the method is effective and efficient.

4 - Eigenbehaviors in Closed Economies: General Economic Equilibrium Constructive Proof
Gabriel Turbay

Considering the world economy as a closed system and based on von Foerster cybernetic principle that eigenbehaviors emerge in operationally closed systems, we use Krilov sequences to exhibit the dynamic feedback price formation processes. Eigenvectors convergence with equilibrium and resilience properties is shown and a general equilibrium constructive proof is given. Game theory views are presented to explain fluctuations around the eigen-prices, thus interrelating macroeconomic structural price formation with microeconomic supply-demand price determination processes.

■ ME-26

Monday, 16:00-17:30 - Room 010

Fuzzy Decision Making 1

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Jaroslav Ramik*
Chair: *Martin Gavalec*

1 - On Geometric Mean Generated Weights in Interval AHP
Jiri Mazurek

Since 1980s the analytic hierarchy process (AHP) became the standard tool for a group and multiple criteria decision making. When an uncertainty is present in a decision making interval or fuzzy AHP is often considered. The aim of this paper is to propose a new method for interval AHP. In the proposed method weights of alternatives (criteria) are estimated by an interval generalization of the geometric mean, and for the final ranking of alternatives a formula based on a possibility measure is employed. The proposed method is computationally simple and its use is demonstrated on examples.

2 - Aggregation of Pairwise Comparison Matrices by Fuzzification
Zuzana Kiszova

The paper deals with the problem of aggregation of individual preferences into one consistent and acceptable group decision which will reflect standpoints of all concerned subjects. A new way of aggregation by means of fuzzification of individual pairwise comparison matrices and subsequent finding of solution by ordering fuzzy numbers is proposed. An illustrative example is attached.

3 - Microsoft Excel as a Tool for Multicriteria Decision Problems
Radomir Perzina, Jaroslav Ramik

This paper introduces a Microsoft Excel add-in called DAME - Decision Analysis Module for Excel. The add-in is free, can work with scenarios or multiple decision makers, allows for easy manipulation with data, offers instant calculations and utilizes capabilities of Microsoft Excel. Decision models can be structured into three levels — scenarios/users, criteria and variants. Various methods for the evaluation of the weights with multiplicative and additive syntheses are supported. The proposed module will be demonstrated on couple of illustrating examples of real life decision problems.

4 - Pairwise Comparison Matrix with Fuzzy Elements on Alo-Group
Jaroslav Ramik

This contribution is aimed on pairwise comparison (PC) matrices with fuzzy elements. We deal with PC matrices with elements from the alo-group over a real interval. Such an approach allows for a generalization dealing with additive, multiplicative and fuzzy PC matrices with fuzzy elements. Moreover, we deal with the problem of measuring the inconsistency of fuzzy PC matrices by defining corresponding indexes. Numerical examples are presented to illustrate the concepts and derived properties.

■ ME-27

Monday, 16:00-17:30 - Room 213

Simulation and Numerical Methods in Finance

Stream: Simulation Methods in Finance
Invited session
Chair: *Katerina Papadaki*
Chair: *Gerhard-Wilhelm Weber*

1 - No-Arbitrage ROM Simulation
Michael Hanke

Random orthogonal matrix (ROM) simulation efficiently generates multivariate samples matching means and covariances exactly. We enhance this method by focusing on applications requiring simulated returns to be free of arbitrage. We analytically derive no-arbitrage bounds for expected excess returns to be used in ROM simulations, and establish the theoretical relation between the number of samples and (no-)arbitrage regions. The new algorithm generates arbitrage-free returns by purposefully rotating a simplex. http://ssrn.com/abstract=2039922

2 - Quantile Optimization via SNM-Q
Kuo-Hao Chang

Stochastic Nelder-Mead simplex method (SNM) is a newly-developed direct-search method for simulation optimization. Because SNM does not require gradient information and has provable convergence property, it is applicable to many practical problems. In this paper, we extend the framework of SNM to enable it to handle quantile-based simulation optimization problems. We prove that the modified SNM, called SNM-Q, can converge to the true global optimum w.p.1. Numerical experiments show that the efficiency of SNM-Q is satisfactory and is worth further investigation.

3 - Stochastic Dynamic Programming Methods for the Portfolio Selection Problem
Katerina Papadaki

We formulate the multistage portfolio selection problem with 100 assets as a dynamic program and solve it using approximate dynamic programming (ADP) methods. We implement linear and piecewise linear approximations for the value functions. Extensive simulations are performed using equity data from the FTSE 100 index, where the ADP methods are evaluated and compared out-of-sample against the market, the equally-weighted portfolio, a single-period portfolio and the multistage stochastic programming method. Simulation results are provided and some very interesting conclusions are drawn.

4 - A Multistage Linear Stochastic Programming Model for Optimal Corporate Debt Management
Davi Valladão, Alvaro Veiga, Geraldo Veiga

Large corporations fund their capital and operational expenses by issuing bonds with a variety of indexations, denominations, maturities and amortization schedules. We propose a multistage linear stochastic programming model that optimizes bond issuance by minimizing the mean funding cost while keeping leverage under control and insolvency risk at an acceptable level. Based on the proposed model, a financial planning tool has been implemented and deployed for Brazilian oil company Petrobras.

■ ME-29

Monday, 16:00-17:30 - Room 011

Multiple Criteria Decision Making and Optimization 1

Stream: Multiple-Criteria Decision Making and Optimization
Contributed session
Chair: *Hwai-En Tseng*

1 - A Multi Objective Decision Making Approach for Determining New Sorting Technology in Order Picking Systems
Nihan Topuk, Rifat Gürcan Özdemir

This study addresses a decision problem on adoption of a new sorting technology for picker-to-goods order picking systems. A multi objective mathematical model is developed to compare the performance of existing and the new technologies with respect to operational costs and picking time. The formulation considers shelf assignment for items delivered from plants and determining order picking process for a given sorting technology. This study also presents a heuristic search algorithm for solving the developed formulation. The proposed approach is implemented for a logistic company in Turkey.

2 - A Multicriteria Ranking Procedure for a Medium-Sized Set of Alternatives based on Evolutionary Multiobjective Optimization
Jaime Solano, Juan Carlos Leyva-Lopez, Diego Alonso Gastélum Chavira

The aim of this paper is to present an approach to solve the multicriteria ranking problem with a medium-sized set of alternatives. Using a new heuristic based on multiobjective evolutionary algorithms, a known valued outranking relation is exploited and then a ranking recommendation is constructed. An empirical study over different hypothetical medium-sized problems is presented. The results indicate that the proposed approach can effectively be used to solve medium-sized multicriteria ranking problems.

3 - A Combined AHP-based Approach for Evaluating and Ranking Economic Partners in a Public Organism
Kamal Hariche, Djamila Boukredera, Mohamed Salah, Rabah Kassa

Selecting potential economic partners is a very important decision in a public organism. Several methods have been used to solve this problem but most attention has been paid to the final choice phase in this process. This paper aims to propose a combined approach using AHP, centroid and L2 metric methods which integrates the required steps in the screening process while considering both qualitative and quantitative criteria that affect the partners' ranking. This allows decision-makers to reduce the large list of potential partners to a manageable number and make the best final choice.

4 - Customization Order Screening in Engineering-to-Order Environment
Hwai-En Tseng

In the engineering-to-order environment exist large differences in product specifications leading to business loss. In the study, the author attempt to set order screening mechanisms at the order taking stage. The Fuzzy Suitable Index is proposed to assess the feasibility of order. Moreover, the Utility Similarity is adopted to distinguish order levels to eliminate inappropriate orders. After the calculation of costs and delivery, TOPSIS is applied to sort orders according to the corresponding profit allocation ratio. The machine tools are used as an example to illustrate the algorithm.

■ ME-30

Monday, 16:00-17:30 - Room 012

Financial Mathematics 2

Stream: Financial Mathematics and OR
Invited session
Chair: *Norio Hibiki*

1 - Rating Models using Logistic and Cox Regression: Medium and Large Companies Case
Aneta Ptak-Chmielewska, Anna Matuszyk

The purpose of this paper is to answer the questions: Is Cox regression model more effective than logistic one in measuring the company's default risk? What are the main advantages of using the survival models? The accuracy power of these two models is similar. Differences are small and mostly due to the different models' specifications. In Cox regression model the log of turnover (time varying) was significant. The main reason why it is preferred to use the survival model instead of the logistic regression is getting the dynamic picture of modeled events when using the survival approach.

2 - Effects of a Sales Tax Increase on Firm Valuation: DCF Approach to Individual Firm Data
Hitoshi Takehara, Keiichi Kubota

This paper investigates how firm values change by increased sales tax rate. Equity values are estimated based on the residual income model in which we construct pro forma financial statements. We find that an increase in sales tax rates decreases equity values for a majority of firms, but not necessarily all firms. An additional corporate tax rate cut helps increase the equity value for a majority of firms. The trade-off relationship of a sales tax rate hike and a corporate tax rate reduction is subtle, but the mix helps increase equity value of firms overall.

3 - Portfolio Selection Based on Bayesian Theory
Yong Fang

On the basis of reviewing Markowitz's mean-variance model, the three portfolio selection models are built in the paper, namely the portfolio selection model based on regression analysis, Bayesian-GARCH (1,1) model and BMS-GARCH (1,1) model. We select data from the exchanges, and compare the portfolio selection models. The BMS-GARCH(1,1) model introducing the Markov states is superior to the portfolio selection model based on regression analysis and Bayesian-GARCH (1,1) model.

4 - Multi-Period Stochastic Programming Model for State-Dependent Asset Allocation with CVaR
Norio Hibiki, Shinya Hirano

We need to solve the multi-period optimization model to decide the dynamic investment policy under various practical constraints. Hibiki(2001,2003,2006) develop the hybrid model where the conditional decision can be made in the simulation approach. In this paper, we propose the piecewise linear model for multi-period and state-dependent asset allocation with CVaR. It is possible to describe the piecewise linear function of the investment proportion with respect to the amount of wealth. We solve the problem for multiple assets, and compare the piecewise linear model with the hybrid model.

■ ME-31

Monday, 16:00-17:30 - Room 013

Recent Advances on Decision Processes

Stream: Decision Processes
Invited session
Chair: *Irene Abi-Zeid*

1 - Organizational Knowledge to Support Project Selection Activities in the Public Administration
Maria Franca Norese, Valentina Torta

An investigation was required to analyze how the departments of the Piedmont Region evaluate projects, programs, feasibility studies and various requests for funding from public or private sources. This produced a map of the situation that was used to transfer indications and guidelines to the actors of the project selection process. A decision support system was created using a multi-criteria decision aiding method, ELECTRE Tri. The analysis and its results, in terms of the map and the ELECTRE Tri application to support activities of the public organizations will be presented and discussed.

2 - Integration of Elements from Prospect Theory into PROMETHEE
Nils Lerche, Jutta Geldermann

An enhanced approach for the integration of elements from Prospect Theory into PROMETHEE will be presented. In particular, the effects of reference dependency and loss aversion are incorporated. For this purpose, defining an adequate reference alternative and adjusting the existing preference functions is necessary. The procedure as well as advantages and challenges of the new approach will be illustrated. Furthermore, results from practical applications concerning the sustainable use of biomass for energy generation are discussed.

3 - Monotonic Additive Preference Model for 3D Fusion System Parameters Adjustment
Vincent Cliville, Lionel Valet

3D image interpretation to understand complex phenomenon is achieved thanks to fusion systems having numerous parameters, difficult to adjust. An approximate model is looking for to simulate the 3D fusion process. The problem is described as a ranking problem and three MCDA methods are considered thanks to holistic preference information on a set of reference pictures: The ACUTA method with linear utilities, the ACUTA enriched by the consideration of linearity pieces and the UTA GMS method. Obtained results show the limit of using monotonic additive utilities for such identification problem.

4 - The Value of Additional Information in Multicriteria Decision Analysis with Information Imperfections
Sarah Ben Amor, Kazimierz Zaras, Ernesto Aguayo

In statistical decision analysis, the expected value of information is a well-known concept where the value of information is assessed regarding sources of uncertainty that are normally considered one at a time. This has not been the case for multicriteria decision analysis where several sources of uncertainty in relation to several attributes can be admitted. The Bayesian model is here extended to the context of multicriteria decision analysis with information imperfections (uncertainty, imprecision, . . .) for a pre-assessment of the required resources to obtain additional information.

■ ME-32
Monday, 16:00-17:30 - Room 014

Network Decision Support

Stream: Humanitarian Operations Research
Invited session
Chair: *Erik Kropat*
Chair: *Silja Meyer-Nieberg*
Chair: *Feixiong Liao*

1 - Incorporating Home-Returning and Home-Staying Decisions in Multi-Modal Multi-Activity Trip Chains of Multi-State Supernetworks
Feixiong Liao, Theo Arentze, Harry Timmermans

Multi-state supernetworks have been advanced for modeling individual activity-travel scheduling. Choice of home-returning and -staying is for the first time represented in the multi-state supernetworks. A path through them still represents a consistent activity-travel pattern. An admissible heuristic is developed to reduce the choice alternatives. An earlier proposed bi-criteria label correcting algorithm is adopted to find the optimal activity-travel pattern. Consequently, the trade-off between time expenditure on travel, out-of-home activities and home-staying can be systematically captured.

2 - Sensitivity Analysis for Analytic Network Models
Magda Gabriela Sava, Jerrold May, Luis Vargas

We propose an extension of the sensitivity and stability analysis for analytic network models previously developed. We study simple ANP models to understand how preference regions are created, and characterize their boundaries as the complexity of the network increases. We use optimization methods to find the most suitable boundaries between the preference regions and define the appropriate stability regions.

3 - Modelling of Intermodal Networks
Karl Etlinger, Manfred Gronalt

This work presents an approach to support intermodal network planning and evaluation by providing a framework for terminal location planning and network design. Therefore a mixed integer linear programming model is introduced to optimize the network structure and determine the locations for operating intermodal terminals and the according type of terminal. The model also considers empty container repositioning and optimizes the location of empty container depots in the network. Within our work the developed model is also implemented in a case study for the area of Central and Eastern Europe.

4 - A Heuristic Approach to Restore Road Network Connectivity after a Disaster
Maziar Kasaei Roodsari, Sibel Salman

We study emergency road restoration problem with the aim of reconnecting a disconnected road network in shortest time. A work troop is dispatched to open roads and achieve connectivity. Finding a route with minimum total traversal and road unblocking time is an NP-hard arc routing problem. We develop an MIP formulation and a Variable Neighborhood Descent (VND) heuristic together with constructive heuristics to get good initial solutions. Tests on Istanbul road network and Rural Postman Problem instances in literature show that the proposed algorithm gives near optimal solutions in short time.

■ ME-33
Monday, 16:00-17:30 - Room 015

Measuring and Optimizing Sustainable Behavior in Existing Systems

Stream: Environmental Sustainability in Supply Chain
Invited session
Chair: *Maria Dos Santos*

1 - Optimization of a Two-Echelon City Distribution Network with Cargo Bikes
Alexandra Anderluh, Vera Hemmelmayr, Pamela Nolz

In our project we focus on sustainable inner city goods delivery. We study a distribution problem on two levels, where goods are delivered from the company depot on the outskirts of a city to customers and to satellites. From satellites goods are transshipped to cargo bikes which deliver to customers located in the city center. Hence, we have two types of customers, those receiving a delivery on the first level and those receiving a delivery by cargo bikes on the second level, where synchronization between vans and cargo bikes is needed.

2 - Applying Dynamic, Process-Aware Information Systems to Supply Chain Data Collection
Thomas Bley, Michael Bierkandt, Christian Feick, Andreas Schiffleitner

Manufacturing companies in the automotive and electronics industries are faced with the need to incorporate suppliers into the measurement of their sustainability performance (e.g. for GHG, RoHS, Conflict Minerals). The complex nature of products and globally distributed supply chains implies challenges related to gathering and processing heterogeneous data. Existing information systems are not able to adress these issues. The EU research project SustainHub proposes a sophisticated data exchange platform which supports automated dynamic data collection from heterogeneous sources.

3 - OREG — Optimal Resource Management of Electric and Electronic Devices
Maria Dos Santos, Sepp Eisenriegler, Walter Hauer, Rita Haubenberger-Hahn, Thomas Maier, M. Merstallinger, Harald Reichl, Gottfried Waizinger

The objective of the project is to investigate the re-use potential and the characterization of valuable and hazardous materials in small and big appliances of Waste Electrical and Electronic Equipment (WEEE). Other objectives are to increase the amounts of appliances for re-use purposes, to estimate the device categorization and the material composition as well as develop a re-use container to increase the current amount of WEEE re-used in the observed sites. Fulfilling the objectives will contribute to improve the collection and recycling systems in the region.

■ ME-34

Monday, 16:00-17:30 - Room 016

Power Systems Economics

Stream: Data Mining in Finance and Commodities
Invited session
Chair: *Marcus Hildmann*

1 - Photovoltaic Energy Production Forecast using Support Vector Regression
Maila Pietrini, Renato De Leone, Antonio Giovannelli

The aim of this study is to predict the energy production of a PV plant in Italy, using a methodology based on Support Vector Machines. The model uses historical data of solar irradiance, environmental temperature and past energy production to predict the PV energy production for the next day with an interval of fifteen minutes. The technique used is based on n-SVR, a Support Vector Regression model where you can choose the number of support vectors. The forecasts of energy production obtained with the proposed methodology is very accurate, with the R2 coefficient exceeding 90%.

2 - Hourly Price Forward Curve for Market Coupling
Marcus Hildmann

We propose an algorithm to calculate the Hourly Price Forward Curve (HPFC) under market coupling conditions. The algorithm uses the supply and demand curves, transfer capacity, weather and seasonal indicators to calculate the HPFC based on the market coupling using implicit capacity auctions.

■ ME-35

Monday, 16:00-17:30 - Room 131

Simulation and Advanced Optimization, in Aviation Management and Manufacturing

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Erik Kropat*
Chair: *Silja Meyer-Nieberg*
Chair:
Chair: *Henrik Andersson*

1 - Delay in Aircraft Routing
Axel Parmentier, Frédéric Meunier

Building sequences of flights for their airplanes that minimize the expected cost of delay is crucial for airline companies. Due to the non-linear propagation of delay, this aircraft routing minimization problem turns out to be challenging. We use the well-established notion of stochastic order to obtain bounds and exploit them in the optimization process. This framework can be adapted to optimize risk measures, or to handle approximate probability constraints. Numerical experiments are currently carried out.

2 - An air traffic decision support model for flight departure in an international airport
Eugene Wong, Josephine Chong

The paper investigates the operation efficiency of the two-runway system, the development of the third runway system, and the airspace congestion problem in the Hong Kong International Airport. A constrained non-linear optimization model is proposed to minimize the time horizon of airspace, gate-holding, and ground time. The arrival and departure times with flight sequences are analyzed. The possibility of reducing aircraft fuel consumption and greenhouse gas emission during the gate-holding is reviewed. Future work on the aircraft scheduling at the taxi runway intersections is suggested.

3 - Hub Location and Fleet Composition in Offshore Personnel Transportation
Eirik Fernández Cuesta, Henrik Andersson, Kjetil Fagerholt

This paper addresses a strategic hub location and fleet composition problem for personnel transportation in the offshore oil production industry. The task is to find the optimal composition of the helicopter fleet and select the best offshore hubs and onshore airport bases to use in the transportation network. We present a mixed integer linear problem (MILP) model for the problem and solve it using a column pre-generation approach. Computational tests are performed on test cases based on data from an oil company's new field development outside the Brazilian coast.

4 - A Semidefinite Optimization Approach to the Parallel Row Ordering Problem
Philipp Hungerländer

The k-Parallel Row Ordering Problem (k-PROP) is an extension of the Single-Row Facility Layout Problem (SRFLP) that considers arrangements of the departments along more than one row. We propose an exact algorithm for the k-PROP that extends the semidefinite programming approach for the SRFLP by modelling inter-row distances as products of ordering variables. For 2 rows, our algorithm is competitive with a recently proposed mixed integer programming approach. Furthermore our algorithm is also applicable for more than 2 rows and even yields better practical results for a larger number of rows.

■ ME-36

Monday, 16:00-17:30 - Room 132

Forest Planning under Risk

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Jordi Garcia-Gonzalo*

1 - A Dynamic Programming Approach to Optimize Short-Rotation Coppice Systems Management Scheduling under Climate Change
Liliana Ferreira, Miguel Constantino, Jose Borges, Jordi Garcia-Gonzalo

Research aiming at the development of an adaptive management model that may take into account climate change for even-aged eucalypt forest ecosystems in Portugal. A Dynamic Programming (DP) approach is proposed to determine the stand management policy (e.g. sprout selection, coppice cycles and rotation length) that produces the maximum expected discounted net revenue under climate change scenarios. The DP model enables an adaptive management, capable to cope with unexpected changes. Different scenarios are introduced in the model to analyze the impact of climate change on the optimal policy.

2 - Approaches for Analyzing Risk and Integrating Risk Attitudes in Forest Management
Kyle Eyvindson, Annika Kangas

Forest management planning requires decisions to be taken based on imperfect information and assumptions regarding the future growth of the forest. Through the use of stochastic programming, the uncertainty can be modeled in a deterministic fashion. An advantage of stochastic programming allows for the decision makers attitude towards risk to be incorporated into the development of a solution. This paper describes methods for managing the different elements of risk, and demonstrates the associated cost of the various risk mitigation methods.

3 - Solving the Raw Materials Reception Process with an Optimization-Simulation Approach
Alexandra Marques, Mikael Rönnqvist

The significant contribution of raw materials inbound logistics to the reduction of the procurement costs have motivated many studies, particularly in routing and wood truck scheduling. Further studies are needed to avoid trucks congestion and queuing at the mill in order to reduce even further the duration and costs of the transport. This talk describes the Raw Material Reception Problem for scheduling in advance trucks unload and also handling their real time arrivals. The proposed solution method combines an optimization technique based in revenue management with discrete event simulation.

4 - A Stochastic Optimization Model to Adressing Climate Change in Forest Planning
Jordi Garcia-Gonzalo, Andrés Weintraub

In this work we consider a short/medium term forest planning problem considering harvesting decisions in the presence of uncertainty due to climate change which impacts in the growth and yield. We present an application in a eucalypt forest where the planning decisions involve which units to harvest in each one of the 15 one-year periods. We introduce a multistage Stochastic Integer Programming model considering 32 climate change scenarios and including the corresponding non-anticipativity constraints. This enables the planner to make more robust decisions than using a single average scenario.

■ ME-37

Monday, 16:00-17:30 - Room 017

Multiobjective Optimization in Asia (I)

Stream: Multiobjective Optimization
Invited session
Chair: *Tetsuzo Tanino*
Chair: *Tamaki Tanaka*

1 - A Complexity Reduction Method for the Multiobjective Multiclass Support Vector Machine
Keiji Tatsumi, Tetsuzo Tanino

In this paper, we discuss a Support Vector Machine (SVM) for the multiclass classification. We focus in particular on the Multiobjective Multiclass SVM (MMSVM), which finds discriminant hyperplanes by solving a single multiobjective optimization problem. The problem, which maximizes the geometric margins for the generalization ability, requires a large amount of CPU resources. Therefore, we propose a complexity reduction method for the MMSVM by using some pieces of information obtained by solving binary classification problems extracted from the original multiclass one.

2 - Parameter Tuning in Support Vector Regressions
Yeboon Yun, Hirotaka Nakayama, Min Yoon

Support Vector Machines (SVMs) have been recognized as a powerful machine learning method and shown to provide high performance. In order to accomplish good generalization ability, it is important to choose appropriate values of parameters in SVMs. We propose a sequential learning using both bagging and boosting for parameter tuning in support vector regression and also effectively extend it to problems with complicated function forms. In addition, it will be shown that the proposed method can improve the calculation time as well as generalization ability through several numerical experiments.

3 - Optimization over the Efficient Set of a Multiple Objective Linear Programming Problem with Reverse Convex Constraint
Syuuji Yamada, Tamaki Tanaka, Tetsuzo Tanino

In this talk, we consider a problem (OES) to minimize a linear function over the efficient set of a multiple objective linear programming problem (MOLP), where one constraint is defined by a strictly convex quadratic function and the other constraint functions are convex. Then, the feasible set of MOLP is formulated as a dc set. Hence, it is not always true that the efficient set of MOLP is connected. In this case, we propose a global optimization algorithm for OES by combining a branch and bound procedure and a method listing all KKT points of a quadratic programming problem.

4 - The Unified Split Fixed-Point Variational Inequality Problem and Algorithmic Consequence
Narin Petrot, Nimit Nimana

The main objective of this paper is to introduce a new split type problem consists in finding a fixed point of a nonexpansive operator which solves the variational inequality problem over the fixed point set of such operator in a Hilbert space and such that its image under a bounded linear operator is a fixed point of a certain nonexpansive operator in another Hilbert space. To find a solution of the problem (if such a point exists) a modified iterative algorithm is proposed.

■ ME-38

Monday, 16:00-17:30 - Room 214

Optimization Techniques for Some Statistics Models

Stream: Convex Optimization Methods and Applications
Invited session
Chair: *Xiaoming Yuan*

1 - On How to Solve Large-Scale Log-Determinant Optimization Problems
Chengjing Wang

We propose a proximal augmented Lagrangian method and a hybrid method, i.e., employing the proximal augmented Lagrangian method to generate a good initial point and then employing the Newton-CG augmented Lagrangian method to get a highly accurate solution, to solve large-scale nonlinear semidefinite programming problems whose objective functions are a sum of a convex quadratic function and a log-determinant term. We demonstrate that the algorithms can supply a high quality solution efficiently even for some ill-conditioned problems.

2 - Exact Relaxations for Rank Minimization Problems in Euclidean Jordan Algebra
Ziyan Luo, Lingchen Kong, Naihua Xiu

Rank minimization problems, arising from many applied fields such as system identification and control, are generally NP-hard due to the combinatorial nature of the rank function. In this talk, several exact relaxation approaches are proposed for rank minimization problems in a more general setting - the Euclidean Jordan algebra. Our results can be regarded as a generalization of the existing relaxation theory in compressed sensing and the low-rank recovery theory in matrix optimization. Deterministic and easy-to-check exactness conditions for problems with special structures are also studied.

3 - Optimization in Censored Quantile Regression
Lingchen Kong

In this talk, we will review the basic concepts and results on censored quantile regression, which include the background, history development and recent works in statistics. In order to understand the optimization models and establish the efficient algorithms, we finally study the properties of Lòwner operator generated by the quantile function. More specifically, we will consider its continuity, (locally) Lipschitz continuity, directional differentiability, F-differentiability, continuous differentiability and strong semismoothness.

■ ME-39

Monday, 16:00-17:30 - Room 018

ORAHS III - Emergency Services

Stream: Health Care Applications
Invited session
Chair: *Sally Brailsford*
Chair: *Brigitte Werners*

1 - Ambulance Planning with and without Region Borders
Theresia van Essen, Melanie Reuter, Stefan Nickel

Border regions are a major challenge in ambulance planning. The border regions obviously occur between countries, but often also within a country. These borders within a country lead to an inefficient use of ambulances as it often happens that there are ambulance bases on both sides of the border even though one ambulance base could serve both sides simultaneously. In this talk, we first introduce solution approaches for efficiently locating ambulance bases and ambulances. Second, we show the improvement in terms of coverage and efficiency when borders between regions in a country are ignored.

2 - Ambulance Planning under Uncertain Demand
Melanie Reuter, Francisco Saldanha-da-Gama, Stefan Nickel

Ambulance planning minimizes the cost for installing ambulances and bases assuring a minimum coverage level. We assume stochastic demand and consider a scenario-indexed formulation. However, the number of scenarios becomes prohibitively high even for small instances and considering one single sample can lead to a misleading solution. Therefore, we present a sampling approach in which we solve several samples and then combine the optimal values in order to estimate the optimal value of the original problem. We test the approach using randomly generated instances inspired by real-world data.

3 - Performance Improvement for Emergency Medical Services (EMS) with Time-Region-Specific Cruising Ambulances
Jiun-Yu Yu, Kwei-Long Huang

Emergency Medical Services (EMS) refers to both patient transport and medical support solution for people with illness or injuries. Recent clinical evidence shows that for out-of-hospital cardiac arrest (OHCA) cases the response time, time spent by the ambulance to arrive at the scene, is critical to the survival rate. To reduce the response time, a time-region-specific ambulance cruising policy is proposed. Analytics and GIS are applied to generate the joint time-region distributions to identify high frequency grids. Simulation models are built to examine various ambulance cruising policies.

4 - Simulation based Evaluation of Different Objectives for Emergency Medical Services
Brigitte Werners, Lara Wiesche, Pascal Lutter, Dirk Degel, Dirk Degel

Resources for Emergency Medical Services (EMS) have to be positioned such that emergencies can be reached within a given time frame. Well-known models in literature consider different variants of demand coverage as a proxy for EMS quality, defined as the ratio of calls served within the legal respond time. In order to evaluate the performance of standard optimization models in literature, a detailed simulation study is conducted. We evaluate different objective functions and the resulting positioning of EMS resources and their influence on real world outcome measures.

■ ME-40
Monday, 16:00-17:30 - Room 019

Advances in Production and the Link with Supply Chain

Stream: Production and the Link with Supply Chain
Invited session
Chair: *Amin Chaabane*
Chair: *Alice Yalaoui*

1 - Inventory Control and Environmental Policies in Reverse Logistics Supply Chain
Amin Chaabane, Marc Paquet, Marthy Stívaliz García Alvarado

Current environmental regulations and economic conditions force organizations to limit Greenhouse Gas (GHG) emissions. Since inventories have proven their crucial role in supply chains, the aim of this paper is to study the impact of inventory control in reducing the environmental damage of an organization. Modeled as a Markov Decision Process (MDP), we dealt with a stochastic recovery inventory system considering an infinite-horizon, and a cap-and-trade mechanism. We show that there is a direct link between carbon credit price and inventory policies.

2 - Mathematical Model to Determine the Configuration of a Reverse Supply Chain (RSC)
Juan Osorio, Carlos J. Vidal, Jose de Jesus Casas Riascos, Katherine Ceron Naranjo

In this paper, we propose a mathematical model to determine the configuration of a reverse supply chain (RSC) that includes the collection, recovery, treatment, and disposal of electrical and electronic equipment waste (EEEW). The model objectives consist of maximizing utility and minimizing CO2 emissions produced by the operation of the chain. The model is multi-objective, multi-product, and multi-level and considers different types of transportation modes and facility capacities. The proposed method is validated by its application to a hypothetical RSC.

3 - Creating an Advanced Order Stream with the Proportional Order-up-to Policy
Qinyun Li, Stephen Disney

Information sharing has been promoted for several decades as a mechanism to enhance supply chain performance but the degree of success from such a scheme is widely variable. In particular some players are reluctant to share end-customer demand with others in the supply chain. We propose an alternative approach where a predicted order stream is given to the supplier as guidance to coordinate and plan their activities accordingly. This order stream is determined by the order-up-to policy which incorporates a proportional feedback controller to enable a smooth, steady order stream to be made.

4 - Value of Disruption Information in an EOQ Environment
Ismail Serdar Bakal, Z. Pelin Bayindir, Deniz Esin Emer

We consider an infinite-horizon, continuous-review inventory model with deterministic, stationary demand where supply is subject to disruption. The supply process alternates randomly between ON and OFF states. Backlogging is allowed only when the supplier is disrupted. We seek the value of disruption information which enables the firm to place an extra order when supply is disrupted. We derive the long-run average cost utilizing the renewal theory, and characterize the order-up-to levels. We also compare the results to the setting with no disruption order opportunity.

■ ME-41
Monday, 16:00-17:30 - Room 216

Lot-Sizing and Related Topics 4

Stream: Lot-Sizing and Related Topics
Invited session
Chair: *Michelli Maldonado*

1 - Integrated Lot Sizing and Cutting Stock Problem
Gislaine Melega, Silvio de Araujo

The lot sizing and the one-dimensional cutting-stock problems have an important role in the production sector, such as, tubular furniture and paper factories, metallurgical, among others and generally these problem are dealt independently. In this work, we approach both problems in an integrated way. We studied a classical model for lot sizing problem and its reformulation based on the shortest path problem. For the one-dimensional cutting stock problem, three different models proposed in the literature were studied. We present a computational study using randomly generated data.

2 - Integrated Supply and Production Planning
Fanny Hein, Christian Almeder

In this work we assess the benefits of an integrated supply and production planning problem where the routing part corresponds to the collection of raw materials and the production planning part is concerned with the conversion of those raw materials into end products. We define two scenarios, one incorporating raw material inventories, and the other one supposing just-in-time (JIT) supply of the raw materials. Based on extensive computational testing we conclude that an integrated planning approach is more beneficial in a JIT-environment but only if there is sufficient excess capacity.

3 - Fuzzy Logic Approach for Dynamic Lot Sizing for a Warm/Cold Process

Ozgur Toy, Ayca Altay, Yeliz Ekinci

Production systems in which the physical structure of the process allows keeping the system warm in order to avoid expensive shut down and start up costs. This type of systems have been studied in the literature. A generalisation of such a system is provided by Toy and Berk (2006) in which the process can be kept into the following period only if the production in the period is at least as much as a pre-specified quantity. Optimal structure of the solution for the problem has been studied and solution algorithm is provided. In this study we present a fuzzy logic approach for this problem.

4 - Mathematical Models for an Integrated Lot Sizing and Scheduling Problem

Michelli Maldonado, Socorro Rangel

Different strategies have been used to model scheduling decisions in the Integrated Lot Sizing and Scheduling Problem (ILSP). To obtain the production sequence, constraints based on the Asymmetric Traveling Salesman Problem (ATSP) are added to the lot sizing formulation. Different approaches are used to model the Sub-tour Elimination Constraints (SEC) in the ATSP. We will present mathematical models for the ILSP based on several SEC approaches to treat the scheduling decisions, and a preliminary computational study to assess the efficiency of the models.

■ ME-42

Monday, 16:00-17:30 - Room 215

Human Aspects in Transportation and Logistics

Stream: Green and Humanitarian Logistics
Invited session
Chair: *Jeyson Andrés Martínez Gamboa*

1 - Innovative Operating Strategies for ADA Paratransit Services

Luca Quadrifoglio

ADA Paratransit services are a very large industry providing transportation services for disabled and elderly customers across the country. They are very cost-ineffective. We propose innovative scheduling policies to enhance the operations of ADA Paratransit services using Zoning strategies. The proposed innovations will allow these services to maintain their desired zonal structures, improve customer service level, reduce operating costs and increase the passenger trip per revenue hour. A set of alternative scheduling options are proposed and discussed, showing pros and cons for each one.

2 - A Relief Distribution Model with Decaying Resilience of the Affected Population

Eiichi Taniguchi, Ali Qureshi

The disaster relief distribution could make a difference between life and death of the affected people. Very little academic research has been done on the planning relief distribution, which only shares specific experiences. None of the relief distribution models has considered the decrease in the resilience of the affected population due to the delay in relief supply and if it is less than the demand. This research aims at developing a new relief distribution model capable of providing a multi-period relief distribution plan considering the diminishing resilience of the affected population.

3 - Public Transportation Preferences of Disabled People

Mehmet Çağlıyangil, Sabri Erdem

In Turkey, almost 15% of people are disabled. However, only a very little minority can be observed in public transportation. There are various factors affect the decision of going outside and choosing a public transportation mode. Subway, bus, ferry, taxi et cetera, can be used for intra-urban transportation by disabled people according to their dysfunctionalities. We classified the transportation mode preferences of disabled people in İzmir with Discrete Choice Analysis. The results can be used by public transportation policy makers for increasing transportation quality for disabled people.

4 - Development of a Logistic Model and its Impact on Resilience

Jeyson Andrés Martínez Gamboa, Ever Angel Fuentes Rojas

There is no distinction when talking about natural disasters. However, most of the victims are given because of the lack of attention after the event in contrary to during it. That is why humanitarian logistic is getting more important among countries, nevertheless the level of uncertainty managed in its supply chain hampers the objective: Safeguarding life.

As a contribution, a humanitarian logistics system was designed, through the development of a mathematical model using integer programming to generate an information system that reduce those levels of uncertainty of the supply chain.

■ ME-43

Monday, 16:00-17:30 - Room 217

Accounting, Corporate Governance and Valuation

Stream: Operational Research in Financial and Management Accounting
Invited session
Chair: *Matthias Amen*

1 - Cost Control for Projects and IAS 11

Matthias Amen

The International Accounting Standard (IAS) 11, called "Construction Contracts" allows to recognise revenues of long-term contracts according to the degree of completion, which could be measured by the cost-to-cost method. We expand the general cost deviation approach to projects and identify some problems that occur when IAS 11 has to be applied. Furthermore, we improve the approach for cost deviation analysis while considering the total network of activities. At last, we suggest some modificatons to IAS 11, especially to the cost-to-cost method.

2 - A Multi Criteria Network Approach for Evaluating the Independency of Individuals in the Corporate Governance System

Kai Kurhofer, Matthias Amen

The individuals who are involved in the corporate governance system should be unbiased and largely independent from the preparers of financial statements and other political influences. We present an approach for analyzing the direct and indirect relations of the individuals who are involved in the system. In this paper we propose a multiple classification for relations and present a method for calculating the combined strength of network relations. Furthermore we suggest practical guidelines for redefining independency criteria.

3 - Valuation of Tax Savings

Felix Streitferdt

One of the most common assumptions in finance is the assumption that all items yielding a tax shield can be deducted from the taxable base in the same period they are accounted. This is not realistic and the resulting values of future tax savings are therefore too high. To attack this problem, we develop a binomial model that allows the taxable base to become negative and to use risk neutral valuation. As a limitng case we propose an arithmetic brownian motion that is used within a Monte-Carlo-Simulation to calculate the value of future tax savings using risk neutral probabilities.

4 - Corporate Liquidity and Dividend Policy under Uncertainty
Nicos Koussis, Spiros Martzoukos, Lenos Trigeorgis

We develop a computational lattice based model of firm valuation under revenue uncertainty that incorporates liquidity choice (retained earnings), debt financing, external financing costs and bankruptcy costs. The irrelevancy of dividend policy and retained earnings holds only in the absence of default risk. Retained earnings have a positive role in the presence of growth options and when external financing costs are high. A high level of retained earnings may enhance the value of debt and improve firm value via larger tax benefits, more importantly in the presence of high bankruptcy costs.

■ ME-44

Monday, 16:00-17:30 - Room 218

Game Theory

Stream: Game Theory
Invited session
Chair: *Miquel Oliu Barton*

1 - Modeling and Solution of COA Development based on Timed Influence Net and Game Theory
Jincai Huang, Chao Chen, Guangquan Cheng, Baoxin Xiu, Weiming Zhang, Cheng Zhu

In the process of operation planning, the development of course of action is one of the key steps. With consideration of conflict game, resource restriction, and the influence of action's execution time, this paper establish a model of course of action development based on timed influence net and game theory, and solution by translate this problem into the standard matrix game model. And at last, an example is given to illustrate this model and it's solution.

2 - Lexicographic Allocations and Extreme Core Payoffs: The Case of Assignment Games
Tamás Solymosi, Marina Nunez

We consider various lexicographic allocation procedures for TU games where the payoffs are computed in an externally given order of the players. Their common feature is that if the allocation is in the core, it is an extreme point of the core. Our main result for assignment games is the coincidence of the sets of lemarals (lexicograhic maximization over the set of dual rational payoff vectors), lemacols (lexicograhic maximization over the core) and extreme core points. This provides a way to compute the Alexia value with no need to obtain the whole coalitional function of the assignment game.

3 - A Monotonic and Merge-Proofness Rule in Minimum Cost Spanning Tree Situations
Juan Vidal-Puga, Gómez-Rúa María

We present a new model for cost sharing in minimum cost spanning tree problems, so that the planner can identify the agents that merge. Under this new framework, we show that, as opposed to the traditional model, there exists a rule that satisfies core selection, cost-monotonicity and merge-proofness.

4 - Co-authorship Model with Link Strength
Leandro Rego, Andrea Maria dos Santos

We generalize a network model for co-authorship by allowing connections with different link strengths. Such link strengths may represent the number of papers a couple of authors have work together on. We investigate which networks structures are efficient and pairwise stable. We analyze a case in which link strengths are unbounded and another considering that they are bounded. We show that there is no pairwise stable network in the first case, while in the second case, the pairwise stable networks consist of disjoint completely connected components in which all the link strengths are maximal.

Tuesday, 8:30-10:00

■ TA-01

Tuesday, 8:30-10:00 - Room 118

(Integrated) Planning Models

Stream: Railway and Metro Transportation
Invited session
Chair: *Leo Kroon*

1 - Train Routing through Stations
Nikola Besinovic, Rob Goverde, Egidio Quaglietta

Routing trains through busy railway nodes is an important part of the timetabling process. A route for each train has to be determined to provide a conflict-free schedule, given the event times of trains. In this paper, we describe the stability routing model aiming to minimize the capacity occupation. We formulate the model as a flexible job-shop scheduling and provide the heuristics based on the max-plus algebra and heaps theory to solve it. Since the microscopic infrastructure is considered, the feasibility is guaranteed. The model is tested on the real-life instances of the Dutch network.

2 - Integrated Rolling Stock Planning for Suburban Passenger Train Services
Per Thorlacius

A central issue for operators of passenger trains is providing a sufficient number of seats while minimising operating costs. This process must be conducted taking a large number of practical, railway oriented requirements into account. Because of this complexity, a stepwise solution was previously used, the result being the loss of optimality. The talk will present a new matheuristic based integrated rolling stock planning model in which many requirements are handled all at the same time. Real-world results from DSB S-tog, the suburban train operator of the City of Copenhagen are presented.

3 - Timetabling with Crew Scheduling Integration at a Freight Railway Operator
Lukas Bach, Twan Dollevoet, Dennis Huisman

We investigate to what degree we can integrate the Train Timetabling/Engine Routing Problem (TERP) and the Crew Scheduling Problem (CSP). The overall integration is achieved by obtaining an optimal solution for the TERP, while exploiting the fact that numerous optimal solutions exist. We extract the solutions where it is possible to alter the timetable while keeping engine routings intact. This is implemented in a mathematical model for the CSP. The model is solved using a Branch-and-Price scheme. Hereby it is possible in the CSP to adjust the timetable, and achieve a better overall solution.

4 - A New Approach to Crew Scheduling in Rapid Transit Networks
Manuel Fuentes, Ángel Marín

A new approach to the Crew Scheduling Problem is presented. This approach is oriented to solve the daily planning in Rapid Transit Networks, where movements are typically short and frequencies high, leading to combinatory complexity. The structure of the resulting formulation can be exploited with decomposition methods, and it can take advantage of its similarities with the train (or bus) routing problem when integrating both.

■ TA-02

Tuesday, 8:30-10:00 - Room 111

Routing and Scheduling

Stream: Vehicle Routing
Invited session
Chair: *Hocine Bouarab*

1 - Multi-Denomination Currency Distribution Problem with Transportation Security Consideration
King-Wah Anthony Pang, Yan-Feng LI
With rapid development of the social economy in China, the amount of currency supply and circulation are drastically increasing year-on-year, so as the issuance cost. This issuance cost is significantly affected by the decision on currency distribution operation. Also, risk management is another critical measure for currency distribution as banknotes are being transported. We formulate the currency distribution problem as multi-type currency pickup and delivery model and we propose to develop heuristic methods to solve the problem using decomposition technique with local improvement schemes.

2 - Optimization of Inter-Depot Trunking with Heterogeneous Fleet and Semi-Trailer Swap Option
Raza Khan, Jian-Bo Yang, Julia Handl
This research deals with the inter-depot trunking by using heterogeneous and multi-compartment fleets. The unique feature of this problem are swapping of semi-trailers between different trucks and loading of two categories of products in adjustable-size compartments with an aim to minimize the total number of vehicles used. Real-life data is used to test the linear-programming based model. The comparison of human-generated and model-generated solutions suggests that equally good-quality solutions are produced thus reducing the dependence and cost associated with human-planners.

3 - Use Fibonacci Numbers to Improve Performance of a Genetic Algorithm
Anita Gudelj, Danko Kezić
In this paper, the authors focus on the effect of variable population size on accelerating evolution in the context of our algorithm which integrates MRF1 Petri net with genetic algorithm GA. Our approach uses Fibonacci sequence to select the number of individuals in populations. The motivation is to add new individuals when the GA is reaching a stagnation phase. This model we tested on some scheduling problems with shared resources. Results confirm that our model finds solutions of similar quality to the ones found by Standard GA, but with a smaller amount of computational effort.

4 - Improving the Quality of Dual Solutions in Column Generation
Hocine Bouarab, Issmail El Hallaoui, Francois Soumis, Abdelmoutalib Metrane
Column generation (CG) is a largely used algorithm for solving routing problems. When the columns added to the master problem (MP) represent routes, the MP is very degenerate and produces poor quality dual solutions increasing drastically the number of CG iterations. We propose a new CG algorithm where, at each iteration, the dual solution is partially given by the MP and completed by an auxiliary problem. This approach produces more central dual solutions and the iterations number is considerably reduced. We report numerical results on instances of the Vehicle and Crew Scheduling Problem.

■ TA-03

Tuesday, 8:30-10:00 - Room 001

Aviation Management and Processes

Stream: Aviation
Invited session
Chair: *Stefan Wolfgang Pickl*
Chair: *Matthias Dehmer*

1 - A System Dynamics Approach to the Boarding Process
Elisa Canzani, Joachim Block, Renato De Leone, Stefan Wolfgang Pickl
As an aircraft generates revenues only when it is flying, airlines aim to minimize ground times. The boarding process is one of the most time consuming processes and relevant for airlines but also for passengers. Feedbacks and nonlinearities inherent to this process makes it difficult for the application of analytical methods. However, coping with feedbacks and nonlinearities are strenghts of System Dynamics. We have developed a SD model to get a better understanding of the boarding system's behavior. Our model allows airline managers to simulate different policies and to optimize the process.

2 - Flexibility and Customer Value in Airline Revenue Management
Sebastian Vock, Catherine Cleophas

Flexible products are a powerful tool for airlines to induce new customer markets and generate more revenue while improving the utilization of fixed capacities. In this context, we take a look at customer value related effects in long-term revenue management. We formulate a combined model for revenue management with flexible products and the integration of customer value. In a second step we provide first numerical results for this approach resulting from several simulation experiments.

3 - A Game-Theoretic Model for Aviation Management Processes
Stefan Wolfgang Pickl, Matthias Dehmer

With Game-Theoretic Models certain Aviation Management Processes might be modeled, simulated and optimized. This talk gives an overview; especially the tau-value will be introduced. We present an allocation rule for designing runways, and extend this procedure to general allocation processes within aviation management.

■ TA-04

Tuesday, 8:30-10:00 - Room 119

Contracting

Stream: Supply Chain Management
Invited session
Chair: *Gultekin Kuyzu*

1 - Unsold versus Unbought Commitment: Minimum Total Commitment Contracts with Nonzero Setup Costs
Geoffrey A. Chua

We study a minimum total commitment contract where the buyer commits to purchase a minimum quantity of a single product from the supplier over the contract duration. We consider non-stationary demand and per-unit cost, discount factor, and nonzero setup cost. Since existing methods fail, we develop a new method based on a state transformation technique using unsold commitment instead of unbought commitment as state variable. We prove for the first time the optimality of a modified (s,S) policy. We also discuss four extensions to show the generality of our method's effectiveness.

2 - Optimal Periodic Flexible Policies for Two-Stage Serial Supply Chains
Fang Liu, Nagesh Gavirneni

In a two-stage serial supply chain, Periodic Flexible (PF) policies can reduce the inefficiency due to decentralization by 43%. We show a general way to find the optimal PF policies through an example of periodic flexible policies of length two. Under the optimal policy, the retailer follows a state dependent capacitated/order upto policy. We approximate the optimal restricted ordering functions by a piecewise linear function. We show that the optimal PF(2) policies are able to reduce the total supply chain cost by 13%. The linear approximation is effective with an error of less than 1%.

3 - Channel Coordination with a Single Supplier and Multiple Retailers Considering Customer Arrival Times and Route Selection
Ilkyeong Moon, Xuehao Feng, Dongwook Kim

We address a decentralized supply chain with one supplier and multiple independent retailers. The supplier distributes a newsvendor-type product to retailers with one vehicle in one trip. The supplier decides the delivery route and the arrival time of products. Without any coordinating contracts, the supplier may prefer a local optimal delivery route. We present a wholesale-price-and-carpooling contract to coordinate such a supply chain. We demonstrate supply chain coordination under such a contract and show that the profit along the supply chain can be arbitrarily allocated.

4 - Shipper Collaboration with Partner Constraints
Gultekin Kuyzu

In truckload shipper collaboration, shippers submit tours with little or no asset repositioning to a carrier, as opposed to submitting individual lanes, with the hope of receiving more favorable rates. The shippers must solve a Lane Covering Problem (LCP) to maximize savings. In this study, we focus on a new variant of LCP, motivated by the need to limit the number of partners. We introduce a MIP formulation for this new variant and develop a column generation based algorithm for its solution.

■ TA-05

Tuesday, 8:30-10:00 - Room 002

Stochastic Programming in Maritime Transportation

Stream: Maritime Transportation
Invited session
Chair: *Lars Magnus Hvattum*

1 - Comparing Optimization and Simulation Models for Stochastic Empty Container Repositioning
Massimo Di Francesco, Alexei Gaivoronski, Paola Zuddas

We consider the problem of moving of empty containers between ports under uncertainty about supply/demand and we examine two approaches for solving this problem. The first approach is a simulation model incorporating parametrized decision parameters, which are optimized by a stochastic gradient method. In the second approach we describe the uncertainty by a finite number of scenarios organized in scenario tree and construct a deterministic equivalent of the original stochastic problem in the form of large scale LP of special structure. The comparison between these approaches is presented.

2 - A Stochastic Model for Vessel Fleet Analysis for Maintenance Activities at Offshore Wind Farms
Elin E. Halvorsen-Weare, Christian Gundegjerde, Ina Blomseth Halvorsen, Lars Magnus Hvattum, Lars Magne Nonås

To execute maintenance activities at offshore wind farms, maintenance personnel and equipment need to be transported from onshore or offshore bases to the individual wind turbines. Vessels and helicopters are used for this purpose. To reduce the cost of energy from offshore wind farms it is essential to keep an optimal or near-optimal vessel fleet. The optimization problem arising is highly stochastic. We propose a stochastic optimization model and computational experiments show that our model can be used to provide a decision maker with an optimal vessel fleet within acceptable time limits.

3 - Optimizing the Maintenance Vessel Fleet at an Offshore Wind Farm
Magnus Stålhane, Elin E. Halvorsen-Weare, Lars Magnus Hvattum, Lars Magne Nonås

We present stochastic programming model to determine the optimal vessel fleet size and mix for executing maintenance activities at offshore wind farms. This includes choosing which vessels to buy, which to charter-in, and selecting which bases to operate from. The model includes uncertainty in the number of maintenance activities and the weather conditions at the wind farm. A computational study is conducted based on realistic data, with results showing that the value of using a stochastic model to solve the strategic fleet size and mix problem is, in many instances, high.

4 - A Maritime Inventory Routing Problem with Uncertain Travel Times
Lars Magnus Hvattum, Agostinho Agra, Marielle Christiansen, Alexandrino Delgado

We consider a short sea shipping problem where a company is responsible for the distribution of oil products between islands as well as the inventory management of those products at unloading ports. Uncertainty in weather conditions and unpredictable waiting times at ports must be considered when creating vessel itineraries. A two-stage stochastic programming model with recourse is presented where the first-stage consists of routing, loading and unloading decisions, and the second stage consists of scheduling decisions.

■ TA-06

Tuesday, 8:30-10:00 - Room 211

Health Care System Design

Stream: Logistics in Health Care
Invited session
Chair: *Elisa Long*

1 - Health Care Supply Chain Design from a Stakeholder's Perspective
Nico Vandaele, Catherine Decouttere, Stef Lemmens

Health care supply chain modelling starts with a stakeholders analysis, including functional, financial and decisional dependencies. This reveals a KPI set and system requirements for the alternatives, obeying technological, financial and human KPI's. A flow model is used to link a subset of system characteristics with a subset of KPI's. The addition of constraints leads to a group decision process for the final scenario choice, with a high degree of implementation success. We illustrate this with a health care supply chain.

2 - Re-Examining the Patient Experience: Using Process Design and Trajectory to Improve Patient Satisfaction in Physician Practices
Grady S. York, Gary Garrison

Patients' perception of service satisfaction is crucial to healthcare providers seeking a sustainable practice. Visits encompass multiple patient contact points impacting satisfaction. 15,068 patients and 1,805 providers were surveyed. Factor analysis identified five factors: provider interaction, medical staff interaction, facility/reception, visit wait time and, pre-appointment wait time. Understanding and managing points of contact along the process trajectory individually and cumulatively will increase process performance through reduced wait times and more efficient use of resources.

■ TA-07

Tuesday, 8:30-10:00 - Room 003

Planning and Operation in Electric Power System

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Shmuel Oren*

1 - Subsidies to Renewables, Ramping Constraints and Plants' Dismantling
Yves Smeers, Sebastian Martin

The European power system is currently undergoing anticipated dismantling of conventional plants because of the low prices on the energy markets, partially due to wind penetration. We consider a two settlement model, separated Power eXchange and System Operator, posed as a stochastic equilibrium problem. It assumes a feed in premium incentive for wind generation and risk averse generators. We examine the impact of various systems features on electricity price, and compare models with price dependent and fixed demand as well as with different representations of ramping.

2 - Improving Do-Not-Exceed Limits for Renewables with Robust Corrective Topology Control
Kory Hedman, Akshay Korad

The Independent System Operator of New England (ISONE, USA) requires variable renewable resources to stay within a dispatch range (or face penalties); this range is known as a do-not-exceed (DNE) limit. The DNE limits are meant to ensure reliability and are determined based on the availability of reserve and network limitations (e.g., congestion, voltage). With the use of robust optimization and by combining corrective topology control with contingency analysis, this work demonstrates how topology control can improve reserve deliverability and, thus, substantially expand the DNE limit ranges.

3 - Self-Commitment of Combined Cycle Units under Electricity Price Uncertainty
Anthony Papavasiliou

Day-ahead energy market clearing relies on a deterministic equivalent model with a limited time horizon, which can be inefficient. Instead, generators may wish to assume the risk of self-committing their units with the hope of securing greater profits. This may reduce the room for economic signals in the day-ahead market. We investigate the influence of risk aversion and price volatility on the decision of generators to self-commit units. We present a Benders decomposition algorithm for self-committing combined cycle units under price uncertainty with a conditional value at risk criterion.

4 - Modeling Incentives in Vertically Integrated Electricity Markets
Andy Philpott

Many electricity markets are vertically integrated: generation companies also own retail companies that buy from the wholesale market and sell to consumers. When entry into the wholesale supply market is limited, vertical integration is often blamed for a lack of retail competition. We present some models that investigate the effects of vertical integration on generator offer behavior and investment incentives.

■ TA-08

Tuesday, 8:30-10:00 - Room 120

Electric Mobility

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session
Chair: *Peter Letmathe*

1 - E-Mobility: Influence of the Second Life of used Batteries on Profit and Demand
Ilhana Mulic, Peter Letmathe, Ramajothi Ramsundar

We analyze the effect of the second life of used batteries on the profit of manufacturers, battery price and demand of batteries for electric vehicles. There are three options to benefit from collecting used batteries namely refurbishing, recycling and reuse. There are also uncertainties with respect to demand for used batteries, cost parameters and parts recovered in terms of quality, quantity and time of return. Our analysis shows that cost savings from collecting used batteries has important implications for pricing decisions, demand and profit of the manufacturers.

2 - Electric Vehicles with a Battery Switching Station: Adoption and Environmental Impact
Buket Avci

We analyze a novel switching-station based business model for the deployment of electric vehicles. We develop a stylized analytical model that captures the salient features of EV adoption decision by modeling range anxiety and the impact of different ownership structures (selling miles vs. selling batteries). We find that electric vehicles with switching stations can incent adoption and reduce oil dependence but, paradoxically, this increased adoption may not necessarily benefit the environment.

3 - Combinatorial Optimization to Energy Management of an Electric Vehicle
Pierre Lopez, Yacine Gaoua, Stéphane Caux

This communication addresses energy management in a multi-source Hybrid Electric Vehicle. Assuming the objective to minimize hydrogen consumption of a fuel cell system, as well as, possibly, a battery discharge, and considering the characteristics of the sources constituting the energy chain of the vehicle involving efficiency and energy losses, we propose a combinatorial linear modeling to solve the problem to optimality. Simulations performed on realistic mission profiles lead to drastically reduced computation times compared to dynamic programming and quasi-Newton methods used previously.

■ TA-09

Tuesday, 8:30-10:00 - Room 121

Enumeration and Discrete Structures

Stream: Dynamical Systems and Mathematical Modelling in OR
Invited session
Chair: *Yasuko Matsui*

1 - A Fast Algorithm for Counting the Number of Primitive Sorting Networks
Yuma Tanaka, Atsuko Ikegami, Yasuko Matsui, Katsuki Fujisawa, Yuichiro Yasui

We address the problem of counting the number of distinct primitive sorting networks that have a minimal number of comparators for a sequence of n elements. Primitive sorting networks are important models in mathematics and engineering. The number of such networks is also the number of oriented matroids of rank 3 on n elements, the number of Amida-Kuji with minimum bars for reversing a sequence, and the numbers of other interesting structures. We developed a fast algorithm for this problem. We present the number of networks for n = 14 and 15, which were previously unknown.

2 - Enumeration of Combinatorial Structures Using Oriented Matroids
Hiroyuki Miyata

Oriented matroids are abstract structures, which provide a unified setting to study various objects such as point configurations and polytopes. In the context of enumeration, they are useful intermediate structures for enumerating various objects.

In this talk, we explain our recent work on enumerations obtained by using oriented matroids. It includes enumeration of combinatorial types of point configurations and polytopes (with K. Fukuda and S. Moriyama), that of P-matrix linear complementarity problem (with K. Fukuda and L. Klaus), and that of neighborly polytopes (with A. Padrol).

3 - Enumeration of All Paths Between All Pairs of Vertices by Zero-Suppressed Binary Decision Diagrams
Takashi Horiyama, Koichi Adachi

We consider the problem of enumerating all simple (i.e., vertex-disjoint) paths in a given graph. Knuth proposed an efficient algorithm for enumerating all s-t paths by Zero-Suppressed Binary Decision Diagrams (ZDDs). It can be considered as one of DP-like algorithms. The key of the algorithm is to share search-nodes by simple knowledge of subgraphs. We can generalize this algorithm to enumerate all paths between all pairs of vertices. In this talk, we propose another algorithm by adding some knowledge on the constructing subpaths. We also give the experimental results.

4 - Enumerating all the Optimal Cost Vertex Coloring of 1-Trees
Yasuko Matsui

In this talk, we propose an algorithm for enumerating all the optimal cost vertex colorings of given 1-trees without repetitions if the optimal cost vertex coloring is not unique. In general, the optimal cost vertex coloring problem is NP-hard for arbitrary graphs. However, there is a linear time algorithm for trees. Recently, we first gave an enumeration algorithm for the problem. Our algorithm is also polynomial delay algorithm. By extending our results, we show the first enumeration algorithm for the optimal cost vertex coloring of given 1-trees.

■ TA-10

Tuesday, 8:30-10:00 - Room 122

Decision Support Models for the Energy Industry I

Stream: Optimization Models and Algorithms in Energy Industry
Invited session
Chair: *Andres Ramos*

1 - Accelerating the Convergence of Stochastic Unit-Commitment Problems by Using a Tight and Compact MIP Formulation
German Morales-Espana, Claudio Gentile, Andres Ramos

MIP-based Stochastic Unit Commitment (SUC) problems are computationally intensive. Research have been focused on improving computer power and solving algorithms, but not on the quality of the MIP formulation, which actually defines its computational complexity. Creating tight or compact computationally efficient MIP formulations is a non trivial task because the obvious formulations are very weak or very large. We propose an SUC that is simultaneously tight and compact. Consequently, the computational burden is dramatically reduced in comparison with common SUC formulations.

2 - Optimal Management of Virtual Power Plants in Liberalised Markets
Pedro Sánchez-Martín, Andres Ramos, Javier García-González

The communication shows the impact of new entrant technologies in liberalized electricity markets that could choose Virtual Power Plant (VPP) as a business or operation model. At the same time a generic model is presented matching liberalized energy markets and VPP implementation. Different technologies are detailed as generation and consumption VPP components, where VPP acts as aggregator and demands side manager. The study uses a unit commitment model within a full year time-span. The Spanish Case Study shows how VPP implementation could benefit the electric system in terms of system costs

3 - Operation Reserve Usage for Different Unit Time Periods of a Stochastic Unit Commitment
Andres Ramos, German Morales-Espana, Javier García-González, Michel Rivier

We analyze the behavior of an IEEE test electric system under different unit commitment (UC) time periods and scenarios of wind generation uncertainty and observe the effects in the use of operation reserves. Firstly, we run a stochastic UC day-ahead planning model where the unit time period can be 15, 30 and 60 minutes and the commitment decisions are taken. Then, a 5-minute economic dispatch (ED) model is run for all the wind generation scenarios to evaluate the operation of the system with the previously determined UC decisions. We present the results based on the simulation of the ED.

4 - An Investigation about Package MINOS and Optimal Power Flow Problem
Edmea Cássia Baptista, Adilson Preto de Godoi, Edilaine Soler

In this paper, we investigate a method for the solution of Optimal Power Flow problem which is formulated as a large scale, non-convex, constrained, nonlinear problem. This method uses the linearization of constraints, an Augmented Lagrangian and the Reduced Gradient Method. The numerical tests are realized utilizing its implementation in the package MINOS, into the GAMS system. The results are presented for different electrical systems, different initialization of the parameters and they are compared with the results obtained by package KNITRO which uses an Interior Point/Trust region method.

■ TA-11

Tuesday, 8:30-10:00 - Room 113

Mixed-Combinatorial Methods in Distance Geometry

Stream: Combinatorial Optimization
Invited session
Chair: *Leo Liberti*

1 - Universal Rigidity of Bar-and-Joint Frameworks and Distance Geometry
Abdo Alfakih

A configuration p in r-dimensional Euclidean space is a finite set of labeled points that affinely span this r-dimensional space. Each configuration p defines a Euclidean distance matrix D. A fundamental problem in distance geometry is to find out whether or not a given subset of the entries of D suffices to uniquely determine the entire matrix D. This problem is equivalent to the problem of universal rigidity of bar frameworks. In this talk, I'll discuss necessary and sufficient conditions for the universal rigidity of bar frameworks.

2 - Algorithms for Unassigned Distance Geometry Problems Arising in Molecule and Nanoparticle Atomic Structure Determination
Phil Duxbury, Saurabh Gujarathi, Simon Billinge, Pavol Juhas, Luke Granlund

Crystallography is effective in solving the structure of materials and proteins, however preparing large enough crystal samples is difficult. Finding the atomic structure of non-crystalline or nano-crystalline materials is the key challenge in this area. NMR of proteins or scattering experiments in other materials often yield a list of inter-atomic distances and we seek to invert the distance lists to find atomic structure. We will describe two algorithms we have developed to solve the unassigned distance geometry problems arising in molecular and nanoparticle atomic structure determination.

3 - The Importance of Atom Orderings in Distance Geometry Applied to Protein Structure Determination
Carlile Lavor

Distance Geometry is related to the problem of finding an embedding of a weighted undirected graph G in some space, where there is an edge between two vertices if their relative distance (the weight associated to the edge) is known in such space. A very interesting application arises in the field of biology, where experiments of Nuclear Magnetic Resonance are able to estimate distances between some pairs of atoms of a protein and the problem is to determine the 3D protein structure based on the distance information. We will discuss the importance of atom orderings in solving this problem.

4 - Exact and Approximate Methods for Large Scale Distance Geometry Problems
Leo Liberti

The Distance Geometry Problem (DGP), which asks to find a graph realization in a K-dimensional Euclidean space given K and a weighted graph, is an NP-hard problem with applications to clock synchronization, wireless sensor network localization, protein conformation, control of autonomous vehicles and more. We present fast exact and approximate methods for solving such problems.

■ TA-12

Tuesday, 8:30-10:00 - Room 004

Graphs and Networks V

Stream: Graphs and Networks
Invited session
Chair: *Pavel Irzhavski*

1 - Improved Bounds on the Generalized Acyclic Chromatic Number
Guiying Yan, Yuwen Wu

An r-acyclic edge chromatic number of a graph G is the minimum number of colors used to produce an edge coloring of the graph such that adjacent edges receive different colors and every cycle C has at least min(|C|, r) colors. We prove that the r-acyclic edge chromatic number of a graph G is not larger than (4r + 1)Delta(G), when the girth of the graph G equals to max(50, Delta(G)) and r ranges between 4 and 10. If we relax the girth restriction to max(220, Delta(G)), the upper bound of the r-acyclic edge chromatic number of a graph G is not larger than (2r+5)Delta(G) with r between 4 and 10.

2 - New Technique of Coloring of Vertices in the Graphs
Abdelouhab Aloui, Kamal Amroun

The vertex coloring problem has received much interest these later years. If each vertex of the graph G can be assigned one of the k colors, such that adjacent vertices get different colors we say that G is k-colorable. The smallest sufficient number of colors is called the chromatic number of G. The problem consists of giving the chromatic number of G. In this paper we give a new technique for the determination of the chromatic number of certains classes of graphs.

3 - A Fast Greedy Sequential Heuristic for the Graph Colouring Problem
Larisa Komosko

In this talk we present a fast greedy sequential heuristic for the graph colouring problem. Its high performance is based on two improvements. First after colouring the current vertex we mark its colour as forbidden for its neighbours. Second we calculate a colour for the current vertex and forbid it for its neighbours by means of bitwise operations with adjacency and colour matrices. In the colour matrix c_ij=1 if vertex j can be coloured in colour i and c_ij=0 if colour i is forbidden for it. In comparison with the classical greedy heuristic the speedup reaches 100 times on DIMACS instances.

4 - On the Complexity of the Hamiltonian Cycle Problem in Locally Connected Graphs
Pavel Irzhavski

Chartrand and Pippert (1974) proved that a locally connected graph of maximum degree at most 4 and nonisomorphic to K(1,1,3) is Hamiltonian. Gordon et al. (2011) showed that a connected locally connected graph of maximum degree 5 and minimum degree at least 3 is Hamiltonian. They also showed that the Hamiltonian cycle problem is NP-complete in locally connected graphs of maximum degree 7 and conjectured that bounding the maximum degree to 6 makes the problem polynomially solvable. We proved that the problem is NP-complete even for planar locally connected graphs of maximum degree 5.

■ TA-13

Tuesday, 8:30-10:00 - Room 123

Project Scheduling 2

Stream: Scheduling
Invited session
Chair: *Servet Hasgul*

1 - A Project Scheduling Algorithm Considering Resource Constraints and Seasonal Effects
Servet Hasgul, Cem Atasever

A resource-constrained project scheduling problem aims at scheduling a set of activities at minimal duration subject to precedence and limited resource availabilities. Resource costs and resource capacities may change seasonally. In this situation, resource scheduling has to be done by considering the seasonal variations. While the resource costs are under seasonal variations, the total cost is aimed to be minimized. In this study, an algorithm is designed for resource constrained project scheduling with seasonal variation, and some experiments are conducted on the test problems.

2 - Project Scheduling with Rework: An Application in the Animation and Videogame Industry
Gonzalo Enrique Mejia Delgadillo, Karen Niño, Maria Angélica Sánchez Olaya

This research presents a Petri Net-based approach for project scheduling with rework. The modeling of the project activities and the associated resources is accomplished via a Timed Place Petri Net. The static schedule is generated with a Beam Search algorithm which explores the Petri Net state space. The same algorithm is adapted to handle reworks. In this way we are able to calculate a more realistic schedule and simulate its execution. We test our approach on a real project from the Animation and Videogame (A&V) industry and compare the results versus the current practice.

3 - Multimode TCSP with Generalized Temporal Constraints: A MILP Formulation
Tamara Borreguero, Miguel Ortega-Mier, Álvaro García-Sánchez
In this work, we present an Event Based MILP formulation for a Multimode Time Constraint Scheduling Problem of direct application for some industries, such as aeronautical assembly lines. Taking as a starting point a RCSP Event Based MILP formulation, our contribution is threefold: we include the allowance of multiple modes per task as well as the use of more general temporal constraints. Also it has been dealt as a TCSP rather than a RCSP. This alternative approach is more suitable for some industries where the total makespan is usually fixed by the production rate or the client demand.

4 - Genetic Algorithm for a Two-Agent Scheduling Problem with Position-Dependent Learning Effects
Jin Young Choi
We consider a two-agent single-machine scheduling problem with linear job-dependent position-based learning effects. Specifically, two agents competing for the usage of the common single machine have their own objectives to minimize the sum of the weighted completion times and to limit the makespan within a given upper bound, respectively. Moreover, the job processing times are determined by the learning effects and the processing sequence. To solve this problem, we developed an efficient genetic algorithm to find a near optimal solution and verified its performance by a numerical experiment.

■ TA-14
Tuesday, 8:30-10:00 - Room 124

DEA in Transportation and Logistics

Stream: DEA Applications
Contributed session
Chair: *Cristiano Morini*

1 - Evaluating the Operational Efficiencies of Bus Transit Systems Considering Air Pollution
Chao-Chung Kang
This paper employed slack-based measure models with and without undesirable outputs to assess the technical efficiency for bus transit firms because air pollution factors were seldom incorporated in analysis efficiency before. A case study with 12 bus transit firms for years 2007-2010 is conducted. The results indicate that the efficiency scores obtained from the SBM without undesirable outputs are estimated more than those with the undesirable outputs. In addition, the technical efficiency with air pollution emissions has significantly differed from that without considering them.

2 - Efficiency Analysis of Seaport Container Terminals in Brazil
Cristiano Morini, Matheus Mauricio, Anibal Azevedo, Rodolfo Cunha, Edmundo Ignacio Junior, Antônio Moretti
The increase of flow of goods through Brazilian seaports has revealed inefficiencies in operations. This study aims to identify relative efficiencies in main seaport container terminals in Brazil. The method considers the Data Envelopment Analysis (DEA). Berth extension and stowage available area are input variables. Outputs are container movements, mooring services, and tons of cargo stowed in containers. A sensibility analysis was included. The biggest port in number of container movements in Brazil, Port of Santos, does not achieve upper levels in the variables observed.

■ TA-15
Tuesday, 8:30-10:00 - Room 125

Behavioral Research in Pricing and Revenue Management

Stream: Revenue Management II
Invited session
Chair: *Ioana Popescu*

1 - Dynamic Pricing in the Presence of Social Learning and Strategic Consumers
Nicos Savva, Yiangos Papanastasiou
When a product of uncertain quality is first introduced, consumers may be enticed to strategically delay their purchasing decisions in anticipation of the product reviews of their peers. This paper investigates how the presence of social learning interacts with the adoption decisions of strategic consumers and the dynamic-pricing decisions of a monopolist firm, within a simple two-period model. We examine two cases: pre-announced and responsive pricing.

2 - Pricing with Anticipation
Javad Nasiry, Ioana Popescu
We study a market where customers derive emotional utility from anticipating pleasurable purchase outcomes, but experience disappointment if outcomes fall short of what they anticipated. In this context, we show that firms can profit by adopting randomized pricing policies.

3 - Impact of Price Recommendation Tools by Salespeople
Wedad Elmaghraby
We investigate how salespeople use the information provided to them to set the prices; of particular interest to us is how salespeople use price recommendations coming from a decision support tool. We do this by building reduced-form models and testing those on a data set obtained by a grocery products distributor. We identify customer-specific and salesperson-specific market factors that moderate the influence of the price recommendations.

4 - Social Influence and Customer Spending in Online Games
Ioana Popescu, Yue Wu, Paddy Padmanabhan
Monetization is a major challenge for companies offering free-to-play online games. Using a unique and very rich industry data set, we investigate the determinants of customer spending in an online multi-player computer game. In particular, our empirical analysis quantifies the effect of social influence on customer spending.

■ TA-16
Tuesday, 8:30-10:00 - Room 127

Copositive and Polynomial Optimization V

Stream: Copositive and Polynomial Optimization
Invited session
Chair: *Immanuel Bomze*

1 - Towards Absolute Delivery Schedule Reliability in Container Liner Shipping Using Copositive Cones
Zhichao Zheng, Abraham Zhang, Siu Lee Lam, Chung Piaw Teo
Container liner shipping is crucial to global supply chain performance as it is the primary mode of moving goods across continents. Partly due to inherent uncertainties at sea and ports, the liner shipping industry has long had a notorious reputation of schedule unreliability. We exploit the connection between distributionally robust optimization and conic programming to formulate a copositive programming model for the liner scheduling problem. Comprehensive analysis of copositive schedules with real data and a detailed simulation model reveals interesting insights on liner schedule design.

2 - Copositive Optimization Based Bounds on Box Constrained Quadratic Optimization
Gizem Sağol, E. Alper Yildirim
Box constrained quadratic optimization problems (BoxQPs) can be formulated as a linear optimization problem over the cone of completely positive matrices in several different ways. We consider two alternative formulations. We study the sequences of upper and lower bounds on the optimal value of a BoxQP arising from two hierarchies of inner and outer polyhedral approximations for both of these formulations.

3 - Completely Positive Reformulations for Polynomial Optimization
Luis Zuluaga

There is a well-established body of research on quadratic PO problems based on reformulations of the original problem as a conic program over the cone of completely positive (CP) matrices. We consider PO problems that are not necessarily quadratic and provide a general characterization of the class of PO problems that can be formulated as a conic program over the cone of CP tensors. As a consequence, it follows that recent results for quadratic problems can be further strengthened and generalized to higher order PO problems.

■ TA-17

Tuesday, 8:30-10:00 - Room 005

Nonconvex Programming: Local and Global Approaches I

Stream: Global Optimization
Invited session
Chair: *Hoai An Le Thi*
Chair: *Tao Pham Dinh*

1 - A DC Programming Approach for Sparse Linear Discriminant Analysis (LDA)
Duy Nhat Phan, Hoai An Le Thi

LDA is a standard tool for classification and dimension reduction in many applications. However, the problems of high dimension is still a great challenge for the classical LDA. We present a novel approach to the sparse LDA and develop a sparse version of mixture discriminant analysis. Our work is based on the optimal scoring and the zero-norm. The difficulty in treating the zero-norm is overcome by using an appropriate continuous approximation such that the resulting problem can be formulated as a DC (Difference of Convex functions) program to which DCA (DC Algorithms) is investigated.

2 - DC Programming and DCA for Solving Binary Quadratic over a Special Polytope
Hoai An Le Thi, Tao Pham Dinh, Hoai Minh Le

The problem is first equivalently reformulated as quadratic minimizations over a polytope with the help of exact penalty whose penalty parameter is known. Appropriate DC decompositions and their resulting DCA are investigated for solving the corresponding DC programs. Some choice strategies of initial points for DCA via DC/SDP relaxation are developed. Finally computational experiments are conducted on some real-world problems.

3 - Feature Selection for Ranking based on DC Programming and DCA
Hoai Minh Le, Hoai An Le Thi, Tao Pham Dinh

Ranking is a very important topic and has recently emerged as a crucial issue. Given a set of objects, ranking methods compute a score for each of them and then the objects are sorted according to the scores. We deal with the problem of feature selection in Ranking. The problem can be formulated as a mixed integer quadratic program. We first reformulate the original problem as a continuous one then develop an efficient algorithm based on DC programming and DCA for solving the resulting problem. Numerical experiments on real world datasets show the efficiency of the proposed method.

4 - The Performance of the Flying Elephants Approach for Solving Traditional Non-Differentiable Problems
Adilson Elias Xavier, Vinicius Layter Xavier

Flying Elephants is a generalization and a new interpretation of the Hyperbolic Smoothing approach. The name is definitely not associated to any analogy with the biology area. It is only a metaphor. The Flying feature is directly derived from its differentiability property, which permits intergalactic trips of the Elephant into spaces with large number of dimensions, differently of the short local searches associated to traditional heuristics. Computational results for solving distance geometry, covering, clustering, Fermat-Weber and hub location problems show the performance of the approach.

■ TA-18

Tuesday, 8:30-10:00 - Room 112

Robustness in Multiobjective Optimization I

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Christiane Tammer*
Chair: *Alexander Engau*

1 - A Unified Approach for Different Concepts of Robustness and Stochastic Programming via Nonlinear Scalarizing Functionals
Christiane Tammer, Kathrin Klamroth, Elisabeth Köbis, Anita Schöbel

We show that many different concepts of robustness and of stochastic programming can be described as special cases of a general nonlinear scalarization method by choosing the involved parameters and sets appropriately. This leads to a unifying concept which can be used to handle robust and stochastic optimization problems. Furthermore, we introduce multiple objective (deterministic) counterparts for uncertain optimization problems and discuss their relations to well-known scalar robust optimization problems by using the nonlinear scalarization concept.

2 - The Relationship Between Multicriteria Robustness Concepts and Set-Valued Optimization
Elisabeth Köbis, Christiane Tammer, Anita Schöbel, Daishi Kuroiwa, Jonas Ide

We present connections between concepts of robustness for uncertain multi-objective optimization problems and set-valued optimization. We extend some of the existing concepts to general spaces and cones. Furthermore, we derive new concepts of robustness for multi-objective optimization problems using different set relations. We point out that robust multi-objective optimization can be interpreted as an application of set-valued optimization. Finally, we provide algorithms for solving uncertain multi-objective optimization problems.

3 - Pareto Efficiency in Robust Optimization
Nikos Trichakis, Dan Iancu

We formalize the concept of Pareto efficiency in the context of the robust optimization (RO) methodology. We characterize Pareto robustly optimal (PRO) solutions, and extend the RO framework by proposing methods to verify Pareto optimality and generate PRO solutions. Our approach requires solving problems that are of the same complexity as the nominal RO problems, and numerical experiments demonstrate the significant potential upside of PRO solutions compared with classical RO solutions.

4 - Trade-Offs - A Lost Dimension in Robust Optimization?
Alexander Engau

This presentation explores a question similar to the one posed by Ignacy Kaliszewski in his paper "Trade-Offs - A Lost Dimension in Multiple Criteria Decision Making" in 2002. We will investigate the role of tradeoffs in robust compared to stochastic optimization and subsequently offer several new approaches to compromise between advantages and drawbacks of these two different paradigms. Our discussion will both address relationships to scalarization functions in multiobjective programming and provide several new results about the existence and characterization of properly efficient solutions.

■ TA-19

Tuesday, 8:30-10:00 - Room 128

Retail Forecasting

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Kai Hoberg*

1 - Weather Effect on Apparel Sales in France
Jean-Louis Bertrand, Xavier Brusset

In 2012, French apparel industry suffered weak sales for the fifth consecutive year. Trade professionals feel that the weather played a significant role. Its impact on retail sales in general has not been formally quantified. This is an urgent issue for managers in climate-sensitive sectors as climate change is aggravating naturally occurring climate variability. In this paper we provide managers with tools to evaluate the impact of temperature anomalies on sales volumes. We present a statistical method to separate out the weather effect from the underlying real performance of apparel sales.

2 - The Influence of Weather in Online Retailing - An Empirical Analysis
Kai Hoberg, Sebastian Steinker

In this paper, we incorporate weather information into the sales forecast of a European online fashion retailer. Based on actual weather information we find a highly significant impact of sunshine, temperature and rain, in particular in the summer, on weekends and on days with extreme weather. Our analysis highlights that daily fluctuations of online sales, that are attributable to the weather effect, can be as much as 18.8%. Using weather forecasts we are able to improve the forecasting accuracy by an incremental 62.4% on weekends that require special attention from a logistics perspective.

3 - Collaborative Forecasting and Channel Coordination in a Perishable Goods Chain
Jan van Dalen, Clint Pennings

We examine the collaborative forecasting process in a perishable goods chain with one supplier and many different retailers. The supplier has access to the point-of-sales data of its retailers and recommends an order quantity per SKU for each store (this recommendation also includes an assortment proposition). The retailer can accept this offer or propose a different quantity, after which they jointly decide on a final number. We analyze how this channel coordination process was set up, how it is affected by the forecast performance, and how the process changes over time.

4 - Public Forecast Information Sharing in a Market with Competing Supply Chains
Noam Shamir, Hyoduk Shin

Studying the operational motivation of a retailer to publicly announce his forecast information, this paper shows that by making forecast information publicly available to both his manufacturer and to the competitor, a retailer is able to credibly share his forecast information - an outcome that cannot be achieved by merely exchanging information within the supply chain. We show that just by announcing his forecast publicly a retailer can induce the manufacturer to invest in the proper capacity level.

■ TA-20

Tuesday, 8:30-10:00 - Room 129

From the Old to the New: Managing the Transformation of our Energy System

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Valerie Thomas*

1 - Learning in Optimization: Integrated Assessment Modeling of Climate Change under Uncertainty
Soheil Shayegh, Valerie Thomas

We develop a method for finding optimal greenhouse gas reduction rates under uncertainty from climate parameters. Uncertainty about climate change includes both overall climate sensitivity and the risk of extreme tipping point events. We introduce a two-step-ahead approximate dynamic programming algorithm to solve the finite time horizon stochastic problem. The uncertainty in climate sensitivity may narrow in the future as the behavior of the climate continues to be observed and as climate science progresses. We use a Bayesian framework to update the two correlated uncertainties over time.

2 - Grid Integration Costs and the Optimal Climate Change R&D Portfolio
Robert Barron, Noubara Djimadoumbaye, Erin Baker

Many low carbon energy technologies incur integration costs when connected to the grid. This paper examines the impact of grid integration costs on the optimal energy technology R&D portfolio for minimizing the cost of climate change. This paper's goal is to place bounds on the size of the problem, and to determine under what circumstances integration costs are relevant to policy design. This research finds the importance of getting grid integration costs right depends on the specific question that is being asked: how to allocate a given budget, or what the size of the budget should be.

3 - Optimisation of Intelligent Oil Wells using Stochastic Algorithms
Morteza Haghighat Sefat, Khafiz Muradov, Ahmed ElSheikh, David Davies

Oil production enhancement in intelligent fields is a nonlinear, high-dimension, conditional optimisation problem with a computationally expensive objective function. Stochastic estimated-gradient-based optimisation algorithms have proved to be an effective tool to solve this class of problems. Solutions to this challenging problem using the Simultaneous Perturbation Stochastic Approximation (SPSA) and Ensemble-based Optimisation (EnOpt) algorithms are evaluated and their performance compared for multiple case studies. Optimisation guidelines will also be provided.

4 - Understanding the Diffusion of Residential Solar Panels using a Hazard Rate Model
Sebastian Souyris, Varun Rai

In this talk we will discuss the diffusion of residential solar panels in the US. What types of households are keener to install solar PV? What factors enter into account in the decision process? What types of marketing campaigns are more efficient to incentivize adoption? Is word of mouth playing a role in the diffusion? In what degree the historic and forecasted electricity prices do affect the adoption decision? To answer these questions, we collect a detail adopters data set and we cross it with other data streams. We analyze these data using a Hazard Rate Model.

■ TA-21

Tuesday, 8:30-10:00 - Room 006

Optimization Modeling Applications in Manufacturing 1

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *Tugba Saraç*

1 - Minimisation of Production Costs and Chemical Pollutants in a Tin Foundry Plant
Janis Martinez, Juan Cabrejos

The investigation consisted in the design of a mathematical model, adapted from Kim and Lewis (1987), which allows the reduction of production costs in a tin foundry operation and the reduction of pollutants. This investigation was motivated by the insufficient quantitative techniques in the production programming around foundry operations, where the effect a batch has over others is not considered. After testing the model, the results indicated estimated savings of $1'192,433 per year, an estimated saving of 23% in the use of the melting furnace and a decrease in the content of pollutants.

2 - Advanced Optimization and Simulation-based Tool for Complex Automated Manufacturing Systems
Carlos A. Mendez, Natalia Basán

A unified computational decision-making tool based on mixed integer programming, discrete-event simulation and improvement-based approaches for the efficient operation of complex industrial processes will be presented. The principal aim of this work is to provide a computer-aided tool for solving industrial-scale automated flow-shop scheduling problems in a computationally efficient way. We will centre our attention in a real-world problem arising in the automated wet-etch station during the fabrication of wafer's lots in the semiconductor manufacturing industry.

3 - A Multi-Objective Optimization Approach for Plastic Injection Molding Machine Scheduling Problem
Tugba Saraç, Aydin Sipahioglu

In this study, the multi-objective plastic injection molding machine scheduling problem is considered. Since this problem is a very complicated one, a two stepped solution approach is proposed. In the first step, a goal-programming model is used for assigning jobs to the machines. In the second step, schedules of each machines are obtained using another mathematical model. In order to show the performance of the proposed solution approach, randomly generated instances are solved using the GAMS Cplex solver and obtained results are presented.

4 - Project Selection with Uncertain Lifetime and Initial Outlay
Xiaoxia Huang, Qun Zhang

In traditional project selection, lifetimes of candidate projects are all treated as deterministic numbers, which is usually not suitable in real life. In this paper, we treat the projects lifetimes as uncertain variables. In addition, considering the complex of real world, we also regard the initial outlays of the candidate projects as uncertain variables. Using uncertainty theory, a new optimization project selection model is developed. In addition, to help investors use the existing tools to solve the problem, the deterministic equivalents of the model is also provided.

■ TA-22

Tuesday, 8:30-10:00 - Room 007

Cooperation in Operations Management

Stream: Game Theory and Operations Management
Invited session
Chair: *Ana Meca*
Chair: *Ignacio García-Jurado*

1 - Cost Allocation in Inventory Pools with Service-Differentiated Demand Classes
Mario Guajardo, Mikael Rönnqvist

We consider an inventory pool subject to a service level constraint, where the members of the pool may have different target service levels. This occurs, for example, in inventory of spare parts for oil and gas operations. We show examples where a cost allocation method results in core-stable allocations when the members have the same target service levels, but not when these targets differ. In order to deal with this problem, we propose the novel Minimum Deviation from the Service Level Referential Cost Method (MIND). The resulting allocation is core guaranteed, if the core is not empty.

2 - Cooperation in Service Systems: The 3-D Assignment M/G/c/c Game
Shoshana Anily

We consider a cooperative game that consists of a number of M/G/c/c queuing systems (players), each is associated with a Poisson arrival rate, mean service rate, and a room size. The cost of a system is the average number of lost (blocked) customers. When a coalition of systems is formed, the service rates and room sizes are reassigned to the arrival rates in order to minimize the average number of lost customers. This 3-D assignment (bi-permutation) problem is NP-complete. Interesting results on the balance and on the core of this cooperative game will be presented.

3 - Centralized Inventory in a Farming Community
Manuel Alfredo Mosquera Rodríguez, Mª Gloria Fiestras-Janeiro, Ignacio García-Jurado, Ana Meca

A centralized inventory problem is a situation in which several agents face individual inventory problems and make an agreement to coordinate their orders with the objective of reducing costs. In this paper we identify a centralized inventory problem arising in a farming community in northwestern Spain, model the problem using two alternative approaches, find the optimal inventory policies for both models, and propose allocation rules for sharing the optimal costs in this context.

4 - Cooperation in Capacitated Inventory Situations with Fixed Holding Costs when Shortages are Allowed
Ignacio García-Jurado, Mª Gloria Fiestras-Janeiro, Ana Meca, Manuel Alfredo Mosquera Rodríguez

We analyze a situation in which several firms deal with inventory problems concerning the same type of product. Each firm uses its limited capacity warehouse for storing purposes and faces an economic order quantity problem where storage costs are irrelevant and shortages are allowed. We show that firms can save costs by placing joint orders and we obtain an optimal order policy for the firms. Besides, we identify an associated class of cost games which we show to be concave. Finally, we introduce and study a rule to share the costs among the firms which provide core allocations.

■ TA-23

Tuesday, 8:30-10:00 - Room 008

Behavioural Issues in Problem Structuring

Stream: Behavioural Operational Research
Invited session
Chair: *Leroy White*

1 - Exploring Novice Facilitated Modelling Supported by Scripts
Elena Tavella, Thanos Papadopoulos

There is limited research on how novice facilitators use scripts to successfully manage Facilitated Modelling (FM) and achieve workshop outcomes. We explore this gap by presenting a micro-level analysis of a transcript from a FM workshop held in a food cooperative in Denmark. We identify two distinct script-supported FM behaviours and related facilitation practices that enable novices to (a) acquire skills and technical competencies; and (b) switch between and combine skills and technical competencies to successfully manage workshops and achieve outcomes.

2 - Coat-Tailing Behaviour in Decision
Isabella Lami, Leroy White

Most of the practice-based studies of the process of OR does not explicitly consider the issues relating to visualisation and boundary objects. By building on the concepts drawn from activity theory, we identify several patterns of behaviour and enactments in practice. Empirical evidence is based on a post- analysis of two infrastructure projects. Our findings show that successful collaboration is based on coat-tailing systems. Coat-tailing means to inextricably bind together individual action and collective activity through careful design of technological, mental and cultural artefacts.

3 - Behavioural Issues in PSMs
Leroy White

Problem structuring settings functions most obviously as a vehicle for knowledge exchange and mobilisation. However, they also play a valuable socio-psychological role, enabling the participants both to pass on important facets of their understanding of the problem at hand while continuing to want to make an impact on the organisational world they are in. This paper will provide some thoughts on the behavioural aspects of PSM interventions, drawing on insights from situated social cognition, social networks and systems thinking theories.

4 - Integrating TRIZ with DEMATEL to tackle a systematic problems on evaluating the cloud system for long-term healthcare
Sam Liu, Dong Shang Chang, Yi-chun Chen

The methodology of TRIZ has been widely employed on technology innovation and extended to resolve managerial decision issues. Although there are some useful approach being proposed to deal with the misuse of mental models in TRIZ for identifying conflict among resolutions, the generated alternatives might be little applicable in real setting due to lacking of systematic analysis aspect. With newly development on DEMATEL approach, it strengthens the quality of decision making by incorporate systematic viewpoint on risk. This study aims to integrate the TRIZ with the DEMATEL for tackling systema

■ TA-24

Tuesday, 8:30-10:00 - Room 212

Ethics and OR I

Stream: OR and Ethics
Invited session
Chair: *Cristobal Miralles*
Chair: *Fred Wenstøp*

1 - Implications of Nomology for Ethics
Cathal Brugha

This paper uses nomology to develop a three-level model for ethics. At the top level ethics focuses on commitment to values. At the middle level ethics in company practice usually is about serving the interests of the company, employees and the environment. At the lowest level it is about implementing the above levels by making adjustments to ensure that there is a balance between sets of issues such as responsibility, transparency, authority and accountability. The paper gives examples of ethics' codes of practice used by companies to show how they illustrate the three-level model.

2 - Operational Research Virtues in the Face of Climate Change
Fred Wenstøp, Søren Wenstøp

To expect operational researchers to be virtuous has an honorable tradition, and virtues are even more important now in the context of climate change. We identify scientists' virtues that we believe are conducive for work with mitigation, adaption, restoration, etc. This includes a humble, accurate, and truthful understanding of the complex dynamic processes, which are changing the world we live in. We present a simple dynamic model of the global energy balance, which demonstrates the processes involved in global warming.

3 - Strengthening Decision-Making for Emergency Planning using Participatory Problem Structuring: A Case of Operational Research in the New Zealand Volunteer Sector
Robyn Moore

This is an account of collaborative decision-making for emergency planning in the volunteer sector, using the problem structuring methodology Theory of Constraints in a facilitated World café-style workshop. An emergency plan is ethically acceptable depending on its substantive content (what it tells people to do and the consequences of doing it) and on the deliberative process used to approve it (Jennings, 2014). The World café setting was used to gather rich data from 35 managers of volunteers, while TOC was used to examine and represent their perspectives in a structured way.

4 - Ethical Rationality: Enriching Economic Rationality with Values and Dreams
Marc Le Menestrel

Ethical Rationality articulates economic rationality with values that are excluded from it. Taking the point of view of decision sciences, I summarize some key limitations of the economic paradigm of rationality at the descriptive, normative and formal levels. I then show how extending this paradigm leads to a more open form of rationality, where actors face dilemmas which can be objectively studied but do not necessarily have a normative solution. Descriptive observation of actual behaviour reveals how these actors have chosen to give weight, or not, to values beyond economic values.

■ TA-25

Tuesday, 8:30-10:00 - Room 009

Applications of Game Theory

Stream: Mathematical Economics
Invited session
Chair: *Elena Mielcová*

1 - Multi-Criteria Games: Ranking of Companies using Financial Indicators
Adriana Kroenke, Nelson Hein, Volmir Wilhelm

This research aimed to evaluate the accounting placement of the iron and steel companies listed on the BM&Fbovespa (Brazil) in 2012 by means of multi-criteria games, using four lots of financial indicators. Reading is done using business strategies as player I and financial indicators as the strategies of player II. The first ranking was defined through the methods suggested by Fernández, Monroy and Puerto (1998). The second is an adaptation of the first, with the inclusion of goals. The third ranking was inspired by the work of Sakawa and Nishizaki (2001), using diffuse goals.

2 - Transboundary Environmental Problems: A Multicriteria Games Approach
Naouel Yousfi, Mohammed Said Radjef, Fazia Aoudia-Rahmoune, Aichouche Oubraham

The present paper deals with transboundary environmental problems. In order to incite the countries to join an international environmental agreement, we propose to link environmental negotiations to trade negotiations. Several works are based on this idea, but considering distinctly the two aspects. To avoid this limit, we used the multicriteria games. The constructed game is solved using the Pareto-Nash equilibrium concept and an aggregation method. Thus, we determine following the weights used in the aggregation method, the most favorable situation to the emergence of linked agreements.

3 - Asymmetric Shapley-Shubik and Banzhaf Power Indices Applied on Real Voting Data
Elena Mielcová

The main aim of this paper is to compare the results of classical Shapley-Shubik and Banzhaf power indices with results of the respective asymmetric power indices extended to the cooperative games with real coalitions applied on the real data of the cooperative simple game — in this case the data from the voting in the Lower House of the Czech Parliament 2006-2013. Results indicate the improvement in predictability of the real power of existing political coalitions comparing to the values based on the classical Shapley-Shubik and Banzhaf power indices.

■ TA-26

Tuesday, 8:30-10:00 - Room 010

Fuzzy Decision Making 2

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Martin Gavalec*
Chair: *Jaroslav Ramik*

1 - X-Simplicity of a (Strong) Tolerance Eigenvector and an Interval Fuzzy Matrix
Ján Plavka, Martin Gavalec

Fuzzy matrices can be used in a range of practical problems related to scheduling and fuzzy optimization. A fuzzy matrix is said to have an X-simple image eigenspace if any eigenvector belonging to interval vector X is the unique solution of the corresponding system fuzzy linear equalities in the interval vector. We present equivalent condition for interval matrix and (strong) tolerance eigenvector to have an interval version of X-simple image eigenspace and polynomial algorithms for checking of interval X-simplicity are introduced. Supported by the grants APVV-04-04-12 and GACR-14-02-424S.

2 - Eigenspace Structure of a Max-Lukasiewicz Matrix
Zuzana Nemcova, Martin Gavalec

Max-Lukasiewicz algebra belongs to the family of max-T fuzzy algebras. The multiplication of vectors and matrices in these algebras uses the binary maximum operation and a triangular norm T (T is the Lukasiewicz triangular norm in this contribution). Classification of the eigenspace structure of a matrix over the max-Lukasiewicz algebra will be presented. Computation of the basic characteristics of matrices will be illustrated by examples, and Illustrative graphs and spatial representation of the eigenspace will be given.

3 - Topologies and Uniformities of Rough Set Approximations
Milan Vlach

To extend the range of applicability, the original rough set theory has been generalized from various viewpoints. We deal with two generalizations. One is based on replacing the equivalence relations by more general binary relations, the second relaxes the partitions to more general coverings. First, we discuss relationships between set approximations in the relation-based and covering-based rough set models. Then we draw attention to the important (and often overlooked) fact that some approximation operators induce not only topologies but also uniformities.

4 - Tolerance Eigenproblem in Fuzzy Algebra
Martin Gavalec, Ján Plavka

The tolerance eigenproblem in fuzzy algebra concerns several important classification types of the interval eigenvectors which are motivated by the fact that most of the practical applications work with imprecise input data. The following types of tolerated eigenvectors will be investigated: the strongly tolerated, the tolerated and the weakly tolerated eigenvector. The existence and the description of such eigenvectors will be presented. The relations between the considered eigenvectors are also studied and illustrated by examples. Supported by the grants APVV-04-04-12 and GACR-14-02-424S.

■ TA-27

Tuesday, 8:30-10:00 - Room 213

Advances in Operations/Marketing Interface

Stream: Operations/Marketing Interface
Invited session
Chair: *Kerstin Schmidt*

1 - Considering the Effective Ad Promotion Tool by Palmore's Cohort Analysis
Qin Nuo, Satoshi Takeuchi, Cong Tingting, Hong Seung Ko

Picking up an effective promotion tool for getting customers is a very important issue connected with the company's sales and profits. But, we cannot say that in the changing business environment, the current promotion tool with high effects is certainly useful in the future. Thus, it is needed to prospect which promotion tool will produce a high effect in the future. We quantify the effect of promotion tools and then analyze it with using data related to the current main promotion tool. Consequently, we suggest the efficient promotion tool in the future by Palmore's cohort analysis.

2 - Coordination by Contracts in Distributed Product Development Processes with Complete Substitution
Kerstin Schmidt, Thomas Volling, Thomas Spengler

In distributed product development processes system integrators collaborate with suppliers to provide marketable products. Considering a converging supply chain with two suppliers and one system integrator, we apply a Stackelberg game to model the contract-based coordination of such processes under uncertain development results, complete substitution and maximum price clause. Assuming uniformly distributed development results, we analyze the coordination ability of a wholesale price contract and a penalty contract and present numerical illustrations of centralized and decentralized solutions.

■ TA-28

Tuesday, 8:30-10:00 - Room 130

Challenge ROADEF/EURO 3

Stream: Challenge ROADEF/EURO
Award Competition session
Chair: *Eric Bourreau*

1 - Two Phase Approach Combining Heuristic and Integer Programming for SNCF Rolling Stock Problem
Mirsad Buljubasic, Michel Vasquez, Haris Gavranovic, Saïd Hanafi

We propose a two phase approach combining mathematical programming and heuristics for the ROADEF/EURO challenge 2014, dedicated to the rolling stock management on railway sites problem proposed by SNCF. In the first phase, a train assignment problem is solved with a combination of a greedy heuristic and integer programming. The objective is to maximize the number of assigned departures while respecting technical constraints. The second phase consists of scheduling all the trains in the station's infrastructure while minimizing the number of canceled departures, using a constructive heuristic.

2 - Solving the ROADEF/EURO 2014 Challenge by a Double Column Generation Based Heuristic
Lucas Létocart, Marco Casazza, Antoine Rozenknop, Emiliano Traversi, Roberto Wolfler-Calvo

We present an exact formulation for the ROADEF/EURO 2014 Challenge based on an exponential number of variables and constraints. We solve it heuristically using an exact separation algorithm for the incompatibility constraints and a double column generation for the scheduling and routing variables. The pricing problem for the train scheduling consists of solving a matching problem that couples trains with departures and adding maintenance when needed. The pricing problem for the train routing consists of solving a shortest path problem with resource constraints on a discrete time horizon.

3 - Modeling the Rolling stock unit management problem with Mixed Integer Programming and Constraint Programming
Hadrien Cambazard, Nicolas Catusse

We propose a solving methodology based on modeling with MIP + CP technologies. Due to the complexity of the problem formulation, we believe that a robust engineering is easier to achieve by relying on models rather than dedicated code. Firstly, we suggest handling the assignment of the arrivals to the departures as well as the choice of platforms for all events. Secondly, we address the routing under time-windows constraints.

■ TA-29

Tuesday, 8:30-10:00 - Room 011

Multiple Criteria Decision Making and Optimization 2

Stream: Multiple-Criteria Decision Making and Optimization
Contributed session
Chair: *Nikolaos Matsatsinis*

1 - Performance Evaluation of European Insurance Companies: A Comparison of Robust MCDA Approaches
Constantin Zopounidis, Giacomo Nocera, Michael Doumpos, Emilios Galariotis

In this study we apply and compare multicriteria models based on multiattribute value theory and outranking relations for the evaluation of the financial performance of insurance companies. Emphasis is given on the robustness of the results with respect to the specification of the models' parameters. The analysis is based on a large European sample over the period 2000-2012. At a second stage the multicriteria results are analyzed to identify differences between countries as well as to examine the role of non-financial attributes on the performance of insurance companies.

2 - A Multicriteria Approach to Sort Time Series Models Applied to Stochastic Scenarios Generation
Hugo Ribeiro Baldioti, Bruno Ribeiro, Fernando Luiz Cyrino Oliveira, Reinaldo Souza

In the context of the Brazilian energy planning, some stochastic models are proposed for generating energy scenarios, whose adherence to the historical data is measured by statistical criteria, applied independently. This paper proposes the development of a methodology able to sort the models using a multicriteria approach, through the Analytic Hierarchy Process. Aiding the decision maker, the proposed method has been efficient and indicates, through sensitivity analysis of the attributes, the volatility of the alternatives, pointing at different options from the current model.

3 - Selection of Investment Alternatives in Power Generation Expansion using Multiobjective and Multicriteria Optimization Methods
Mariantonieta Molina, Jose Ceciliano Meza, Néstor Raúl Ortiz Pimiento

This research proposes a framework based on a linear programming model to solve the multiobjective generation expansion planning problem in two phases. A Multiobjective method is used to decide the new capacity to install. Then, a multicriteria method is used to select the best alternative. Quantitative (economical, environmental) and qualitative (social, sustainability) criteria are considered. The projected demand is satisfied considering renewable and conventional sources, especially in places where there is not interconnection to the electrical system, focusing in a Colombian case.

4 - Educational Marketing Decision System Based on Multicriteria Analysis: The e-Marketing Online Platform
Nikolaos Matsatsinis, Evangelos Grigoroudis

e-Marketing Online is a modern web application that aims to familiarize students or potential entrepreneurs with modern marketing techniques and product development decisions. Offering a virtual market environment of products that simulates real-world situations, e-Marketing Online adopts the MARKEX methodology in order to enable users (or user teams) following modern marketing strategies. Through this approach, users gradually learn how to effectively implement MCDA methods in order to take essential decisions about product marketing or new product development.

■ TA-30

Tuesday, 8:30-10:00 - Room 012

Financial Mathematics 3

Stream: Financial Mathematics and OR
Invited session
Chair: *Teruyoshi Suzuki*

1 - Optimal Capital Injection Problem under Financial Crisis
Teruyoshi Suzuki

We will introduce an optimal capital injection problem and propose an algorithm to solve it. The problem can be represented by a linear programming formulation under Eisenberg and Noe's model. We present a sequential method to solve both the firm's payoff to debt holders and the government's capital injection to the firms. We will show that the priority rule of capital injection does not depend on the amount of the budget by the government.

2 - Multilevel Monte Carlo Simulation for Game Option
Hitoshi Inui, Katsunori Ano

In this talk, we present the valuation method of Game option (Kifer (2000)) by multilevel Monte Carlo (MLMC) method that was originally developed by M.B. Giles (2008). From the view point of variance decaying, it has been reported that MLMC performance is superior to the performance of the standard Monte Carlo (SMC) method. We use MLMC and SMC to price the Game options based on Ano's dynamic programming backward search algorithm (Suzuki, Seko and Ano, RIMS Kokyuroku (2001)) . We compare the difference between SMC and MLMC.

3 - Optimal Impulse Control for Cash Management with Double Exponential Jump Diffusion Processes
Kimitoshi Sato, Atsuo Suzuki

We consider a cash management problem where the cash demand is assumed to be double exponential jump-diffusion processes. We formulate the model minimizing the sum of the transaction and holding-penalty costs as an impulse control model. The model reduces to the problem of solving a Quasi-variational Inequality (QVI), and the function satisfying QVI is derived. We show that there is an optimal policy of the two-band type. Moreover, we discuss the effect of jumps on the optimal policy through some numerical examples.

4 - American Double Exercise Put Option on Geometric Random Walk
Yuki Usui, Jun Oishi, Katsunori Ano

We study a discrete optimal double stopping problem for the American put type reward on geometric random walk, that is, on CRR market. It is shown that there exists double stopping boundaries and the optimal first and second stopping times are respectively the first hitting time to the corresponding boundary.

■ TA-31

Tuesday, 8:30-10:00 - Room 013

Processes of Applying MCDA

Stream: Decision Processes
Invited session
Chair: *Theodor Stewart*

1 - Problem Structuring for MCDA: Incorporating External Expertise
Valerie Belton

Facilitated workshops, in which a group of key stakeholders are helped to structure, build and use a multicriteria model, are a common and effective approach to MCDA. However, often it is not possible to bring together all those with relevant expertise and ownership. This talk will describe and reflect on the lessons learned from two case studies which have used different ways of sourcing expert input to inform the building of multicriteria models to be used by others, one associated with the UNEP MCA4Climate Project and the other the EPSRC Highly Distributed Energy Futures Project.

2 - Explanations for MCDA models
K. Nadia Papamichail, Theodor Stewart

This paper presents an explanation system that helps individuals and groups to build and interpret MCDA models. A library of text plans has been developed using natural language generation techniques. The system establishes what makes an alternative most favourable, highlights the pros and cons of choices and identifies those factors that differentiate between two options. Such explanations increase confidence and reduce overall cognitive effort.

3 - Decision Processes for MCDA in a Developing Countries Context
Theodor Stewart

In this paper we extract lessons learnt from using MCDA to facilitate policy analysis in a development context. Areas of application have included water resource management, fisheries rights allocation and operation of foodbanks. The challenges include the wide diversity of criteria that have to be elicited, including highly qualitative issues, and the diversity of stakeholders from PhD scientists to effectively illiterate fishermen. Simple post it sessions, summarized as causal maps, together with simple assessment methods have been found effective.

4 - A Multi-Criteria Multi-Period Decision-Making Approach for Sustainable Project Selection
Anissa Frini

This work is concerned with project selection in sustainable development context. This decision-making problem must guarantee a long-term balance between maintaining the integrity of the environment, the social equality and the economic efficiency. In addition, the consequences of projects have to be evaluated under uncertainty in the short, medium and long term horizons. This work will: i) provide a state-of-the-art survey on sustainable project selection and ii) propose a multi-criteria multi-period approach, which considers the requirements of sustainable development under uncertainty.

■ TA-32

Tuesday, 8:30-10:00 - Room 014

Disaster Management

Stream: Humanitarian Operations Research
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair: *Degang Liu*

1 - The Adaptive Orienteering Problem with Stochastic Travel Times
Irina Dolinskaya, Zhenyu (Edwin) Shi, Karen Smilowitz

In this work, we analyze an adaptive routing problem that arises in humanitarian relief settings. We focus on a specific variation of the Adaptive Orienteering Problem with Stochastic Travel Times (AOPST) that integrates path finding between the reward nodes. At the beginning of the time horizon, one commits to the set of reward nodes visited and the sequence of visits. During the planning horizon, as information on stochastic travel times is updated, the path between nodes to be visited can be adapted. We present the model, algorithms and analysis of results.

2 - Applying Multicommodity Transshipment Network Flow Optimization Technique under Uncertainty to Measure the Robustness of the Transportation Network for Emergent Situation
Novia Budi Parwanto, Hozumi Morohoshi, Tatsuo Oyama

Given a seriously emergent situation occurring, e.g., just after large-scale natural disasters, how to deal with victims, survivors, and damaged areas is a very critical and important problem. To obtain an optimal strategy for this problem we try to make necessary and desirable response strategies for managing emergent cases by solving multicommodity transshipment network flow optimization problems under various types of uncertain situations. Assuming uncertainty related with each road segment's robustness, obtained from applying Monte Carlo simulation technique and supply-demand situations.

3 - Modeling and Optimizing Disaster Relief Inventories
Degang Liu

As disasters happen at increasing frequency, disaster relief inventories become a very important social system for government and NGOs. Compared with commercial logistics systems, disaster relief inventories are less investigated. It also difficult to model because of its characteristics of social and political factors, great uncertainty in demand and supply, and uncertain distribution and transportation infrastructures during severe disasters. In this talk, we will present problems in modeling disaster relief inventory procurement, location, and distribution problems in china's situation.

4 - Software Platform for Managing UAV Operations
Dusan Starcevic, Mlađan Jovanović

Due to technological advances, interest in UAVs as a practical, deployable technological component in many civil applications is rapidly increasing and becoming a reality, as are their capabilities and availability UAV performs various kinds of missions such as mobile tactical reconnaissance, surveillance, law enforcement, search and rescue, land management, environmental monitoring, disaster management. UAV is a complex and challenging system to develop. In this paper we present software platform for visualizing, controlling and simulating UAV's data acquisition operations.

■ TA-33

Tuesday, 8:30-10:00 - Room 015

Defence and Security Applicatons

Stream: Defence and Security Applications
Invited session
Chair: *Ana Isabel Barros*

1 - Network Enabled Capabilities (NEC): From Long-Term Visions to Short-Term Operational Effects
Havard Fridheim, Stein Malerud, Frode Rutledal

Given the many visions on how Network Enabled Capabilities can increase future military operational effect, it is often surprisingly hard to identify relevant short-term NEC measures. Challenges include an insufficient description of current NEC maturity status, cultural differences, security concerns and limited funding of cross-service measures. Based on Norwegian experiences, we will discuss how a multi-methodological approach comprising problem structuring, scenario analysis and studies of military exercises can help measure current NEC maturity and identify relevant short-term measures.

2 - A New Approach to Deterrence: Planning to Achieve Deterrence Effects
Nicholas Taylor

Thinking regarding deterrence remains stuck in the Cold War. This presentation describes a new deterrence planning process that is being researched by the UK. The presentation provides an overview of deterrence theory and some of the shortcomings of the approaches taken by most nations. The steps of the new planning process are described, with proposals for its application. The presentation will finish with identification of challenges and issues posed by deterrence planning, activities and assessment. We will describe the current state of the UK research programme as well as the next stages.

3 - Assessment of a Conflict Intervention
Elin Marthinussen, Baard Eggereide

There is no easy solution to assess the situation in a conflict area. Nonetheless, this is an important task both during an international intervention, but also after such an intervention in order to evaluate the intervention and to identify lessons for future operations. Based on Norwegian operational research lessons from Afghanistan, we will discuss the challenges and best practices regarding such analysis and how the analysis of multiple data sets can be applied in support to the planning of future operations.

4 - Dealing with Complexity and Chaos: The Military Experience
Jan Frelin

Military doctrine stresses that defence forces have to handle complexity. In that situation, a mechanism for feed-back from the environment is necessary. The current methods for feedback have fallen short of requirements, creating a gap between military practice and doctrine. This failure is explained using theory from cognitive research, organizational learning and complexity research. Ways forward are suggested.

■ TA-34

Tuesday, 8:30-10:00 - Room 016

Portfolio Optimization 1

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Ralph E. Steuer*

1 - Asset Allocation Powered by Information Flow Correlation
Jose Faias

We propose an alternative approach to optimizing portfolios that reduces sampling error. The complete opportunity set holds the risk-free and two possible risky assets that are negatively correlated. The traditional approach is to maximize the expected utility of wealth based on the entire opportunity set. Instead, we use a timing switch between the two risky assets in the opportunity set which depends on the Information Flow Correlation computed from a stochastic variance model. At each rebalancing time, our outcome is to allocate between a risky and a risk free asset.

2 - Extracting from the Classical for Large-Scale Semi-Continuous Variable Efficient Frontiers
Ralph E. Steuer

Computing the efficient frontier of a large-scale (up to 3000 securities) mean-variance portfolio selection problem with semi-continuous variables has been an out-of-reach task. Given the speed at which the efficient frontier of a classical portfolio problem can now be computed and the likelihood of overlaps between the frontier of a realistic semi-continuous variable problem with that of its corresponding classical problem, the paper shows how large amounts of the efficient frontiers of large-scale portfolio problems with semi-continuous variables can be obtained in very little time.

3 - Multi-Period Mean-Variance Portfolio Selection with Risk Control over Bankruptcy and Uncertain Exit Time
Wu Xianping

In this paper, we consider optimal multi-period mean-variance portfolio selection with risk control over bankruptcy and uncertain exit time. Instead of embedding scheme, we employ mean-field formulation to deal with the nonseparable feature of this problem in dynamic optimization problems. We derive the analytical optimal strategies and efficient frontier and the whole process is simple and direct compared to the embedding technique.

4 - Efficient Simulations for a Bernoulli Mixture Model of Portfolio Credit Risk
İsmail Başoğlu, Wolfgang Hörmann, Halis Sak

We consider the problem of calculating tail loss probability and conditional excess for the general Bernoulli mixture model of credit risk. We propose an efficient simulation algorithm for this model in contrast to previous works that focus on specific credit risk models. The algorithm we propose is a combination of stratification, importance sampling based on cross-entropy, and the geometric shortcut method. Numerical results suggest that the proposed general algorithm is more efficient than the benchmark methods for the specific models.

■ TA-35

Tuesday, 8:30-10:00 - Room 131

Game Theory with Applications I

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Takahiro Watanabe*

1 - Harmonic Analysis of the Slutsky Effect
Toru Maruyama

Certain moving average process of white noises exhibits a periodic behavior. This well-known phenomenon was found out in 1930's by E.Slutsky in the course of his research into business cycles. The aim of the present paper is to give a solid mathematical foundations for Slutsky's insight from the viewpoint of modern Fourier analysis. Slutsky's process is a kind of weakly stationary stochastic process and the periodicity of its path can be characterized by the properties of the spectral measure (the Fourier transform of which is equal to the covariance of the process).

2 - Game Theoretic Approaches to Weight Assignments in DEA Problems
Jing Fu, Shigeo Muto

This paper deals with the problem of fairly allocating a certain amount of divisible goods or burdens among individuals or organizations in the multi-criteria environment. It is analyzed within the framework of DEA. We improve the game proposed by Nakabayashi and Tone (2006) and develop an alternative scheme by re-assigning the total weight or power for the coalition members. Under our new proposition, we analyze the solutions for both TU and NTU game, as well as the equilibria of the strategic form game in the DEA problems.

3 - Animal Spirits, Competitive Markets, and Endogenous Growth
Kenji Miyazaki

I use a simple model with an endogenous discount rate and linear technology to investigate whether a competitive equilibrium has a higher balanced growth path (BGP) than the social planning solution and whether the BGP is determinate or indeterminate. The implications are as follows. To start with, people with an instinct to compare themselves with others possess an endogenous discount rate. In turn, this instinct affects the economic growth rate in a competitive market economy. The competitive market economy also sometimes achieves higher economic growth than a social planning economy.

4 - Existence of Pure Strategy Equilibrium in Finite Games and Direction Preservingness of Best Reply Functions
Takahiro Watanabe

This paper investigates a new approach for the existence of pure strategy equilibrium in finite games. Our approach is based on discrete fixed point theorem established by Iimura Murota and Tamura (2005) and Yang (2009). We first show that a pure strategy equilibrium exists if the best reply direction functions of all players are simplicially direction preserving for a common triangulation. We also show that some sufficient conditions for the direction preservingness of the best reply functions.

■ TA-36

Tuesday, 8:30-10:00 - Room 132

Forest Management to Reduce Fire Risk

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Andrés Weintraub*

1 - Flexible Planning of the Investment Mix in a Wildland Fire Management System: Spatially-Explicit Intra-Annual Optimization, Considering Preparedness and Escape Costs
Abílio Pereira Pacheco, João Claro

We model intra-annual forest fire management as a multistage capacity investment problem, with a portfolio of resources for fuel treatment and suppression, and fires as demand. We consider two flexibility types: commitment postponement (prevention, suppression) and spatial flexibility (ground crews, helicopters). The analysis confirms that higher weather volatility leads to postponement and shows qualitative changes in the prevention/suppression mix with the burnt area cost. The changes match observed behavior and challenge several myths. Fuel treatments are always needed above a certain cost.

2 - A Three-Step Approach to Forest Optimization Modelling for Assessing Trade-Offs in Spatial Fuel Management Strategies
Brigite Botequim, Alan Ager, Abílio Pereira Pacheco, Tiago Oliveira, João Claro, Ana Barros, Jose Borges

The research contains spatial and temporal dimensions to integrate landscape-scale properties required to meet fire management goals in eucalyptus farms distributed over Portugal, without encroaching budget constraints. Specifically: Developing a Forest System Dynamic Model in order to identify temporal stand-scale and fuel dynamics;

Characterizing for each fuel arrangements the spread rate curve trends, thereby allowing the calculation of changes in the annual expected wood loss; Simulating in the Landscape Treatment Designer tool the optimal levels of fuel landscape treatment configurations.

3 - A Heuristic for Satisfying Adjacency Constraints when Scheduling Timber Harvests on Flammable Forest Landscapes

Andrés Weintraub, David Martell, Juan José Troncoso

We develop a heuristic solution to the problem of scheduling harvests on forest landscapes subject to adjacency constraints. Our heuristic is based on a threat index incorporated in a mixed integer programming spatial harvest scheduling model whose solutions accelerate the harvesting of high risk stands while satisfying adjacency constraints. We illustrate and evaluate our heuristic in a simulated planning environment for a hypothetical forest to determine how well the simulated forest would be managed were our heuristic used to determine when and where harvesting activities should occur.

■ TA-37

Tuesday, 8:30-10:00 - Room 017

Multiobjective Optimization in Asia (II)

Stream: Multiobjective Optimization

Invited session

Chair: *Tetsuzo Tanino*

Chair: *Tamaki Tanaka*

1 - LP Well-Posedness for Bilevel Vector Equilibrium and Optimization Problems with Equilibrium Constraints

Somyot Plubtieng, Phan Quoc Khanh

The purpose of this paper is introduce several types of Levitin-Polyak well-posedness for bilevel vector equilibrium and optimization problems with equilibrium constraints. Criteria and characterizations for these types of Levitin-Polyak well-posedness we argue on diameters and Kuratowski's, Hausdorff's, or Istràtescu's measures of noncompactness of approximate solution sets under suitable conditions, we prove that the Levitin-Polyak well-posedness for bilevel vector equilibrium and optimization problems with equilibrium constraints.

2 - Well-Posedness for the Bilevel New Generalized Mixed Equilibrium Problems in Banach Spaces

Rabian Wangkeeree

In this talk, the well-posedness and generalized well-posedness for the problem (BNGMEP) are introduced by an epsilon-bilevel mixed equilibrium problem. Also, we explore the sufficient and necessary conditions for (generalized) well-posedness of the problem (BNGMEP) and show that, under some suitable conditions, the well-posedness and generalized well-posedness of (BNGMEP) are equivalent to the uniqueness and existence of its solutions, respectively. These results are new and improve some recent results in this field.

3 - Existence and Convergence of Common Fixed Points via an Iterative Projection Technique for Two Strict Pseudo-Contractions in Hilbert Spaces

Kasamsuk Ungchittrakool

In this paper, the existence and convergence theorems of common fixed points for two strict pseudo-contractions are obtained by using an iterative shrinking projection technique with some suitable conditions. The method permits us to obtain a strong convergence iteration for finding some common fixed points of two strict pseudo-contractions in the framework of real Hilbert spaces. Further, some related applications are discussed to inverse strongly monotone operators in real Hilbert spaces.

■ TA-38

Tuesday, 8:30-10:00 - Room 214

Optimality Conditions and Algorithms: From Convex to Nonconvex Optimization

Stream: Convex Optimization Methods and Applications

Invited session

Chair: *Russell Luke*

Chair: *Shoham Sabach*

1 - A Simple Algorithm for Nonconvex and Nonsmooth Minimization Problems

Shoham Sabach, Jérôme Bolte, Marc Teboulle

We introduce a new algorithm for a broad class of nonconvex and nonsmooth problems. It relies on an elementary mixture of first order methods and data information. We outline a self contained convergence analysis framework describing the main tools and methodology to prove that the sequence generated by the proposed scheme globally converge to a critical point. The resulting scheme involves elementary iterations and is particularly adequate for solving many problems arising in fundamental applicaions. This is a joint work with Jerome Bolte and Marc Teboulle.

2 - Sparse Optimization over Symmetric Sets

Nadav Hallak, Amir Beck

We consider the problem of minimizing a general continuously differentiable function over symmetric sets under a sparsity constraint. We investigate both stationarity-based optimality conditions as well as conditions of a coordinate-wise type, and show, by exploiting various symmetry properties, how to verify and attain points which satisfy the derived optimality conditions. For that purpose, we also develop algorithms or expressions for the orthogonal projection operator onto sparse symmetric sets.The algorithms and optimality conditions are illustrated by examples. Joint work with Amir Beck.

■ TA-39

Tuesday, 8:30-10:00 - Room 018

ORAHS VI - Treatment Optimization

Stream: Health Care Applications

Invited session

Chair: *Sally Brailsford*

Chair: *Joana Matos Dias*

1 - Development and Evaluation of a Continuous-Time Semi-Markov Model for the Disease Progression of Acute Heart Failure

Qi Cao, Douwe Postmus, Hans Hillege, Erik Buskens

The care provided to heart failure (HF) patients is organized around multidisciplinary management programs (MPs) in which health care professionals collaborate to improve outcomes. However, it is currently still uncertain how intensive these programs should be to produce the associated clinical benefits in an affordable manner. To address this issue, we used data from a clinical trial to develop a continuous-time semi-Markov model for the disease progression of HF patients. We subsequently used this model to evaluate the cost-effectiveness of the 3 MPs considered in the clinical study.

2 - Tactical Planning at a Breast Cancer Outpatient Clinic

Maartje van de Vrugt, Richard Boucherie

Patients suspected of breast cancer must rapidly get access to diagnostic tests. In some cases additional unscheduled same-day tests are required. All patients should be diagnosed within a week after the first visit to the outpatient clinic. Therefore, we analyze appointment planning on two time scales: the access process and the day process. Invoking two discrete-time queueing concepts, we obtain a new blueprint schedule that satisfies the access norms and minimizes same-day waiting times. The methods are applied to a Dutch hospital.

3 - A Simulated Annealing Approach Using a DDS-based Neighborhood for IMRT Beam Angle Optimization
Joana Matos Dias, Humberto Rocha, Brígida da Costa Ferreira, Maria do Carmo Lopes

Intensity Modulated Radiation Therapy planning requires several decisions to be taken beginning by which radiation angles to use: Beam Angle Optimization problem. The angles can be determined by a lengthy and planner dependent trial-and-error approach (forward planning). Another possibility is to consider inverse planning where optimization models and algorithms are used to automatically determine the angles. We consider Simulated Annealing using a Dynamically Dimensioned Search based neighborhood structure to tackle this large, non-linear, multi-modal and computationally demanding problem.

■ TA-40

Tuesday, 8:30-10:00 - Room 019

Production Planning

Stream: Production and the Link with Supply Chain
Invited session
Chair: *Yuan Huang*
Chair: *Julie Rubaszewski*

1 - Managing an Assemble-To-Order System with After Sales Market for Components
Mohsen Elhafsi, Essia Hamouda

We study an ATO system subject to demand not only for the assembled product but also for individual components. Demand inter-arrival and component production times are exponentially distributed. We formulate the problem using a Markov Decision process framework and characterize the optimal production and inventory allocation policy that minimizes the expected total holding and backorder costs. We propose three simple heuristic policies and show that two of these heuristics are not only very effective in mimicking the optimal policy but also are simpler to implement in practice compared.

2 - A Comparison of Two Priority Rules in Kanban-Controlled Job Shop
Ali Ardalan, Rafael Diaz

We have shown that 2 modifications in JIT by including MRP Customer demand significantly improve performance of Job shops in customer wait time and WIP. The modifications were made to adapt JIT to Job shops. This study uses simulation to compare the effect of the 2 modifications at levels of number of kanbans, length of withdrawal cycle, FCFS and SPT on customer wait time and inventory. Results show that there is a statistically significant difference in both customer wait-time and inventory in the 2 modification approaches, with the first being superior to the second.

3 - A Decision Support System to Facilitate the Implementation of Workload Control in Make-to-Order Companies
Yuan Huang

Workload Control (WLC) is a production planning and control method uniquely designed for make-to-order companies. However, implementation of WLC has encountered significant difficulties due to the gap between theory and practice. This paper describes a state-of-the-art WLC decision support system which is considered an effective enabler of WLC application. To address the practical challenges (e.g., lack of quotation support, unexpected incoming of workloads) noted in the literature, the system has been developed through a user interactive action learning and reflection approach.

■ TA-41

Tuesday, 8:30-10:00 - Room 216

Green Logistics in Rich Vehicle Routing Problems

Stream: Simulation-Optimization in Logistics & Production
Invited session
Chair: *Javier Faulin*

1 - Evaluating the Willingness to Pay using an Econometric Model for Road Transportation in the Spanish Pyrenees
Adrian Serrano, Javier Faulin, Fernando Lera-Lopez, Mercedes Sanchez

All logistic activities generate environment costs because of externalities such as noise and air pollution. One well-known method to study those costs is the use of surveys about the willingness to pay (WTP) of the interviewee to compensate the damage caused. Here, we propose an econometric model in which we analyze the WTP in road transportation crossing the Pyrenees in the Basque Country and Catalonia. In this study, we consider some factors such as road distance, personal income, style of life, and other socioeconomic features of people living in the affected area by externalities.

2 - A Biased-Randomized Algorithm for the Vehicle Routing Problem with Backhauls
Javier Belloso, Angel A. Juan, Javier Faulin, Elena Perez-Bernabeu

We consider the Vehicle Routing Problem with Backhauls (VRPB) where the group or cluster of delivery customers has to be served before the first pickup customer can be visited. We propose an algorithm based on an adaptation of the algorithm SR-GWCS-CS introduced by Juan et al. (2011). Promising solutions have been obtained from the application of our method to classical benchmark instances for the VRPB. We also consider the environmental implications associated with the resolution of this problem.

3 - Teaching Logistics and Routing Online: Experiences and Challenges using Virtual Campuses
Francisco Faulin, Javier Faulin, Angel A. Juan

We describe here some benefits and challenges related to teaching Logistics and Routing (L&T) in online environments related to virtual campuses. Information technologies (IT) offer new ways to teach and learn Operations Research models, because they facilitate the shifting to an emergent educational paradigm which considers students as active and central actors in their learning process. In this sense, we describe some real experiences, developed during the last years at three different universities in Spain.

4 - Optimal Routing of Ambulances on Service with Queues and Demand Uncertainties. A Case Study of Zomba Central Hospital.
Javier Faulin, Elias Mwakilama, Levis Eneya

We aim at improving the pick-up and delivery of patients while minimizing both unmet stochastic demand and waiting times. An optimal schedule algorithm for routing a few available ambulances to meet the desired stochastic demand is designed. Such goals are met through efforts of combining the vehicle routing problem and queuing theory disciplines.

■ TA-42

Tuesday, 8:30-10:00 - Room 215

Big Data Analytics for Quality Improvement

Stream: Big Data Analytics
Invited session
Chair: *Mustafa Baydoğan*

1 - A New Procedure for Fault Variable Identification in Multistage Processes

Myong K Jeong, Jinho Kim, Khalifa Nasser Khalifa, Wook Yeon Hwang, Abdelmagid S. Hamouda, Elsayed Elsayed

In modern manufacturing systems with a large number of process variables, it is challenging to identify the variables that cause an out-of-control signal. In this talk, we present a new procedure for fault variable identification. We compare the diagnostic performance of the proposed procedure with existing methods using simulations. The computational experimental results show that the proposed procedure is an efficient diagnostic tool for the real time fault variable identification in high-dimensional processes such as multistage manufacturing systems.

2 - Ensemble Learning Strategies for Large-Scale Time Series Analysis and Data Mining

Mustafa Baydoğan, George Runger, Didem Yamak

We introduce a novel time series (TS) representation based on a tree-based ensemble learning strategy. Earlier, many high-level representations have been proposed for TS data mining but these representations require many parameters and have problems with generalizability. Our proposed approach is scalable, imposes no constraints on the data and has only one parameter. We illustrate the benefits of our approach on 45 TS classification problems. The proposed approach has promising extensions to forecasting, clustering, anomaly detection etc.

3 - A Model-based Prognosis of the Gas Pipeline with Corrosion Defects

Seong-Jun Kim, Byunghak Choe, Hyo-Tae Jeong, Woo-Sik Kim

Corrosion is one of the major causes of failure in the gas pipeline. This paper deals with assessing the pipeline reliability in the presence of corrosion defects. In order to consider uncertainty involved with pipeline parameters, statistical approaches such as First Order Second Moment (FOSM) and First Order Reliability Method (FORM) are incorporated with fuzzy clustering technique. The simulation result based upon a field dataset indicates that our method provides more advisory estimation of the pipeline reliability. Additional issues on its maintenance planning will be discussed as well.

4 - Learning a Bayesian Network Having One Latent Variable

Chi-Hyuck Jun, Jun-Seong Kim

This paper proposes a new probabilistic graphical model which contains one unobservable latent variable that affects all other observable variables. Linear Gaussian models are used to express the causal relationship among variables. The proposed iterative method uses a combined causal discovery algorithm of score-based and constraint-based methods to find the network structure, while Gibbs sampling and regression analysis are conducted to estimate the parameters. The proposed model is applied to ranking evaluation of institutions using a set of performance indicators.

■ TA-43

Tuesday, 8:30-10:00 - Room 217

Accounting and Financial Crisis

Stream: Operational Research in Financial and Management Accounting
Invited session
Chair: *Jonathan Crook*

1 - Classification Algorithms for Imbalanced Business Financial Data

Georgios Marinakos, Sophia Daskalaki

Classification algorithms such as Linear Discriminant, k-Nearest Neighbor, Decision Trees and Neural Networks are evaluated as for their performance on an imbalanced financial dataset from the Greek private sector. Our focus is on the ability of the algorithms to predict the minority class of businesses that declared financial distress in a sample where the vast majority is solvent businesses. The imbalance affects the classifiers' prediction performance and rebalancing techniques as random undersampling and synthetic minority oversampling are used to improve it.

2 - The Stability of Survival Model Parameter Estimates for Predicting the Probability of Default: Empirical Evidence over the Credit Crisis

Jonathan Crook, Mindy Leow

We investigate the stability of parameter estimates of discrete survival models by developing two survival models for accounts that were accepted before and since the credit crisis. We find that the two sets of parameter estimates are statistically different, with different predictions of probabilities of default when applied onto a common test set. We investigate whether changes in predicted probability distributions are due to the quality of the cohort accepted under different economic conditions, or due to the drastically different economic conditions, or a combination of both.

3 - Intensity Modelling with Macroeconomic Effects and Simulated Transitions

Mindy Leow, Jonathan Crook

Using application, behavioural and macroeconomic variables, we estimate intensity models to predict probabilities of delinquency and default for individual accounts over the duration time of loans. We find different trends for different groups of accounts and over time. Using Fleishman's power method transformation, random distributions based on properties of observed transition rates are generated and compared against predicted probabilities to get predicted transitions for accounts over time. From the results of this simulation, we calculate distributions for the transitions and losses.

■ TA-44

Tuesday, 8:30-10:00 - Room 218

OR in Regular Study Programs

Stream: Initiatives for OR Education
Invited session
Chair: *Elise del Rosario*
Chair: *Ariela Sofer*
Chair: *Liudmyla Pavlenko*

1 - Integrating OR and Systems Engineering in Masters Capstone Projects

Ariela Sofer, Karla Hoffman

We discuss how we combine MS in OR students and Masters in Systems Engineering (SE) students in joint capstone teams. The students' collaboration fosters a productive synergy that provides OR students with a broader systems perspective and provides SE students with a better understanding of the benefit and potential of OR models and methods. Examples of applied capstone projects from various industrial and government sponsors will be discussed

2 - Object-oriented Coordinate Design of Course and Teaching Mode in OR

Gang Du

In this paper, the concept of three-dimension design space and object-oriented coordinate design method of course and teaching mode are proposed. The idea is the design based on three dimensions including knowledge dimension, object dimension and mode dimension. The design procedure consists of dimension division, courses design and teaching mode design is described. As an implement assistance, a teaching design handbook is suggested. A real example, the OR course and teaching design, including a handbook design, in Tianjin University in China is given in this paper.

3 - Operational Research Education in Taiwan

Yu-Lin Wang

This study investigates differences between business schools and engineering schools in operational research in Taiwan. To assess the divergent educational approaches, this study investigates the (1) number of operational research-related courses per school, (2) design and arrangement of operational research-related course curricula, (3) content of operational research-related courses, and (4) teaching methods in operational research-related courses, across differing institutional settings in these two schools.

4 - Academic planning for OR education
Erwin Reizes

A report of 52 years of engineering and teaching and learning with experience applied to OR academic planning is presented. In this paper, the methodology and taxonomy presented at EURO conference 2012 Vilnius (TD41/TD11.3) will be used. We end with a conclusion and an outlook.

■ TA-45

Tuesday, 8:30-10:00 - Room 219

International Aspects of OR History and Education

Stream: International Aspects of OR: Cooperation — Coordination — Communication
Invited session
Chair: *Ulrike Reisach*

1 - Acquisition of Relative Clauses in Brazilian Portuguese Studied by Categorical Data Analyses
Gastão Gomes, Sergio Camiz, Christina Gomes, Ana Abreu

In this work we study the interdependence among five categorical variables related to the accuracy of the repetition of stimulus. For this purpose we use techniques like Correspondence Analysis and Loglinear Analysis.

2 - Relationship between Architectural Education and Graph Theory
Mehmet Inceoglu

The basic design course, Architectural education in the first year, teaching and the effectiveness of the implementation of the meets the expectations of the design does not satisfy the targeted, it is a matter of debate. At this stage, the designer interprets the information acquired in the problem solution-oriented thoughts in advance to improve the effort. In this study, we examined the concept of Basic design education in architecture texture. The basic design has been in the Studio with the texture work "graph theory" is scrutinized.

3 - Consideration of Intercultural Challenges and Different Thinking Patterns in Teaching German Understanding of Academic Research to Foreign Students
Mitja Stefan Weilemann, Kristina Weilemann

Foreign students need to apply the host/target country's understanding of academic research and integrity. This holds true for international students in Germany as well as for Non-Germans studying German language mediation in their home country. Lecturers deal with intercultural challenges and different thinking patterns. The authors compare two approaches from different perspectives: 1) research assistants teaching academic methods to international students at the University of Applied Sciences Neu-Ulm/Germany and 2) German language assistants at the Università degli Studi di Sassari/Italy.

4 - Applying Grey Relation Analysis to Explore the College Students Studying Motivation, Learning Stress and Academic Achievement under Declining Birthrate Phenomenon
Hua-Kai Chiou, Mei-Chun Mao

With unemployment soaring in Taiwan society, shrinking wages and other factors, the formation pressure and an economic and psychological burden on a family and raise children. Here we apply grey relational analysis to explore the studying motivation of students, learning stress and academic achievement, and through our surveys as a mutual view schools and departments as in curriculum planning and teaching, and thus motivate students the pursuit of learning motivation and achievement, improve the content and quality of education, strengthen students' employability and competitiveness.

Tuesday, 10:30-12:00

■ TB-01

Tuesday, 10:30-12:00 - Room 118

Railway Timetabling

Stream: Railway and Metro Transportation
Invited session
Chair:
Chair: *Jonas Harbering*

1 - New Heuristic Solution Techniques for the Periodic Event Scheduling Problem (PESP)
Jacint Szabo, Sabrina Herrigel-Wiedersheim, Marco Laumanns, Ulrich Weidmann

The increasing capacity usage in railway networks and the demand for more frequent and reliable offers to passengers make railway timetabling progressively challenging. In this research we concentrate on the Periodic Event Scheduling Problem (PESP), a method to construct periodic timetables. We introduce new heuristic solution methods based on iterations over several mixed integer linear programs to accelerate the computation of timetables close to optimality. Computational studies on real world timetabling instances show promising results.

2 - Combining Cyclic Timetable Optimization and Traffic Assignment
Michael Kümmling, Jens Opitz, Peter Großmann

Usually, timetable optimization follows a simple route-wise traffic assignment, neglecting the feedback of the optimized timetable on the traffic assignment. We use constraint programming to incorporate the timetable's constraints into a new multi path traffic assignment. A set of rules especially fitted to railway journeys reduces the search space further. Using the determined multiple paths, a cyclic timetable optimization is conducted, based on the periodic event scheduling problem.

3 - Solving the Train Path Assignment Optimzation Problem by Column Generation
Karl Nachtigall

Given a fixed set of train paths along side its' schedule, train path assignment in railway timetabling is an NP-complete problem. In this work, we introduce several objective functions to highlight important and corner cases in train path assignment. A method for optimal assignment of train paths by a branch-cut-and-price algorithm will be shown, which implies a research foundation for further investigations. Computational results and evaluation of real-world scenarios show promising results for the presented approaches.

4 - Approaches to Solving Single Track Timetabling
Jonas Harbering, Marie Schmidt, Abhiram Ranade

Timetabling has been intensively studied in many different versions. In this work, we present a very simple timetabling problem which has not been investigated so far. Consider a single track with uncapacitated stations at irregular but known positions on the track and fixed numbers of trains traversing the track from both sides. The task is to minimize the time from the start of the first train until the arrival of the last train under the additional condition that trains are only allowed to pass each other at stations. In this talk, we present different approaches to solve this problem.

■ TB-02

Tuesday, 10:30-12:00 - Room 111

Inventory-Routing Problems

Stream: Vehicle Routing
Invited session
Chair: *Okan Ozener*

1 - Inventory-Routing Scheme for an ATM Network Replenishment Problem
Pablo A. Rey, Alejandro Cataldo, Cristián Cortés, Juan Perez, Homero Larrain

We present an inventory-routing scheme for a real ATM network replenishment problem. This application includes time windows constraints together with strong penalizations for stock-outs of specific machines. We propose a mixed-integer linear programming formulation solved through a decomposition approach for decoupling the routing from the lot-sizing problem. The model is tested with real data of 500 machines distributed over Santiago-Chile, all of them operated by a single company; results are promising compared with the performance observed from current operation.

2 - An Inventory-Routing Problem with Pickups and Deliveries Arising in the Replenishment of Automated Teller Machines
Roel G. van Anholt, Leandro Coelho, Gilbert Laporte, Iris F.A. Vis

This paper introduces, models and solves a multi-period inventory-routing problem with simultaneous pickups and deliveries. Commodities can be brought from and to the depot, as well as being exchanged among customers to manage their inventories. This problem arises, e.g., in the replenishment operations of recirculation ATMs. We formulate the problem as a MILP model and propose an exact branch-and-cut algorithm for its resolution. We assess the performance through extensive computational experiments using real data. Good lower and upper bounds for this new practical problem are obtained.

3 - Cyclic Distribution Strategies for an Inventory Routing Problem
Okan Ozener, Ali Ekici, Gultekin Kuyzu

We study a variant of inventory routing problem where a set of customers with deterministic and continuous demand is replenished from a central depot by routing a fleet of capacitated delivery vehicles. Assuming a cyclic distribution policy where the proposed delivery schedule is repeated with a given frequency, we propose a solution approach and test it on a set of randomly generated instances in terms of solution quality and solution time.

4 - City-Courier Quick Service Network Topological Design
Tsung-Sheng Chang, Yu-Hsuan Hsu

This research tackles the problem of topological optimization of city-couriers' service networks to effectively reduce the couriers' service time. This research first mathematically models the problem, which involves multiple objectives and time periods. Then, this research applies hierarchical optimization and rolling horizon techniques to deal with the multi-objective and multi-period issues, respectively. Finally, this research further decomposes the problem into topological network design problem and m-TSP with balance and familiarity constraints that are solved by proposed heuristics.

■ TB-03
Tuesday, 10:30-12:00 - Room 001

Airline and Airport Operations

Stream: Aviation
Invited session
Chair: *Mourad Boudia*
Chair: *Valentin Weber*

1 - Reducing Airport Gate Holdouts in Passenger Aviation
Brian Lemay, Jeremy Castaing, Amy Cohn

Commercial flights are routinely assigned a gate at their destination airport prior to departing their origin airport. However, events such as an early incoming flight and/or a late outgoing flight can cause an arrival to wait for its assigned gate to become available. This "gate holdout' can result in missed passenger connections, delayed crews, and increased fuel costs. We formulate an optimization model for the gate assignment problem that incorporates the system variability in order to minimize the expected impact of gate holdouts. We test our model with data from a major U.S. Carrier.

2 - Aircraft Line Maintenance Planning Optimisation
Syed Shaukat, Cheng-Lung Wu

This paper aims to develop algorithms for scheduling tasks in multiple maintenance windows available at multiple locations to optimise aircraft line maintenance cost. A heuristic of a hybrid combination of classic job scheduling methods was developed with a lexicographic formulation of hierarchical constraint propagation and a soft objective function. The algorithm produced near optimal solutions with significant gains in execution speed and task yield compared to manual scheduling. The knowledge will contribute to operations research and scheduling automation in airline maintenance operation.

3 - Adaptive Process of Schedule Recovery for Airline Operations
Valentin Weber, Gregoire Spiers, Mourad Boudia, Rodrigo Acuna Agost

Airline schedule recovery consists in minimizing the impact of disruptions for the schedule and in returning as quickly as possible to the planned operations. The available tools for repairing depend on the closeness to the operations. Few days before, we only consider equipment changes or cancellations; the day before, we can also delay legs, change the aircraft type or create ferry flights. Our solution is based on a sequence of algorithms that is adaptable to the context. We illustrate its behavior on real life data sets including maintenances and passengers from a major European airline.

■ TB-04
Tuesday, 10:30-12:00 - Room 119

Warehousing

Stream: Supply Chain Management
Invited session
Chair: *René de Koster*

1 - A Flexible Routing Strategy for Improving the Performance of a Sequential Zone-Picking Line
Ying-Chin Ho, Jian-Wei Lin

Because of the fixed-sequence restriction in a sequential zone-picking line, totes or cartons of orders may waste time on waiting in zones' input queues and time on zones they do not need to visit. To overcome this disadvantage, a flexible routing strategy is proposed. We propose not only a new design to convert a sequential zone-picking line into a system that allows flexible routing of totes or cartons, but also rules to dispatch totes or cartons to their next destinations. Simulation experiments are conducted to understand the performance of the proposed strategy and dispatching rules.

2 - Lean Six Sigma: An Application in a Warehouse Operation
Haluk Hekimoğlu, Sabri Erdem

In today's evolving world, companies from all around the world choose cost reduction solutions for maximizing their profitability. Lean six sigma is an innovative management discipline focusing on loss elimination and continuous improvement for the companies trying to achieve high profitability and low cost rates.This paper presents an application from logistics sector, how losses detected and reduced by using lean six sigma tools in a warehouse operation. As a result of the study achievements and improvements are clearly expressed.

3 - Evaluation of Satellite Information Tasks Processing Capacity
Gang Liu, Peide Xu

The capacity of satellite information processing node need to be assessed, to solve the capacity allocation problem. We first analyze the basic process of satellite information processing, and build a network model of it. Then we present a queuing network model for the entire processing network, and the nodes is regarded as servers. After that we build a priority queuing system with reneging, to deal with the priority and time deadlines of tasks. We use block matrix solution method to solve the model. At last, a case study is provided.

4 - The Impact or Order Picker Skills on Warehouse Performance
René de Koster, Marek Matusiak

We study batching orders and routing order pickers in a picker-to-parts warehouse and additionally take differences in picking skills of the workers into account. We first apply multilevel modeling to forecast batch execution times for individual pickers. Next, these forecasts are used to minimize total batch execution time, by assigning the right picker to the right order batch. We solve the problem with an ALNS algorithm and show that state-of-the-art batching and routing methods can be improved by almost 10% by additionally taking skill differences among pickers into account.

■ TB-05

Tuesday, 10:30-12:00 - Room 002

Sustainability in Maritime Transportation

Stream: Maritime Transportation
Invited session
Chair: *Harilaos N. Psaraftis*

1 - Impact study of the new sulphur regulations on a North Sea short sea route
Oriol Algaba Birba

The aim of the current study is to analyze the impact of the IMO and EU sulphur regulations for a specific short sea route in the North Sea. These regulations may have significant impact on the profitability of such routes because of higher costs and may also induce reverse modal shifts and more CO2 overall. The study first analyzes the impact of the new regulations on costs and prices for the specific route. Then an analysis regarding the different available measures to comply with the requirements is carried out and relevant recommendations are provided.

2 - The Economic Speed of an Oceangoing Vessel in a Dynamic Setting
Evangelos F. Mageirou, Theodore Bouritas, Harilaos N. Psaraftis

Environmental and economic considerations have led to dramatic decreases in speed of all types of oceangoing vessels esp. since 2008. In the authors' previous work, a tramp vessel's optimal speed was analyzed in a dynamic setting given probabilities for future freight rates. The approach involved a unified setting for voyage and speed selection and was solved by dynamic programming. We extend this approach by introducing a Markov chain model for the fuel prices / environmental cost and b. a continuous state model for the charter market. Computational experiments are presented.

3 - Combining Speed and Routing Decisions in Maritime Transportation
Christos Kontovas, Harilaos N. Psaraftis, Min Wen

We present recent results on the problem of combining ship speed and routing decisions. Speed is a key determinant of the economic and the environmental performance affecting variables such as trip duration, fuel costs, and air emissions, among others. It is seen that inputs such as fuel cost, ship charter costs and cargo inventory costs may impact both speed and routing decisions. We develop models that optimize speed for a spectrum of routing scenarios and we use a heuristic method to solve them. Some examples are presented so as to illustrate the various trade-offs that are involved.

4 - Maritime Fleet Deployment with Speed Optimization: Case Study from RoRo Shipping
Kjetil Fagerholt, Henrik Andersson, Kirsti Hobbesland

We propose a new modeling approach for integrating speed optimization in the planning of shipping routes, as well as a rolling horizon heuristic for solving the combined problem. As a case study we consider a real deployment and routing problem in RoRo-shipping. Computational results show that the rolling horizon heuristic yields good solutions to the integrated problem within reasonable time. It is also shown that significantly better solutions are obtained when speed optimization is integrated with the planning of shipping routes.

■ TB-06

Tuesday, 10:30-12:00 - Room 211

Translation of Health Systems Engineering Research into Clinical Practice

Stream: Logistics in Health Care
Invited session
Chair:
Chair: *Jeremy Castaing*

1 - Implementing a Residency Scheduling Program at the University of Michigan Pediatric Emergency Department
Amy Cohn, Young-Chae Hong, Jennifer Zank, Elizabeth Perelstein, Zachary VerSchure, William Pozehl

Residency schedules are often created manually by the Chief Residents, despite tremendous complexity, lack of decision-support tools, and the need for quality schedules. A key challenge is the fact that there is no one clearly defined objective function. In close collaboration between the Industrial and Operations Engineering Department and the Pediatric Emergency Department, we have developed a MIP-based tool to facilitate scheduling. The results are both a significant reduction in the time required to generate the schedules and a significant improvement in the quality of the schedules.

2 - Spine Surgery Surgical Schedule Optimization
Jeanne Huddleston, Tarun Mohan Lal

Spine surgeries are complex, difficult to schedule due to the length and variability of the surgery thereby making surgical scheduling challenging. This presentation will cover the methodology used to optimize the surgical schedule, implementation challenges and results till date achieved at Mayo Clinic by implementation of a decision support tool that predicts the surgical duration and uses an optimization model that improving patient access and financial performance for the spine surgery practice.

3 - Priority Scheduling of Jobs with Unknown Types
Serhan Ziya

In some healthcare applications where priority decisions need to be made, the information that is crucial to determine the importance or urgency level of a job may not be available immediately, but can be revealed through some preliminary investigation. While investigation provides useful information, it also delays the provision of services. Therefore, it is not clear if and when such an investigation should be carried out. In this talk, we develop and analyze a simple mathematical model to provide insight into how this decision should be made.

4 - Stochastic Optimization to Reduce Wait Times in an Outpatient Infusion Center
Jeremy Castaing, Amy Cohn, Brian Denton

The University of Michigan Infusion Center is faced with common complaints of excess patient wait times. In an effort to improve the quality of cancer care delivery and infusion center operations, we formulate a large scale integer programming optimization model that creates a patient appointment schedule aiming to reduce waiting times and total hours of operation. An algorithm returning a good approximation to the optimal solution is proposed. We then develop a simulation model to evaluate performance of schedules provided by the optimization model and others heuristics.

■ TB-07

Tuesday, 10:30-12:00 - Room 003

Convex and Complementarity Models for Electricity Market Analysis

Stream: Equilibrium Problems in Energy
Invited session
Chair:
Chair: *Yelena Vardanyan*

1 - Optimal Network Operations using a SOCP-OPF model
Mohamadreza Baradar, Mohammad Reza Hesamzadeh

This research derives the second-order cone programming (SOCP) formulations for improving network operations. The transmission network constraints with VSC-type DC grid systems are convexified through linear approximations and convex relaxations. The accuracy of linear approximations and exactness of the convex relaxations are studied. Transmission loss minimisation, transfer capability enhancement, and system loadability maximisation are modeled as SOCP problems.

2 - An EPEC Approach for Modelling Exercise of Market Power on Ramp Rate
Ekaterina Moiseeva, Mohammad Reza Hesamzadeh

With increasing penetration of wind power, there is a need for security-constrained short-run dispatch as a welfare-maximizing way of procuring fast-ramping generation. However, it is observed, that on the occasion of contingency some generators bid low ramp rates, which enforces the dispatch of fast-ramping generators, so the prices spike up. Such ramp-rate withholding is a new type of strategic behavior. Using game-theoretic framework, we model the problem as an EPEC and recast it as a single-stage MILP. We demonstrate the computational performance and discuss the scaling of such problems.

3 - Multi-regional Transmission Planning as a Non-cooperative Decision-making
Yaser Tohidi, Mohammad Reza Hesamzadeh

There are few literatures on multi-regional transmission planning problem and its cooperative and non-cooperative solutions. This paper contributes to the literature by bridging this gap. The paper derives the mathematical model for non-cooperative transmission planning based on the game theory concepts in applied mathematics. The solution concept of the worst-Nash equilibrium is introduced to solve the set-up game. Different mathematical techniques are employed to formulate the worst-Nash equilibrium solution as a mixed-integer linear programming problem.

4 - The Optimal Coordinated Bidding of Risk Averse Hydropower Producer in Sequential Markets
Yelena Vardanyan, Mohammad Reza Hesamzadeh

The electricity prices in different market places are unknown when the bidding takes place. Thus, to develop a statistical planning model for price-taker hydropower producer in sequential markets is a challenging, meanwhile an important task. This paper develops stochastic Second Order Cone Program (SOCP) to generate optimal bidding strategy for three sequential markets for a profit maximizer hydropower producer. The model considers not only expected profit but also profit variance modeling objective function as a linear combination of expected value and a variance of the profit.

■ TB-08

Tuesday, 10:30-12:00 - Room 120

Power Management and Decision Analysis in Sustainable Development

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Invited session
Chair: *Semra Agrali*

1 - Monitoring Electricity Power Grids using Chernoff Faces
Valter Senna, Carlos Alberto Caria Carneiro Filho

Chernoff faces are used to obtain a multivariate representation of quality indexes in power grids. Using the R language, we capture five important electrical parameters and continuously show properly configured faces that depict their values on the grid substations. Looking at the faces, one can follow the magnitudes of the parameters and the differences between substations. In developing countries, such as Brazil, where the power grid needs constant attention and skilled manpower is scarce, it provides clear identification of spots or regions that require attention by the system operator.

2 - A Pareto Analysis for Evaluating Energy Trade-Off in Part Supplying
Victoria Rodriguez, Juan Bermeo, Masood Fathi, María Jesús Alvarez

Energy savings at present is one of the main concerns of the industries and companies in the world because most of them for their bad practices in their production processes are contributing directly to the greenhouse gases emission.In the present study a realistic mathematical model for the JIT part-supplying problem at mixed model assembly line is presented. The model considers two typical objectives which are the reduction of the inventory level and the reduction of the transport cost with consequent reduction of emissions. The aim is to find a representative set of Pareto optimal solution.

3 - Deciding Between Carbon Trading and CCS: An Optimisation-based Case Study for Methanol Synthesis from Syngas
Semra Agrali, Gorkem Uctug, Yildiz Arikan, Eray Avcioglu

We consider the problem of installing a carbon capture and sequestration (CCS) unit for a production plant in order to ensure that the amount of CO2 emissions is within its allowable limits. We formulate this problem as a non-linear optimisation problem where the objective is to maximise the net returns from pursuing an optimal mix of the two options: to invest in CCS or buy carbon credits for the excess emissions above their limits. The results were found to be sensitive to carbon credit prices and the discount rate. The model was applied to a methanol synthesis plant.

■ TB-09

Tuesday, 10:30-12:00 - Room 121

Control Theory & System Dynamics

Stream: Dynamical Systems and Mathematical Modelling in OR
Contributed session
Chair: *Mona Soufivand*

1 - Optimal Control of One Economical Problem Using a Principle of Maximum
Phridon Dvalishvili, Aleksandre Mosidze, Liana Karalashvili

It is clear that overproduction and the necessity to store commodities lead to obvious losses for the company. Losses will be even bigger in the case of shortage, taking into consideration the unmet demand and a smaller profit. It is obvious that the fact that shortage impairs the company's reputation should also be taken into account. One model of optimal control for a problem of commodity production and supply is given. Using a principle of maximum it is constructed production volume change dynamics (optimal control) and commodity supply functions, so that the overall loss is minimal.

2 - System Dynamics Model for Firm level R&D Investment Decision Making
Jiyoon Son, Hongsuk Yang, Soo Wook Kim

This study develop an system dynamics model for Firm level R&D investment decision making while considering the impact of market dynamics and new product diffusion on market maturity perspective system dynamics methodology is adopted to describe the dynamic system of market condition.

3 - Stabilizable Switched Systems by Partial State Reset
Isabel Brás, Ana Carapito, Paula Rocha

A switched linear system is considered to be a family of continuous linear time invariant systems governed by a switching law. For each time instant, the switching law defines which of the linear systems is active. Usually, the state trajectory is considered to be continuous. In this talk, we analyze switched systems where state jumps are allowed in some components of the state, during the switching instants. More concretely, we identify some classes of switched systems where it is possible to perform suitable jumps in those state components in order to obtain a stable dynamics.

4 - Towards Fostering the Improvement of Public-Private Partnership in Social Services using System Dynamics Approach
Mona Soufivand, Enzo Bivona, Roberto Strazzeri, Marco Alessi

Considering the significant role of interaction between private and public charity centers in current social welfare systems, this paper aims to support such a partnership in order to foster the quality of service delivery system. To do so, a specific case study in Lecce, South Italy, is analyzed using System Dynamics approach. The analysis intends to improve the public-private partnership and fostering co-creating the value among the key partners of a "food donation" service supply chain.

■ TB-10

Tuesday, 10:30-12:00 - Room 122

Decision Support Models for the Energy Industry II

Stream: Optimization Models and Algorithms in Energy Industry
Invited session
Chair: *Andres Ramos*

1 - An Iterative Method for Coupling Computationally Heavy Profit-Maximizing Electricity and Gas Market Models
Pablo Dueñas

Energy companies support their decision-making process with detailed market models. Decisions include budget elaboration, assets management or contracts exercise. Depending on the level of detail, a simulation may take from minutes to hours to be solved. Due to last years electricity and gas markets integration, companies have found new business opportunities in joint operations. A single integrated market model may become intractable or require excessive simplification. An iterative method for coupling two large market models is proposed. Robust profit-maximizing decisions are achieved.

2 - Robust Transmission Expansion Planning (TEP) Applying Shrinkage
Sara Lumbreras, Victor DeMiguel, Andres Ramos

Stochastic optimization finds the best solution in terms of expected cost for a given scenario tree, but the definition of this tree is often incomplete or subjective. In these cases, it is desirable to make the solution robust with respect to small changes in the definition of scenarios. We propose to shrink the stochastic solution towards a robust benchmark, this is, modify it to make it is more similar to another TEP solution which is calculated independently from the scenario tree. A case study illustrates the method

3 - Including Short-Term Operation Details in Strategic Generation Expansion Models
Adelaida Nogales, Sonja Wogrin, Efraim Centeno Hernáez

Renewable generation technologies are expected to reach large penetration levels in a number of electric power systems. These technologies are changing the plant scheduling of the rest of the generating facilities and as a result, operation-related issues become more important for an adequate analysis of generation expansion problems. A generation expansion equilibrium model which introduces start-ups and shut-downs under an oligopolistic market representation has been developed. A new approach to solve the equilibrium problem via an equivalent optimization problem has been used.

4 - Strategic Forward Trading and Technology
Heikki Peura, Derek Bunn

Forward trading in electricity markets is often driven by hedging motives, but with market power may also result from strategic considerations. In increasingly technologically diverse markets, the flexibility and reliability of production technologies may influence not only spot prices but also the nature of forward trading. We develop a theoretical model to study the impact of these factors and their interactions on spot and forward market equilibria, with important implications on both firm strategy and market design.

■ TB-11

Tuesday, 10:30-12:00 - Room 113

Network Routing

Stream: Combinatorial Optimization
Invited session
Chair: *Michael Juenger*

1 - The Cut Property under Demand Uncertainty
Sara Mattia

Given a graph and a set of uncertain traffic demands, we investigate when capacities satisfying the robust version of the cut inequalities are sufficient to guarantee a feasible routing for the demands independently of the realization of the uncertainty (robust cut property). We provide conditions for a problem to have the robust cut property and show how to use such conditions to generalize to the problem with uncertain demands the results that are known for the problem without uncertainty, when possible. Both static and dynamic routing are considered.

2 - Single-Commodity Robust Network Design Problem: Complexity, Instances and Heuristic Solutions
Valentina Cacchiani, Eduardo Álvarez-Miranda, Andrea Lodi, Tiziano Parriani, Daniel Schmidt

We study a single-commodity Robust Network Design problem in which an undirected graph with edge costs is given together with a discrete set of balance matrices, representing different supply/demand scenarios. The goal is to determine the minimum cost installation of capacities on the edges such that the flow exchange is feasible for every scenario. We present complexity results and define computationally hard instances, which are solved by means of a new heuristic algorithm. The comparison with solutions obtained by Cplex on a natural flow formulation shows the effectiveness of our method.

3 - Designing Robust Client-Server Networks under Simple Polyhedral Demand Uncertainties
Daniel Schmidt, Valentina Cacchiani, Michael Juenger, Frauke Liers, Andrea Lodi

We design optimal robust client-server networks: A single commodity (e.g., data) is to be transfered among the nodes of a network. Each node has a minimum/maximum supply or demand of that commodity. Our aim is to find minimum cost integer capacities such that all possible realizations of supplies and demands can be routed. Applications for the model lie in networks with identical servers.

We build on previous work by Buchheim, Liers and Sanità (INOC 2011) and a previous joint work by the authors (ISCO 2012) with Álvarez, Dorneth and Parriani to develop a branch-and-cut-algorithm.

4 - Approximate Earliest Arrival Flows
Melanie Schmidt, Martin Groß, Jan-Philipp Kappmeier, Daniel Schmidt

We consider the Earliest Arrival Flow Problem: Given a set of factories and a set of clients with prescribed supplies and demands, we ask for a network flow over time that satisfies as much demand as possible in each point in time. Because of the enforced pointwise optimality, earliest arrival flows do not necessarily exist in arbitrary networks. In this talk, we report how to bypass this problem by defining and finding suitably relaxed definitions of earliest arrival flows.

■ TB-12

Tuesday, 10:30-12:00 - Room 004

Nonstandard Numerical Methods for Differential Equations

Stream: Continuous and Discontinuous Dynamical Systems
Invited session
Chair: *Mevlüde Yakıt Ongun*

1 - A Crack Problem for a Nonhomogeneous Strip
İlkem Turhan, Elçin Yusufoğlu

In this study, a linear elasticity problem is considered. It is assumed that the strip consists of two materials. While material 1 is homogenous, material 2 is nonhomogeneous coating in y-direction. To solve the considered linear elasticity problem, a system of singular integral equation is derived under the boundary and continuity conditions. The system of singular integral equations is solved and numerical computations are presented to interpret the effect of stress intensity factors (SIFs).

2 - Efficiency of Differential Transform and Variational Iteration Methods for the Solutions of Some Differential Equations
Onur Karaoğlu

There are many methods to find the approximate or exact solutions of differential equations. In this study, differential transform method and variational iteration method that are from these solution methods in literature have been discussed. Differential transform method is based on Taylor series expansion, while variational iteration method is a method producing successive approximations by using iteration of the correction functional. Numerical solutions of some differential equations through methods mentioned in study were searched and affects for the solution of methods were assessed.

3 - Numerical Solution of Time-Fractional Zakharov-Kuznetsov Equation via Generalized Differential Transform Method
Ozan Özkan, Ummugulsum Cansu, Serkan Sönmezer

In this paper, a new application of generalized differential transform method (GDTM) has been used for solving time-fractional Zakharov-Kuznetsov equation.The presented method is a numerical method based on the generalized Taylor series formula which constructs an analytical solution in the form of a polynomial. The fractional derivatives are described in the Caputo sense.The results obtained are in good agreement with the ones in the open literature and it is shown that the technique introduced here is robust, effcient and easy to implement.

4 - Nonlinear Fuzzy IVPs Using by Nonstandard Finite Difference Schemes
Mevlüde Yakıt Ongun, Damla Arslan

In this talk, a nonstandard numerical method is presented for Fuzzy initial value problems. The scheme based on the nonstandard finite difference scheme is discussed. Some examples and figures are given including nonlinear Fuzzy firs order differential equations.

■ TB-13
Tuesday, 10:30-12:00 - Room 123

Advances in Scheduling

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*

1 - A New Algorithm for Multi-Agent Scheduling to Minimize Makespan on Two Machines
Xiwen Lu

In this paper, we study a multi-agent scheduling problem on two identical machines. Each agent aims at minimizing the makespan. We present a (1+1/6, 2+1/6,..., g+1/6)-approximation algorithm which produces a schedule such that the makespan of the ith completed agent is no more than (i+1/6) times its minimum makespan, i=1,2,...,g. This ratio vector is tight.

2 - Non-Identical Parallel Machine Scheduling with Sequence-Dependent Setup Times
Shiegheun Koh

This research deals with a problem that minimizes makespan in a non-identical parallel machine system with sequence and machine dependent setup times and machine dependent processing times. We first present a new mixed integer programming formulation for the problem, and using this formulation, one can easily find optimal solutions for small problems. However, since the problem is NP hard and the size of a real problem is large, we propose four heuristic algorithms including genetic algorithm based heuristics to solve the practical big-size problems in a reasonable computational time.

3 - Multi-Attribute Scheduling on Unrelated Machines
Pierpaolo Caricato, Antonio Grieco, Sandro Zacchino

We address a loading and scheduling problem on multiple machines, in which setup time depends on the values of one or more jobs features. This is very common in manufacturing environments, where setup times descend from the need to tune production machines in order to respond to variations in jobs physical characteristics such as size or weight. We propose a heuristic approach that exploits this specific nature of setup, extending and improving a former approach limited to the single machine case. Experimental tests based on actual industrial data prove the validity of the proposed approach.

4 - Lot-Sizing and Lot Sequencing on a Single Imperfect Machine with Breakdowns and Product Rejects
Alexandre Dolgui, Ksenyia Schemeleva, Xavier Delorme, Frédéric Grimaud

A multi-product sequencing and lot-sizing problem for a line that produces items in lots is studied. There are two types of uncertainties: random lead time induced by machine breakdowns and random yield because part rejects. Sequence dependent setup times are also present. The goal is to maximize the probability of producing a required quantity of items of each type by the end of a planning horizon. Decomposition can be used to separate sequencing and lot-sizing. A genetic algorithm (GA) is proposed. Computational results comparing GA performance with and without decomposition are reported.

■ TB-14
Tuesday, 10:30-12:00 - Room 124

DEA in Services

Stream: DEA Applications
Contributed session
Chair: *Sérgio Santos*
Chair: *Yu Chao*

1 - Network DEA Model to Evaluate Post-Graduate Engineering Courses in Brazil
Silvio Gomes Júnior, Placido Moreno, João Carlos Soares de Mello

Brazilian post-graduate courses are evaluated every three years. This evaluation is unclear. It tries to measure the academic productivity, among other factors. Therefore, the aim of this work is to evaluate the ability of post-graduate Engineering III programs of CAPES areas to produce scientific papers from masters' degrees and doctoral theses in a proper way. We have implemented a two-stage Network DEA (NDEA) model using the number of theses as an intermediate variable. The model allows us to compute the efficiencies from both the academic and research aspects of the post-graduate courses.

2 - Market Orientation, Innovation Capability, Marketing Proficiency, and New Product Market Success
Yu Chao, Chun-Mei Lai

The role of marketing orientation as an antecedent of new product performance has been extensively documented in the literature. Marketing Orientation has attracted ever-increasing interest because of the publication of seminal works and is a strategically valuable resource for successful new product development (NPD). This article focuses on NPD projects in the Taiwanese bio-tech industry and examines the mediate relationship between market orientation and new product market success through innovation capability and marketing proficiency.

3 - Determining Mobile Communication Operators' Efficiency by using DEA
Ahmet Aktas, İzzettin Temiz

Mobile communication technologies have shown great improvements in the last 20 years. Operators are making new investments to compete against their rivals and to increase the number of their customers. As a result of these investments, a positive change of efficiency is expected. In this study, an application of Data Envelopment Analysis (DEA) has been done in order to determine efficiency of mobile communication operators in Turkey. Efficiency of each operator is calculated for 6 periods of three-months between January 2012 and July 2013. Efficiency change of operators has also been analysed.

4 - Efficiency and Seasonality in the Portuguese Post Offices and Postal Distribution Centers
Sérgio Santos, Carla Amado, Ana Fadísta

This study uses Data Envelopment Analysis (DEA) to assess the efficiency of Portuguese post offices and Postal Distribution Centers (PDCs) and to explore the extent to which seasonality impacts on their performance. To this effect, we use data from 85 post offices and 44 PDCs. The results indicate that whilst there is a remarkable variation in the performance of the units assessed, seasonality seems to play an important role in explaining this variation, indicating that, in order to remain efficient, some units may need to adjust their capacity according to the season.

■ TB-15

Tuesday, 10:30-12:00 - Room 125

Pricing and Consumer Behavior: Modeling and Estimation

Stream: Revenue Management II
Invited session
Chair: *Ozalp Ozer*

1 - Markdown or Everyday-Low-Prices? The Role of Consumer Regret and Availability Misperception
Ozalp Ozer, Karen Zheng

We study a seller's optimal pricing and inventory strategies when consumers' purchase decisions are affected by anticipated regret and misperception of product availability. We show that these behavioral factors reinstate the profitability of markdown over everyday-low-price, in sharp contrast to prior studies. We quantify that ignoring these behavioral factors can lead to excessive profit losses. We determine that pricing offers the seller additional means to leverage consumers' behavioral issues, while mitigating potential consequences of mis-calibrating behavioral issue.

2 - Optimal Reference Pricing for Healthcare Procedure Payments
Victoire Denoyel, Laurent Alfandari, Aurelie Thiele

In reference pricing (RP), a payer determines a maximum amount for a procedure; patients who select a provider charging more pay the difference. This has strong potential in costs reduction for payers, quality increase for patients and visibility for high-value providers. Inspired by a CalPERS program, we use robust optimization to set reference price and providers subject to it. We develop a MIP payer decision model to fill the gap of quantitative insights on RP due to price, quality and geographic coverage. Preliminary results give promising leads on pitfalls and benefits of this policy.

3 - Customer Behavior Modeling in Revenue Management Systems using a Global Optimization Approach
Shadi Sharif Azadeh, Gilles Savard

In revenue management systems it is necessary to precisely predict demand of each product at a given time. This could be a challenging task, as registered bookings are censored to booking limits. In order to have a precise forecasting model, uncensoring methods are applied to unconstrain the registered data. We propose an optimization model to estimate the demand of each product at a given time as well as the product utilities for customers arriving from different segments. We introduce an algorithm that takes availability constraints into account.

4 - Behavioral Anomalies in Consumer Wait-or-Buy Decisions and Their Implications for Markdown Management
Nikolay Osadchiy, Anton Ovchinnikov, Manel Baucells

Deciding whether to buy an item at a regular price or wait for a markdown a consumer trades-off the delay in getting an item, the likelihood of getting it and the magnitude of savings — all of which are prone to behavioral anomalies/regularities. We propose a model that incorporates such anomalies and analytically solve the consumer wait-or-buy problem. Through a behavioral study estimate the model parameters and numerically show that accounting for the behavioral anomalies a firm would offer larger markdowns yet generate higher revenue compared to the current literature's predictions.

■ TB-16

Tuesday, 10:30-12:00 - Room 127

Structure Learning and Applications

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Ivan Reyer*

1 - Bayesian Sample Size Estimation for Patient Classification Survey
Anastasia Motrenko

We seek to increase the quality of classification of Cardio-Vascular Disease patients. As a part of research, arises the problem of determining the minimum sample size necessary for statistical significance of classification. Previously, we proposed a method of sample size determination that involved comparing empirical distributions, evaluated on different subsets of a sample. To measure similarity, the Kullback-Leibler distance was used. We now investigate further the features of this distance and provide some theoretical background for the method.

2 - A Machine-Learning Paradigm that Includes Pointwise Constraints
Giorgio Gnecco, Marco Gori, Stefano Melacci, Marcello Sanguineti

The classical framework of learning from examples is enhanced by the introduction of hard point-wise constraints, i.e., constraints, on a finite set of examples, that cannot be violated. They arise, e.g., when imposing coherent decisions of classifiers acting on different views of the same pattern. Constrained variational calculus is exploited to derive a representer theorem that provides a description of the functional structure of the solution. The general theory is applied to learning from hard linear point-wise constraints combined with classical supervised pairs and loss functions.

3 - Structure Learning and Forecasting Model Generation
Vadim Strijov, Mikhail Kuznetsov, Anastasia Motrenko

The aim of the study is to suggest a method to forecast a structure of a regression model superposition, which approximates a data set in terms of some quality function. The problem: algorithms of model selection are computationally complex due to the large number of models. The solution: we developed a model structure forecasting algorithm based on previously selected models.

■ TB-17

Tuesday, 10:30-12:00 - Room 005

Nonconvex Programming: Local and Global Approaches II

Stream: Global Optimization
Invited session
Chair: *Hoai An Le Thi*
Chair: *Tao Pham Dinh*

1 - DC Programming and DCA for Dictionary Learning
Xuan Thanh Vo, Hoai An Le Thi, Bich Thuy Nguyen Thi, Tao Pham Dinh

Sparse representations of signals based on learned dictionaries have drawn considerable interest in recent years. However, the design of dictionaries adapting well to a set of training signals is still a challenging problem. For this task, we propose a novel algorithm based on DC (Difference of convex functions) programming and DCA (DC Algorithm). The efficiency of proposed algorithm will be demonstrated in image denoising application.

2 - Internet Routing by DC Programming and DCA
Thi Thuy Tran, Hoai An Le Thi, Tao Pham Dinh

We consider an Internet Routing problem (Open Shortest Path First), where select paths are based on link weights. The problem is formulated as minimizing the sum of some increasing and convex link cost functions with some nonconvex constraints. We present two approaches based on DC programming and DCA for solving this problem which is in fact a DC program with DC constraints. They consist in reformulating those programs as standard DC programs in order to use standard DCAs for their solutions. Computational exepriments are conducted on some real-world problems.

3 - DC Programming and DCA for Minimizing L1/L2 — Norms of Polyhedral Convex Function Vector over a Polyhedral Convex Set
Tao Pham Dinh, Hoai An Le Thi, Hoai Minh Le

Minimizing a sum of absolute (resp. square) values of polyhedral convex functions over a polyhedral convex set, being important by their applications, are (NP hard) nonsmooth nonconvex programs. We investigate DC programming and DCA to reformulate them as appropriate DC programs (the polyhedral DC1 and DC2) and to devise customized DCAs for their solutions. It turns out that DCA consists in solving at each iteration a linear (resp. convex quadratic) program. Moreover the resulting DCA1 applied to DC1 has finite convergence.

4 - Tracking of Potentially Threatening Target Evolution in a Network
Frédéric Dambreville

The issue is to track the target being given limited and scarce information, where classical filtering approaches provide irrelevant tracking of the target. The grounding idea is to use a threat cost criterion, to be optimized, as a complement of the prior, and deal the threat tracking as a goal-oriented filtering. This leads to a dynamic zero-sum game where the strategy of the intruder is characterized by a constrained flow along the network, and where the cost is multiplicative along the trajectory. We show that the whole problem is solved as a Linear Program.

■ TB-18

Tuesday, 10:30-12:00 - Room 112

Robustness in Multiobjective Optimization II

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Alexander Engau*
Chair: *Christiane Tammer*

1 - Robust Multi-Criteria Location Problems
Christian Günther

We consider continous multi-criteria location problems with uncertainties in the data. The uncertainties are given in the objective function of the location problem. In our models we use currently developed concepts of robustness for multi-objective optimization problems. Particularly, we focus on the concept of minmax robust efficiency introduced by Ehrgott, Ide and Schöbel (2013). Furthermore, we use algorithms based on decomposition approaches like presented by Alzorba, Günther and Popovici (Optimization 2013) to solve a special class of robust multi-criteria location problems.

2 - The Robustness Space Framework for Pareto Set Reduction
Jorge Leon, Daniel Jornada

This presentation deals with identifying a reduced subset of robust solutions from a given Pareto Front. The framework maps the k-dimensional Pareto set onto a 2-dimensional space called the robustness space (RS). Given a set of uncertainties related to the values of the decision variables, the dimensions in RS represent the robustness of a solution with respect to its objective values and infeasibility. We present structural properties and a solution approach for the case of multi-objective linear programs. Examples illustrate how the RS may be useful in multi-criteria decision making.

3 - Assessing the Robustness of Pareto Sets in Multi-Objective Integer Programming Problems
George Mavrotas, José Rui Figueira, Eleftherios Siskos, Haris Doukas

We provide measures of robustness for Pareto sets in Multi-Objective Integer Programming (MOIP) problems. The robustness of each one Pareto Optimal Solution (POS), as well as the robustness of the Pareto set as a whole is assessed, providing appropriate indices. The method is based on a combination of Monte Carlo simulation with Multi-Objective Programming (using method AUGMECON2) and is illustrated using a multi-objective knapsack problem. The method provides an illustrative way of presenting the robustness of Pareto front in two and three dimensions.

4 - Pareto-based Definitions of the Optimal Value and Optimal Solutions of a Fuzzy Program
Benoît Pauwels, Serge Gratton, Frédéric Delbos

The values of a function to be optimized may be subject to imprecision of non-stochastic nature. Such uncertainty can be modeled with fuzzy sets theory. However fuzzy optimization literature lacks coherent definitions for the optimal value and optimal solutions. We propose such definitions based on the Pareto-efficient sets of bi-objective programs associated with the cuts of the fuzzy objective function. The case when the fuzziness of the objective function results from the presence of fuzzy parameters - which includes the linear and quadratic cases - is investigated further.

■ TB-19

Tuesday, 10:30-12:00 - Room 128

Inventory Planning I

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Contributed session
Chair: *Mahsa Ghandehari*

1 - A Hybrid Optimization Approach for Inventory Space Allocation with Assembly Line Balancing
Tugbanur Sezen, Rifat Gürcan Özdemir

This study aims to develop a hybrid approach in which a mathematical model is fed back by a simulation model to solve component inventory area allocation and assembly line balancing problems. The mathematical model assumes that all parameters regarding to the assembly line are deterministic and solves space allocation and line balancing problems simultaneously. However, the parameters related to the inventory replenishment are random. Thus, some constraints are updated by a simulation model based on the results of fill rate. The developed approach is implemented in automotive industry.

2 - Some New Findings About the Newsboy Problem
Jing-An Li

The newsboy problem has been studied for a long time and is being studied till now. Most researchers are good at using the classical Newsboy model to solve all kinds of related problems. Considering the expected objective function generated by the stochastic demand, we have some new findings about the newsboy problem. And these findings are also illustrated at http://www.scmgame.org for your reference.

3 - Determining Strategic Inventory Ratio in Leagile Supply Chain Considering Desirable Decoupling Point
Mahsa Ghandehari, Arash Shahin, Azam Khalili

Performance of a leagile supply chain strongly depends on the location of the decoupling point. The aim of this paper is to determine optimum ratio of strategic inventory and desirable decoupling point in leagile supply chain. Speed and variety factors have been considered as agility criteria evaluated by stockout and lost sales costs and order and inventory holding costs have been considered as leanness variables. Finally, considering each chain as a decoupling point, the desirable decoupling point is selected so that the total cost is minimized.

■ TB-20

Tuesday, 10:30-12:00 - Room 129

Managing Smart Energy Grids under Uncertainty - I

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Samira Safaei Farahani*
Chair:

1 - Optimal Bidding Strategy of a Plug-in Electric Vehicle Aggregator in Day-ahead Electricity Mmarkets under Uncertainty
Marina González Vayá, Göran Andersson

We approach the problem of a plug-in hybrid vehicle (PEV) aggregator bidding into the day-ahead electricity market with the objective to minimize charging costs while satisfying PEV's flexible demand. The problem is formulated a bi-level problem, where the upper level problem is the aggregator's cost minimization, and the lower level problem is the market clearing. Since driving behavior is uncertain, chance constraints are introduced and solved using a scenario-based approach providing probabilistic guarantees.

2 - Distributed Model Predictive Control for an Uncertain Smart Thermal Grid
Samira Safaei Farahani, Zofia Lukszo, Bart De Schutter, Tamas Keviczky

Smart Thermal Grids (STG) are one type of smart energy systems that, if controlled efficiently, can contribute to maintain the supply-demand balance in the energy distribution and to reduce the energy costs for producers and consumers. This paper focuses on modeling and control of STGs in which the uncertainties in the demand and production are included. The control approach we propose is stochastic distributed model predictive control and its implementation relies on the real-time solution of an optimization problem. Our aim is to increase the computational efficiency of this control approach

3 - Multi-Stage Reserve Policies for Large-Scale Power Systems
Joseph Warrington, Paul Goulart, Manfred Morari

Multi-stage reserve policies are planned, time-coupled responses to errors in the prediction of uncertain renewable infeeds or loads in power systems. Affine functions represent an attractive, tractable parameterization of such policies, which in our earlier work were shown to have the potential to reduce expected operating costs under inaccurate predictions. This talk describes our latest work in extending the approach to practical large-scale power systems using distributed optimization principles.

4 - Robust Portfolio Planning of Offshore Wind Farms
Alexana Cranmer, Erin Baker

Applying a spatial version of robust portfolio analysis to wind siting will help us better understand the value of each project in the context of the full portfolio of projects. Wind farm sites are generally considered one at a time and current approaches do not account for any interactions between the qualities of the sites. Sites may interact with each other through wake effects, profit potential, and wildlife impacts.

■ TB-21

Tuesday, 10:30-12:00 - Room 006

Optimization Modeling Applications in Manufacturing 2

Stream: Optimization Modeling in OR/MS
Invited session
Chair: *Lena Altherr*

1 - Buffer Allocation and Preventive Maintenance Optimization in Unreliable Production Lines
Nabil Nahas

In this paper, we consider a serial production line consisting of n unreliable machines with n-1 buffers. The problem under study consists of developing an integrated model for the joint determination of buffer sizes and preventive maintenance intervals. The objective is to determine the optimal preventive maintenance policy and the optimal buffer allocation that will minimize the total system cost subject to a given system throughput level. The extended great deluge algorithm (EGD) is proposed to solve the problem. Numerical examples showed that PM has a major impact on the throughput.

2 - Optimization of Pick-and-Place in Die Attach Process
You-Jin Park, Rong Pan, Douglas Montgomery, Connie Borror

In semiconductor manufacturing process, the wafers are moved to an assembly facility and sawed into individual chips after front-end process. Only good chips are picked up by a robot arm and attached to a lead frame on strips. This sub-process is known as the die attach process. To improve the production efficiency, it is necessary to evaluate the performance of the robot arm operation in the die attach process. In this research, a pick-and-place problem of the die attach process is mathematically formulated and efficient methods that can minimize the total transfer distance are obtained.

3 - Maximising over Time the Profit of a Renewable Tool
Aureli Alabert, Mercè Farré

Assume we have a tool or machine from which we obtain a profit, but whose performance degrades in time, it is random to some extent, and has downtimes, maintenance costs, a finite lifetime, and that at some time to be decided by the owner, it must be replaced by a new one. A situation of this kind arises in the dairy industry, where the "tools" to manufacture the milk are the cows in a farm, that must be replaced when the expected (discounted) revenue of a given animal is less that the expected revenue of a new younger one, taking into account the fixed costs of the replacement.

4 - Efficient Dynamic Flow Models with Technical Restrictions
Lena Altherr, Thorsten Ederer, Ulf Lorenz, Peter Pelz, Philipp Pöttgen

We apply Operations Research methods to design energy- and cost-optimal fluid systems. For a given time-varying flow and pressure demand, finding an optimal combination of available components such as pumps, valves, pipes or accumulators and optimal settings for the employed components presents itself as a multi-stage optimization problem. This problem can be solved efficiently by using a hybrid approach which integrates a quasi-static formulation into a time-expanded network. In this work, we present the model formulation and comparative benchmarks for the example of a given fluid system.

■ TB-22

Tuesday, 10:30-12:00 - Room 007

Cooperation in Manufacturing and Service Systems

Stream: Game Theory and Operations Management
Invited session
Chair: *Ulas Ozen*
Chair: *Greys Sosic*

1 - Asymptotic Invariance Results for Assembly Systems
Mahesh Nagarajan, Greys Sosic, Chunyang Tong

We show a set of useful properties for large assembly systems that allow us to extend known results for assembly systems with monopoly suppliers to those with commodity ones.

2 - Competitive Allocation Rules for Cooperating Logistics Providers
Behzad Hezarkhani, Marco Slikker, Tom Van Woensel

This talk addresses allocation rules for gain sharing in consortia of logistic providers where joint planning of truckload deliveries reduces the cost of empty kilometers. The competitive nature of freight transport markets requires allocation rules that distinguish among the players based on characteristics of the situation which are not represented by the associated cooperative game. We introduce desirable properties in these situations and argue that none of the existing allocation rules in the literature satisfy these properties. We propose an allocation rule that accomplishes the latter.

3 - Manufacturers' Competition and Sustainable Cooperation: Cost Structure and Stability Analysis
Greys Sosic, Fang Tian, Laurens Debo

We study a market with two substitutable and one independent product, in which recycling can be either manufacturers' responsibility or undertaken by the government. Each product can be made by a different firm, or one firm makes two independent products. We analyze conditions under which different products are recycled together. We also extend our analysis by considering the case with two pairs of substitutable (but mutually independent) products in which each firm makes two independent products.

4 - Strategic Lateral Transshipment with Communication Constraints
Michal Tzur, Eran Hanany, Shulamit Lederman

We focus on transshipment problems with communication constraints, and aim to find the resulting transshipment configuration. A LP is formulated in order to calculate the system optimum and the problem is analyzed as a Potential Game. Finally, an algorithm is presented, which establishes optimal decisions for each retailer based on imperfect information about retailers' inventory realization. The results indicate that, in most of the cases, the transshipment of units between retailers through a cyclic configuration is optimal. In addition, in the optimal configuration, no split is applied.

■ TB-23
Tuesday, 10:30-12:00 - Room 008

Behavioural Economics and Games

Stream: Behavioural Operational Research
Invited session
Chair: *Gregory Kersten*

1 - Inequity aversion in screening contracts: experimental evidence and model analysis
Guido Voigt

Screening contracts (or "menu of contracts") align the incentives in supply chains with private information. In screening contracts it is assumed that all parties are strictly expected) profit maximizing. We present an experimental study that highlights that the profit maximization assumption is critical. We argue that inequity aversion explains the observed behavior and show how contract design can account for this behavioral phenomenon.

2 - Strategic Customer Behavior in Newsvendor System: Analysis and Experimental Study
Yanan Song, Xiaobo Zhao

We deal with a newsvendor system facing strategic customers. The newsvendor determines the quantity and price, and then each customer chooses buying or waiting for a discount. Although the rational expectations (RE) equilibrium with customer behavior "all-buy" is popularly used in the literature, we show that under the retailer's optimal price and quantity of the RE equilibrium, the customers' game also has "all-wait" Nash equilibrium. A laboratory experiment was conducted, from which the customer behavior exhibited a tendency of "all-wait" in the setting of the RE equilibrium.

3 - Application of the Long-Run Macroeconomic Growth Model of Slovakia
Filip Ostrihon, Tomas Domonkos, Miroslava Dolinajcová

This paper presents a calibrated growth model of Slovakia, which is intended to analyze the effects of various policy scenarios on the Slovak labor market. Furthermore, the analysis covers the impact of these policy decisions considering the social security systems. We also keep in mind the revenue and expenditure side of the public finance and their long-term neutrality. The model is composed of seven interrelated blocks. Special attention is dedicated to the block describing the labor market, which distinguishes participants according to age, gender, education and inclination towards work.

4 - Auctions, Negotiations, and Reciprocity
Gregory Kersten, Tomasz Wachowicz

Experimental study of multi-attribute reverse auctions with (non)verifiable multi-bilateral negotiations confirms that the buyers' surplus is higher in auctions than in negotiations, the winning sellers' surplus-lower, and there is no difference in social welfare. The results show that verifiable negotiations produce worse results than non-verifiable negotiations with negotiators leaving more value on the table than bidders. This indicates that negotiations have potential to yield better results than auctions. They are worse mechanisms because of the buyers' use of reciprocity rules.

■ TB-24
Tuesday, 10:30-12:00 - Room 212

Applications of Analytics to Strategy

Stream: Strategy and Analytics
Invited session
Chair: *Frances O'Brien*

1 - System Dynamics and Big Data: New Frontiers for Strategy
Martin Kunc

System Dynamics is a simulation tool usually associated with the development and analysis of strategies. System Dynamics hasn't been considered a simulation that requires large amount of data. However, there are new trends in the use of System Dynamics and Big Data for the development and analysis of strategies. This paper discusses existing practices and proposes a new research agenda

2 - Soft Analytics and the Strategy Process
Frances O'Brien, Martin Kunc

Strategy is deciding where an organisation wants to be (direction) & how it might get there. Strategy development is an organisational process that supports the collection of inter-related activities (setting direction & goals, assessing the internal & external environment, generating & evaluating initiatives, monitoring performance & progress). We consider definitions of analytics and explore how different categories of analytic tools can be used to support the activities within a strategy process. We pay particular attention to soft approaches & strategy tools.

3 - Dynamics in the Formation of Group Preferences
Clemens Hutzinger

Multi-stage decision problems, in which several dependent decisions are to be taken, frequently occur. Many of these decisions are solved by groups via group discussions. This piece of research analyses the role of group members' characteristics and verbal communication in the formation of group preferences. We show that both group members' characteristics and verbal communication have a great impact on the way group preferences are formed. However, the way group preferences are formed does not match group members' perceptions thereof.

4 - Optimal Strategy Planning Approach againts the Bad Impacts of OTTs on GSM Operators
Neslihan Keskin, Cansu Bahadır, Rifat Gürcan Özdemir

This study focuses on strategy planning against the recently increasing usage of Internet-based applications for GSM operators. The internet-based messaging applications such as WhatsApp, Line, Facebook Messengers are called as Over-The-Top (OTT) players. OTTs are the applications for which GSM operators cannot charge directly. Because of that, it may cause a significant decline in revenue from text-messaging. A mathematical model is developed for determining optimal strategy against decline in revenue due to the OTTs. The proposed approach is implemented for the GSM operators in Turkey.

■ TB-25

Tuesday, 10:30-12:00 - Room 009

Numerical Methods in Data Mining

Stream: Data Mining
Invited session
Chair: *Emilio Carrizosa*

1 - SAS High Performance Procedures for Large-Scale Dense SVM and Quantile Regression
Yan Xu, Joshua Griffin, Leo Lopes

SVM classifiers require solutions to large-scale quadratic optimization problems. In special cases, such as linear or low-degree polynomial kernels, a low-rank factorization of the Hessian is available. Such factorizations create equivalent problem formulations amenable to parallel computing environments via interior point methods. Further, this formulation shares many similarities structurally with certain Quantile Regression optimization problems. By exploiting the SAS High Performance computing infrastructure, dense problems with billions of observations are efficiently solved.

2 - A Modified Frank-Wolfe Algorithm for Large Scale Problems in Data Mining
Francesco Rinaldi, Luigi Grippo, Giovanni Fasano

In this work, we describe a modified version of a classical method in mathematical programming, namely the Frank-Wolfe Algorithm. We analyze its properties and test its efficiency on some large scale problems in Data Mining.

3 - Dimensionality Reduction of Categorical Data in Support Vector Machines
Dolores Romero Morales, Emilio Carrizosa, Amaya Nogales-Gómez

Support Vector Machine (SVM) is the state-of-the-art in Supervised Classification. We propose a methodology to reduce dimensionality in SVM, by clustering the attributes of categorical variables. We present three strategies based on solving: the original SVM, a Nonlinear Mixed Integer Linear formulation and a Mixed Integer Linear formulation. We compare empirically the performance of the SVM classifier derived using the original data against that using the clustered data. We show a reduction in the dimensionality of the categorical data with accuracy comparable to that of the original SVM.

4 - Sparse Computation for Large-Scale Binary Classification
Philipp Baumann, Dorit Hochbaum

Well-known data mining algorithms rely on inputs in the form of pairwise similarities between objects. For large datasets it is computationally impossible to perform all pairwise comparisons. We therefore propose a novel approach that uses approximate Principal Component Analysis to efficiently identify groups of similar objects. The effectiveness of the approach is demonstrated in the context of binary classification using the supervised normalized cut as a classifier. For large datasets from the UCI repository, the approach significantly improves run times with minimal loss in accuracy.

■ TB-26

Tuesday, 10:30-12:00 - Room 010

Fuzzy Decision Making 3

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Jaroslav Ramik*
Chair: *Martin Gavalec*

1 - Fuzzy Classification in HR Management — Evaluation and Decision Making based on Multiple Attributes
Jan Stoklasa, Pavel Holeček, Jana Talasova

In common practice we work with verbally specified classes of objects. In HR management assigning work, identifying the type of the worker, promotion or outplacement decisions can be seen as classification problems. In this paper we discuss linguistic fuzzy rule base classification models suitable for HR management. We show how they can be used in the area of academic faculty management. When a preference relation on the classes exists, the linguistic labels of the categories can be used to express evaluation of objects (e.g. membership in the most preferred class implies the best evaluation).

2 - AHP Model for the Evaluation of Creative Work Outcomes of Art Colleges
Jana Talasova, Jan Stoklasa, Vera Jandova

In recent years a model for the evaluation of creative work outcomes of art colleges has been created in the Czech Republic. Based on this model a part of the subsidy from the state budget is distributed. The model classifies artworks into 27 categories based on three criteria: significance, extent and institutional reception. Scores of the categories are computed by a modified AHP method. This paper describes the progressive development of the model. We focus on the transformation of an expertly defined evaluation strategy into a well-functioning and yet relatively simple mathematical model.

3 - Logical Aggregation in Decision Making: Applications and Perspectives
Ana Poledica, Ana Horvat, Selena Totic

The aim of this paper is to reflect on existing applications of Logical Aggregation (LA), based on interpolative Boolean algebra, in decision making environment. LA has been applied in the areas such as finance (e.g., company financial performance), management (e.g., portfolio matrix), IT (web services selection), education (candidates ranking for master studies), etc.. In this paper, we give an overview of LA applications with various examples using the existing software tool. We also analyze the method with respect to key properties for its application, and outline the future perspectives.

4 - Fuzzy Queuing Cost Model Optimization for Bus Passengers with Customers' Perception of Service
Chie-bein Chen, Hsing Paul Luh, Yi-Chih Chen, Chia-Hung Wang, Yang-Hua Fan

An optimization model whose queues prior to a service and costs depend on the perception of waiting will be proposed. The goal is to minimize the total cost by selecting an optimal service level when the arrival rate, service rate and waiting cost of customers all belong to the fuzzy sets. This research is devoted to an approach of fuzzy queue optimization model and the applications of Markov chains with fuzzy set theory in queue service. Finally, a real case of bus passengers is used to evaluate the compromise solutions and make sure whether the proposed optimization model is feasible or not?

■ TB-27

Tuesday, 10:30-12:00 - Room 213

Pricing, Bundling, and Strategic Consumers in Supply Chain Management

Stream: Operations/Marketing Interface
Invited session
Chair: *Kathryn E. Stecke*

1 - Selling Opaque Goods with Mixed Bundles
Ashutosh Prasad

In addition to pure components selling, a multi-product seller has several available selling strategies. Two possibilities are to create a bundle or to create an opaque good for filling out the product line. Heretofore these have been studied as distinct strategies. The goal of this paper is to examine whether a product line of four products — the original components, the bundle and an opaque good — can be even more profitable, or whether the opaque good will be dominated.

2 - Impact of Sourcing and Pricing Power on Retailer's Optimal Store-Brand Quality under Competition
Candace Yano, Bo Liao

Store-brand products may be produced in-house by the retailer or by a national-brand or third-party manufacturer. Pricing power within each supply chain may also differ: the national brand manufacturer or the retailer may be the Stackelberg leader, or there may be a Nash game between them. We compare the retailer's equilibrium store-brand quality decisions across the nine combinations of sourcing decisions and pricing power relationships.

3 - Demand Shaping through Bundling: A Dynamic Multiproduct Inventory-Pricing Model
Jeannette Song

We study joint optimal inventory, pricing and bundling decisions over a finite horizon. We show that component complementariness, cost structure, initial inventory and demand uncertainty all drive the bundling strategy. For vertically differentiated products, the desired bundling composition depends on the ratio of cost gap to quality gap.

4 - Towards Closer Integration of Planning and Execution Processes in an Retail Environment
Mozafar Hajian

With emergence of Omni-Channel retailing, retailers need to adapt their processes to face more technology-savvy, demanding customers and sophisticated competitors.

Here, we describe how optimization technology is used in a sense and respond system that enables retailers to track real-time changes in demand and prices of their merchandise in the market in order to evaluate their market position, impact on their own profitability and to make appropriate decisions that minimize those impacts.

■ TB-28

Tuesday, 10:30-12:00 - Room 130

Turnkey Optimization on the Cloud (FICO)

Stream: Sponsored Sessions
Sponsored session
Chair: *Oliver Bastert*
Chair: *Susanne Heipcke*

1 - Turnkey Optimization on the Cloud
Oliver Bastert, Susanne Heipcke

In this session we will demonstrate enhancements in the linear, mixed integer and nonlinear solvers in the latest release of the FICO® Xpress, including a ground breaking innovation for simplex algorithms. In addition, we will introduce robust modelling and optimization capabilities in Xpress and demonstrate the ease of modeling complex problems. We will discuss how to deploy optimization applications using FICO® Optimization Modeler on the FICO® Analytic Cloud. Through the FICO® Decision Management Platform, FICO's new cloud-based tools platform, you can build,

■ TB-29

Tuesday, 10:30-12:00 - Room 011

Multiple Criteria Decision Making and Optimization 3

Stream: Multiple-Criteria Decision Making and Optimization
Contributed session
Chair: *Douwe Postmus*

1 - Accident Causation Analysis with Multiple Criteria Decision Making Methods in Workplaces
Erdem Aksakal, Metin Dagdeviren

Nowadays, one of the issues that constitute major problems for businesses is the occupational accident. The number of factors that will affect the size of businesses involved in the accident, area of activity, working conditions, dynamic properties and etc. is directly proportional. In this study, taking on the basis of three main criteria and 12 sub-criteria with using multi-criteria decision-making methods of Entropy and DEMATEL in an integrated manner and aimed to present the most important factor that caused the accident.

2 - Effectiveness Analysis of Ratios from Paired Comparison
William Wedley, Eng Choo, Diederik J.D. Wijnmalen

In MCDM, ratio priorities are often derived from paired comparison matrices. With AHP/ANP, the principal right eigenvector of the matrix is used. Other worthwhile procedures are available. This study analyzes and compares the effectiveness of various methods, where effectiveness is defined as the trajectory to zero as comparison matrix converges to the true comparison matrix. To facilitate this analysis, simulation is used to (1) derive a true comparison matrix and (2) perturb that matrix to different levels of error. Various measures of effectiveness are used to record the convergence.

3 - Multi-criteria decision analysis in medical decision making
Douwe Postmus

The assessment of benefits and risks is a central element in clinical decision making. It also plays an important role in the market authorization of new pharmaceutical treatments and in subsequent decisions to reimburse these treatments. What these settings have in common is that they all require the transformation of a large amount of clinical data on multiple outcome measures into an overall balance to ultimately make a yes/no decision. In this talk, we illustrate by means of a case study how such decisions can be reached in a transparent way by applying multi-criteria decision analysis.

■ TB-30

Tuesday, 10:30-12:00 - Room 012

Advances in Financial Decisions and Their Long-Term Horizon

Stream: Financial Mathematics and OR
Invited session
Chair: *Thomas Burkhardt*
Chair: *Andreas Loeffler*
Chair: *Ursula Walther*

1 - Survival Risks and Risk Averse Management in Forestry
Thomas Burkhardt

Forest investments are subject to survival risks related to calamities. Previous research, mostly based on simulation techniques, has demonstrated the economic relevance on both valuation and management. Recent studies by Möhring et al. (2011) and Burkhardt et al. (2014) developed an analytic perspective on the incorporation of survival risks into a Faustmann-type model, based on expectations. I extend this approach to incorporate value volatility on a stand level, which is of interest conceptually as well as for the management of small private forests.

2 - Transaction Costs and Bid-Ask-Spreads
Andreas Loeffler

The authors investigated a complete order book data set from XETRA 2003, containing all order book snapshots of all DAX titles that were traded during that year. It turned out that the average bid-ask spread over that period, taken over all entries, is closely related to the average number (but not value) of assets of every transaction recorded. This relation is robust with respect to weekly, monthly and yearly averages; daily averages show a different (but also related) pattern. It seems that this relation is based on the fact that transaction costs are much greater than information costs.

3 - Risk Quantification in PPP Projects
Ursula Walther

PPP projects combine a long lifetime with considerable technical and market risks. The optimal allocation of risks to the project partners, especially public versus private parties, is a core challenge. Additionally, an economic assessment of the project's cost effectiveness is necessary. Both tasks require the estimation of appropriate risk costs. We suggest a new method for risk quantification in PPP projects based on a value-at-risk idea. Reconciling state-of-the art risk management methods with practical data limitations we develop adequate risk premiums.

■ TB-31

Tuesday, 10:30-12:00 - Room 013

Portfolio Decision Processes

Stream: Decision Processes
Invited session
Chair: *Juuso Liesiö*

1 - Project Portfolio Selection for Group Decision Making using Multi-Criteria Analysis and Mathematical Programming through an Iterative Approach
Olena Pechak, George Mavrotas, Eleftherios Siskos, John Psarras

We propose an Iterative Trichotomic Approach (ITA) to deal with a group of decision makers (DM) in project selection problems. The basic idea is a separation of projects into three sets: green - selected by all DMs, red - rejected by all DMs and the grey projects - selected by some of them. As iterative process moves from round to round (using a weight convergence process), green and red sets are enriched whereas the grey set shrinks until becomes empty. The final outcome is a consensus portfolio of projects, the degree of consensus on each project and consensus index for the whole portfolio.

2 - Adjustable Robustness for Multiobjective Project Portfolio Selection
Thomas Fliedner, Juuso Liesiö

Robust Portfolio Modeling (RPM) supports project portfolio selection with multiple, uncertain project outcomes. By determining non-dominated portfolios for all realizations of uncertain parameters, RPM considers worst-case scenarios, which are impractical for some real-life decision problems. We reduce the set of outcome scenarios by limiting the number of parameters which may deviate from their expected value. Adjusting this limit, decision makers can choose desired levels of conservatism, in extreme cases considering only expected outcome values or all possible scenarios.

3 - Baseline Value Specification and Sensitivity Analysis in Multiattribute Project Portfolio Selection
Juuso Liesiö, Antti Punkka

A key issue in applying multiattribute project portfolio models is choosing baselines that define the value of not doing a project. Yet, specifying these baselines can be difficult as it may require, for instance, scoring the strategic fit of not doing a project. We develop advanced techniques for specifying baselines which admit incomplete preference statements. Furthermore, we develop integer programming models to analyse the sensitivity of project and portfolio decision recommendations when only incomplete information about the baselines is available.

4 - Multicriteria Decision Support for Planning Renewable Power Production at Moroccoan Airports
Tingting Fang, Risto Lahdelma, Abdellah Menou, Pekka Salminen

The Moroccan Airport Authority ONDA has introduced a "green airports' program by which airports will be supplied by solar and wind power in addition to conventional power from the national grid. The problem is to select at which airports ONDA should build solar and wind power parks, and how large they should be. The choice is made subject to multiple criteria, including economy, technical feasibility, and environmental concerns. In this paper we use Stochastic Multicriteria Acceptability Analysis (SMAA) to compare different alternatives to produce renewable power at airports.

■ TB-32

Tuesday, 10:30-12:00 - Room 014

Crisis and Disaster Management

Stream: Humanitarian Operations Research
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair:
Chair: *Jose Holguin-Veras*
Chair: *Ginger Ke*

1 - Routing for Post-Disaster Needs Assessment Operations
Burcu Balcik, Burak Guragac

After natural disasters, governmental and/or non-governmental organizations conduct rapid needs assessments to identify victims' needs. Due to limited time and resources, it may not be possible to visit all of the affected locations, so an efficient assessment plan must be developed. In this study, we develop a mathematical model to support site selection and routing decisions of the post-disaster needs assessment teams. We develop a tabu search algorithm to solve the realistic problem instances efficiently and present computational results to illustrate the performance of the algorithm.

2 - A Consistent Design Supporting Structure For Crisis Management Integrating Personal Behaviours Case analysis: The 2009 Australian Bushfire
Cerasela Tanasescu, Rudnianski Michel

In crisis management, the issue is to take appropriate decisions that will enable to solve the crisis as satisfactorily as possible. The present paper aims to give a first sketch of a consistent design supporting structure (i.e. a general model depicting the structure of a crisis, and positioning personal behavioural features with respect to the crisis dynamics) applied to the concrete case of Australian bushfire — Victoria 2009. In this respect, the paper proposes a general guideline for addressing crisis management issues in which personal behavioural features play a significant role.

3 - A Resource Distribution Network Model for Emergency Logistics Planning
Rojee Pradhananga, Shaligram Pokharel, Fatih Mutlu, Jose Holguin-Veras, Dinesh Seth

We present a proactive resource distribution approach for emergency response planning, in which actual demands at the post-disaster stage are met through pre-positioned resources at Distribution Centers (DCs) and/or through direct post-disaster shipments of resources from suppliers. A stochastic two stage model is presented to determine locations of the suppliers and DCs along with pre-disaster and post-disaster resource allocations. Application on a case study and analysis of factors affecting the resource allocations are discussed. (Acknowledgement: Qatar/QNRF/NPRP Project: 5-200-5-027)

4 - Facility Location and Network Design for Intermodal Transportation of Hazardous Materials
Ginger Ke, Ghazal Assadipour, Manish Verma

This research studies the network design problem of an intermodal transportation network for hazardous materials, where the government regulates the location of intermodal terminals, and the carrier determines the routing of shipments. We formulate a bilevel programming model, which considers the dominant relationship between the government and carrier, and develop a meta-heuristic-based solution method to solve this model. The proposed framework and methodology is tested on realistic size problem instances. Computational experiments provide detailed managerial insights for the shareholders.

■ TB-33

Tuesday, 10:30-12:00 - Room 015

Defence and Security Applications II

Stream: Defence and Security Applications
Invited session
Chair: *Ana Isabel Barros*

1 - Prioritization of Capability Gaps in Defence Planning
Petter Kristian Køber, Alf Christian Hennum

We propose a procedure for prioritization in long term force structure planning, which is based on a well-established capability and scenario based method for defence analysis. The purpose is to bridge the gap between capability requirements and capability development. The procedure consists of a gap analysis of the structure, an impact assessment of potential gaps, a setting of a level of ambition for the structure as a whole and a risk calculation and analysis. It is flexible in the sense that the ambition level is easily adjusted.

2 - Multi-Criteria Decision Support for Base Closure and Realignment
Özkan Özcan, Ahmet Kandakoglu, Nurdinç Şenay

Base Closure and Realignment (BCOR) has become one of the crucial strategic activities in the defense planning due to the recent budget limitations. This study presents a decision model based on the Stochastic Multicriteria Acceptability Analysis (SMAA) method to support this activity. SMAA is a recent method that handles different kinds of uncertain, imprecise and partially missing information in a consistent way. It assigns probability distributions to the criteria scores and orders the criteria weights, and then applies Monte-Carlo simulation. Finally, an empirical example is given.

3 - Multi Criteria Evaluation of Weapon System Maintenance Methods
Nurdinç Şenay, Ahmet Kandakoglu, Berna Cigdem Baz

Selecting the best maintenance method is one of the critical decisions for weapon systems. In this study, we applied an integrated decision making approach based on Delphi and Analytic Hierarchy Process (AHP) methodologies to solve aircraft maintenance problem. First, Delphi method is utilized to determine the evaluation criteria by a consensus of decision makers. Then, AHP is used to structure the problem, weight the criteria and determine the final scores of the alternatives. Finally, we conclude that integrated approach fits best for this kind of problems in the strategic headquarters.

4 - Multi-Criteria Evaluation of Conceptual Aircraft Designs
Ahmet Kandakoglu, Y. Ilker Topcu, Cengiz Kahraman

This study presents a realistic decision making approach based on Fuzzy Axiomatic Design (FAD) and Stochastic Multicriteria Acceptability Analysis (SMAA) methods for selecting the best conceptual aircraft design during an aircraft development process. While FAD method helps to select the design that meets the operational requirements the most under uncertainty, SMAA method handles different kinds of imprecise and partially missing preference information in a consistent way. This approach is a well suited tool for this kind of decision making problems. Finally, an empirical example is given.

■ TB-34

Tuesday, 10:30-12:00 - Room 016

Portfolio Optimization 2

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Paulo Rotela Junior*

1 - Generalized Interval Multi-Objective Programming Problem and its Application to Portfolio Selection
Pankaj kumar, Geetanjali Panda, Umesh Gupta

We consider a multi-objective decision making model, wherein all parameters and decision variables are intervals. The existence of an acceptable compromise feasible solution of this model is established,and a methodology is proposed to derive such a solution in three major steps:assigning the degree of acceptability to every feasible solution;assigning goals to each objective function;and assigning a degree of acceptability to each objective value corresponding to its goal. This theoretical development is illustrated in the portfolio selection model with data from Bombay Stock Exchange, India.

2 - Clustering Stocks for Portfolio Optimization
AnaSofia Ferreira, Fernando Bacao, Patricia Xufre

Portfolio optimization can be characterized has the decision-making process involved in matching investments to objectives, usually balancing risk and return. Selecting the appropriate assets based on a risk level criterion constitutes a complex procedure and represents one of the most important decisions that investors make. This paper presents experimental results of the use of cluster analysis for identifying different types of assets, which, in a subsequent step, might be selected into a portfolio. The result is a visual SOM model for financial analysis of Nasdaq Index constituents.

3 - Developing a Credit Rating model for Supreme Banking Portfolio at ZABG Bank
Fadzayi Ndlovu

This research focused on identifying the determinants of risk of default and then developing a relevant credit rating model for a bank in Zimbabwe. The empirical results from logistic regression show that there are six variables which increase the probability of default (PD) of the clients. The PDs for each of the supreme banking clients were grouped into ten clusters using the K-Nearest Neighbor (KNN) algorithm. These ten clusters were then adopted as the risk grades for the 490 supreme banking clients that were in the study population.

4 - Forecast and Fuzzy Data Envelopment Analysis: A Portfolio Optimization
Paulo Rotela Junior, Edson Pamplona, Fernando Salomon

This article aims to use forecasting techniques associated with Fuzzy DEA - Data Envelopment Analysis to analyze the behavior of assets portfolio. The research follows the Box-Jenkins methodology using ARIMA model to forecast indicators such as return, variance, beta and others. The prediction interval and the predicted value obtained will be used like values of a triangular Fuzzy distribution of the variables used as input and output of Fuzzy DEA model. Finally, the assets considered efficient in this model will be submitted to the Sharpe approach to optimize the portfolio composition.

■ TB-35

Tuesday, 10:30-12:00 - Room 131

Game Theory with Applications II

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair:
Chair: *Vladimir Mazalov*
Chair: *Katsunori Ano*

1 - The Effect of Shock in Repeated Network Games
Artem Sedakov

The dynamic network formation game is considered. A player who has the largest set of neighbors in the network may leave the game with a positive probability. This effect is called "shock". The effect of shock may appear only once, and the stage number, on which the shock is occurred, is chosen at random. In the cooperative scenario of this repeated network game the characteristic function is constructed. Time-consistency of the Shapley value is investigated. To prevent players from breaking the cooperative agreement, a mechanism of stage payments is designed.

2 - Nash Bargaining Solutions in a Cooperative Fish War Model
Vladimir Mazalov, Anna Rettieva

Discrete-time game-theoretic cooperative fish war models are investigated. The players differ in their time preferences and use different discount factors. We propose to use Nash bargaining solution in order to determine cooperative behavior and present two approaches. In the first one the cooperative strategies are determined as Nash bargaining solution for the whole planning horizon. In the second, we use recursive Nash bargaining procedure determining the cooperative strategies on each time step. The results of numerical modelling and comparison of the schemas are presented.

3 - Sharing Rules for Minimum Cost Arborescence Problems
Yoshifumi Kusunoki, Tetsuzo Tanino

In this talk, we address minimum cost arborescence problems (mcap), which are extensions of minimum cost spanning tree problems (mcstp) with possibility of asymmetric costs of edges. Recently, Dutta and Mishra have proposed a rational cost allocation rule for mcap. We propose a class of cost allocation rules, called sharing rules. We investigate properties of the sharing rules. Moreover, we show that the proposed sharing rules are generalizations of the Dutta-Mishra rule and other allocation rules for mcstp.

■ TB-36
Tuesday, 10:30-12:00 - Room 132

Forest Fire Suppression

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *John Hearne*

1 - Using GPS Data to Model Forest Fire Initial Attack Airtanker Operations
David Martell, Nick Clark

The airtankers that the Ontario Ministry of Nat. Resources uses for forest fire suppression are equipped with GPS units that track their real-time location, velocity and altitude but they do not indicate which fire is being fought, the time each airtanker spends travelling to and from each fire or the time each airtanker spends flying between each fire and the lake from which it scoops water to drop on the fire. We developed a methodology that we used to determine 1) what was happening at each point along the airtanker's track and 2) the time and location of every water drop on each fire.

2 - Optimal Deployment During an Escaped Fire
John Hearne, James Minas, Melih Ozlen

Consider a fire sweeping across a landscape with identified assets. Each asset has a value, resources required and a time-window for treatment to reduce risk of loss. Deployment decisions are complex and time-critical. This problem is addressed by extending the concept of the orienteering problem. Model formulation, illustration and performance will be presented.

■ TB-37
Tuesday, 10:30-12:00 - Room 017

Metaheuristics for Multiobjective Optimization

Stream: Multiobjective Optimization
Invited session
Chair: *Abraham Duarte*

1 - Heuristics for the Bi-objective Path Dissimilarity Problem
Jose Luis Gonzalez-Velarde, Rafael Marti, Abraham Duarte
The aim of this work is to formally introduce the path dissimilarity problem as a bi-objective optimization problem, in which a single solution consists of a set of p different paths, and two conflicting objectives arise, on one hand the average length of the paths must be kept low, and on the other hand the dissimilarity among the paths in the set should be kept high. A new GRASP procedure is proposed and tested against previous methods, which are reviewed, and we show that it is able to create better approximations of efficient frontiers than existing methods.

2 - An Adaptation of the Variable Neighbourhood Search Methodology for Multi-Objective Optimization Problems
Eduardo G. Pardo, Juan J. Pantrigo, Borja Menéndez, Abraham Duarte
Variable Neighbourhood Search is a general-purpose methodology widely used to solve optimization problems when only one objective is minimized / maximized at the same time. However, some of the key ideas of the methodology might also be useful in the multi-objective context. We propose an adaptation of some of the steps of the Variable Neighbourhood Search methodology to solve multi-objective optimization problems. In particular, we describe how to modify the classical design of the shaking, neighbourhood change and improvement procedures of the methodology to address these kinds of problems.

3 - Multi-Objective Hybrid Algorithms for Solving Routing Problems
Ana Dolores López Sánchez, Alfredo G. Hernandez-Diaz, Miguel A. Hinojosa, Francisco Gortázar, Abraham Duarte
The recent interest of some researches to address multi-objective routing problems is motivated by both its theoretical and its practical importance. We address a multi-objective routing problem which objectives are to minimize the number of vehicles, the total distance, and the duration of the longest route (to balance the working day). To solve the problem, we propose four multi-objective hybrid algorithms. Specifically, we combine Greedy Randomized Adaptive Search Procedures to build high-quality feasible solutions and Variable Neighbourhood Descent algorithms to improve them

4 - A Multi-Objective Multi-start Algorithm for a Balanced Real-World Open Vehicle Routing Problem
Alfredo G. Hernandez-Diaz, Ana Dolores López Sánchez, Julian Molina, Daniele Vigo, Rafael Caballero
The aim of this paper is to solve a real-world problem proposed by an international company operating in Spain modeled as a variant of the Open Vehicle Routing Problem in which three objectives are considered: minimize the number of routes used, balance the duration of these routes and minimize the makespan, i.e., the maximum time spent on the vehicle by one person. A competitive multi-start algorithm, able to obtain a set of efficient solutions in reasonable computing time is proposed. The effectiveness of the algorithm is examined through computational testing on hard real-world problems.

■ TB-38
Tuesday, 10:30-12:00 - Room 214

Sparse Optimization Methods

Stream: Convex Optimization Methods and Applications
Invited session
Chair: *Yaxiang Yuan*

Chair: *Xin Liu*

1 - A Subspace Method for Minimizing a Convex Quadratic Function with Sparsity Constraint
Yaxiang Yuan

This talk presents a subspace method for solving a special sparse optimization problem. The problem is to minimize a convex quadratic function subject to a sparsity constraint. The method presented applies subspace techniques, which generates the iteration points in subspaces that have sparsity property. Theoretical properties of the method will be given and numerical results will be reported as well.

2 - Lower Bound Theory for Schatten-p Quasi-Norm Regularized Least Squares Problem
Qingna Li, *Shiqian Ma*

Consider the Schatten-p quasi-norm regularized least squares problem with p between 0 and 1. In this talk, we develop a lower bound theory for the Schatten-p regularized least squares problem. Moreover, we characterize the first and second order necessary conditions for the problem. A smoothing gradient method is proposed, where the developed lower bound is employed to the final solution to get a lower rank output. Numerical results are reported to confirm the efficiency of the method.

3 - A Feasible Direction Method for Nonsmooth Convex Constrained Optimization
Jose Herskovits, *Mario Tanaka*

The present algorithm combines ideas of bundle methods with an interior point algorithm for smooth constrained optimization. An equivalent formulation for the original problem is stated and a sequence of auxiliary problems is built, approximating by planes the objective function and the constraints. At each of the steps, a search direction for the auxiliary problem is computed solving two linear systems. When the step is serious, this direction is feasible with respect to the original problem. We prove global convergence and show very good numerical results for a set of test problems.

■ TB-39

Tuesday, 10:30-12:00 - Room 018

ORAHS VII - Healthcare Systems

Stream: Health Care Applications
Invited session
Chair: *Sally Brailsford*
Chair: *Cigdem Gurgur*

1 - The Doctor Staffing Model in Outpatient Department Based on Queuing Theory and Integer Programming
Li Luo, *Yong Lei*

This study builds a doctor staffing model in outpatient department .This model is designed based on queuing theory and integer programming; the least number of doctors is calculated by using queuing theory based on the waiting time that outpatients can tolerate from the survey reports. Then, its corresponding genetic algorithm is designed to solve the model. Finally, the model is applied to the digestive system department in West China Hospital and the results show that the outpatient doctor staffing model reduces the waiting time of patients and improves the doctors' job satisfaction.

2 - Operating Room Scheduling With Sequence Dependent Uncertain Surgery Times
Enis Kayis, *Tagi Hanalioglu*, *Refik Gullu*

Effective operating room (OR) planning requires right surgery duration estimates. Recent empirical findings suggest that as well as well-known factors such as surgical team assigned to the case, time and sequence within a day may also affect the duration of a surgery. In this work, we study the optimal OR schedule under uncertain surgery duration that depend on the assigned sequence of the case. Our results show that scheduling the surgeries in increasing order of variability could improve the schedule's performance under multiple criteria such as utilization, overtime and waiting time.

3 - Sustainable HealthCare Supply Chains — Bundling Decisions for HealthCare Products
Cigdem Gurgur

With the profound interest in healthcare waste given its impact on costs and the environment, our study considers supplier selection and quantity allocation decisions for a health care provider that may purchase new products, as well as refurbished products in managing the end-to-end supply chain. New products are more expensive than the used ones, but can be delivered any time and in any quantity. Refurbished products have the same quality, but they are sold in bundles. We use data from a large healthcare provider to test the implications of our study.

4 - Network Representation of Subproblem Solution Spaces in Nurse Scheduling
Atsuko Ikegami, *Yuma Tanaka*

Nurse scheduling is known to be difficult to solve. Even evaluating given solutions is hard because it is impossible to explicitly describe all considerations. We construct a network that represents all feasible schedules for a given nurse. In this network, any path from the source to the sink represents a feasible schedule, and the network contains all feasible schedules. If schedules are fixed for all other nurses, we can efficiently obtain optimal and near-optimal schedules by finding the shortest and k-shortest paths in the network. This can be helpful in scheduling nurses efficiently.

■ TB-40

Tuesday, 10:30-12:00 - Room 019

Educational Planning and Development

Stream: Educational Planning and Development
Invited session
Chair: *Laura Lotero*
Chair:
Chair: *Subhash Datta*

1 - Design of Balanced Diets for 1 to 3 Year-Old Children from Government Day-care Centers in Ecuador
Sandra Gutierrez, *Fernanda Salazar*, *Adrian Sarango*

We study the case of government day-care centers in Ecuador, which provide 70% of daily required nutrients to 1-3 year-old children. First, we discuss a nutritional evaluation of current diets served at these centers. Afterwards, we formulate an integer linear version of the Stigler's diet problem in which we take into account not only the satisfaction of lower or upper bounds of nutrients, but also their balanced intake. Finally, we present computational results and conclusions for the problem.

2 - Monte Carlo Simulation and Optimization for pollution reduction strategies at the Colegio Mayor de Antioquia University
Luis Alejandro Builes, *Carlos Hoyos*, *Michelle Muñoz*, *Alejandra Ramirez Muñoz*, *Daniela Valencia Arroyave*

In order to estimate emissions due to commuting to the Institución Universitaria Colegio Mayor de Antioquia, we simulate with a Monte Carlo technique the emission factor assignment to different types of bus technologies available in the city for commuting. We estimate emissions for all transportation modes and then we seek alternatives to pollution reduction using the Simplified Emissions Estimation Model and the occupation factors to formulate the optimization model for the assignment of available private car seats to bus commuters to minimize pollutant emissions.

3 - School Efficiency in a Developing Country
Gerhard Kent, *Hennie Kruger*

To manage a school efficiently in a developing country is a challenge which is often due to mismanagement of resources. In this study the efficiency of secondary schools in the North-West Province of South Africa is investigated. A DEA model without inputs and combined with a layered pareto optimal principle is applied with main outputs being pass rates of different subjects in different grades. Preliminary results indicated that this output only layered model enables the ranking of schools and also provides intermediate goals for the inefficient schools to become more efficient.

4 - Efficiency of Accounting Education in the Philippines
Arlyn Villanueva, Brian Canlas Gozun

The Certified Public Accountant licensure examination in the Philippines is one of the toughest in the country. This paper proposes a method for modeling accounting education in the Philippines in order to improve the passing rates of accounting graduates. Out of the more than 1,200 business schools in the country, there are around 300 schools that offer accountancy. Only 30 to 40% of the graduates pass the licensure examination and this study will propose ways to improve accounting education by benchmarking using data envelopment analysis.

■ TB-41

Tuesday, 10:30-12:00 - Room 216

Metaheuristics and Simheuristics in Logistics and Production

Stream: Simulation-Optimization in Logistics & Production
Invited session
Chair: *Angel A. Juan*
Chair: *Djamila Ouelhadj*

1 - Simheuristics: Hybridizing Simulation with Metaheuristics for Decision-Making under Uncertainty
Angel A. Juan, Scott Grasman, Javier Faulin, Markus Rabe, Tolga Bektas

Many real-world problems in the production and logistics business are complex to solve even in their deterministic representation, in part due to their large size and the rich (real-life) constraints they include. To complicate things even further these problems frequently show stochastic behavior, thus making them difficult to solve by just using exact methods. A suitable and natural approach to solve these stochastic combinatorial optimization problems is to use 'simheuristics', which combine heuristic optimization with simulation techniques.

2 - A Multi-Start based Algorithm with Iterated Local Search for the Uncapacitate Facility Location Problem
Guillem Cabrera, Sergio Gonzalez, Angel A. Juan, Joan Manuel Marques, Scott Grasman

The Uncapacitated Facility Location Problem is a widely researched problem already tackled by many proposals with outstanding results. Our proposal is a new simple-but-effective Iterated Local Search algorithm that outperforms former proposals, both in computing time and result quality. We proved the algorithm value with the well-established benchmarks and then applied the algorithm to solve planning issues on very different fields like logistics, transportation, distributed computing or network deployments.

3 - ReSATyrus: A Distributed Resource-Sharing Control Compiler
Priscila Lima, Daniel Alves, Felipe França

Dealing with consistent, scalable behaviour control of high numbers of entities is a challenge intrinsic to modern problems such as intelligent transportation systems and collective robotics. This work presents a distributed approach to the generation of asynchronous, yet coherent, trajectories of multiple entities sharing common routes and intersections. Derived from a SAT-based constraint programming platform, ReSATyrus translates resource-sharing specifications into constraint graphs, upon which Scheduling by Edge Reversal dynamics is applied to provide the desired distributed control.

4 - Modeling Approach to Simultaneous Scheduling Batteries and Vehicles in Optimization of Transportation and Handling Tasks Realization
Milorad Vidovic

Battery operated vehicles are typical solution to performing material handling and transportation tasks for several decades. Efficient and economic use of transportation and handling equipment requires implementation of different operational and tactical decisions: fleet size determination, optimal routes defining, etc.. For the case of battery operated vehicles, additional decisions related to changing and charging batteries should be also made. However, in the literature and in practical application this impact is not fully recognized.

■ TB-42

Tuesday, 10:30-12:00 - Room 215

Efficient Big Data Algorithms

Stream: Big Data Analytics
Invited session
Chair: *Jonghun Park*
Chair: *Seoung Bum Kim*

1 - Instant Planning with Case Based Reasoning
Jonghun Park, Beom-suk Chung, Yongsuk Yang, Junseok Lim, Inbeom Park, Heewoong Park

A computational framework for instantly solving planning problems is presented in this paper. The proposed framework is broadly based on a case based reasoning approach, and aims to produce a solution very quickly without compromising the solution quality too much through approximating the decisions made by an optimal planner in the form of state-based decisions. Experiment results show that the proposed framework works satisfactorily for real-life planning and scheduling problems and helps promoting a firm's agility through enabling real-time (re)planning as well as what-if analysis.

2 - Non-Parametric Machine Learning Models for Predicting American Option Prices: Comparison Study
Hyunwoong Ji, Sangwoo Han, Jaewook Lee

In this paper, we investigate the performance of non-parametric machine learning models with respect to the in-sample pricing and out-of-sample prediction performances of index American options. The comparisons were performed on the 10 years S&P 100 Index American options from January 2004 to December 2013. We also verified the statistical differences between the compared methods by testing the null hypothesis that two series of forecasting errors have the same mean-squared value.

3 - U.S. Senate Network Analysis based on Roll Call Votes
Young Joon Park, Seoung Bum Kim

Several quantitative analyses have been conducted to understand the collective behavior of social groups. In this study, we propose a systematic approach to comprehend the political tendencies and voting patterns of politicians resulted by their social positions and relationships. The proposed analytic methodology measured the voting similarities of senators by the results of roll-call vote from 1989 to 2013, and is represented as a social network graph. Our results show that each senate network has different topological properties according to subjects of bills.

■ TB-43

Tuesday, 10:30-12:00 - Room 217

Accounting and Management Decisions

Stream: Operational Research in Financial and Management Accounting
Invited session
Chair: *Markus Puetz*

1 - Implementing Value Engineering based on a Multidimensional Quality-Oriented Management Control Calculus within a Target Costing and Target Pricing Approach
Markus Puetz, Stefan Bock

In order to meet customer needs and to achieve the business objectives, value engineering (VE) has become a crucial part of target costing. This presentation addresses a new VE-procedure which is based on a multidimensional quality-oriented management control calculus. The structure of the VE-procedure is illustrated at first. Subsequently, its mathematical problem model and an according approach for effective production planning are introduced. Moreover, specific aspects of the proposed procedures for the analysis and control of occurred cost and proceeds deviations are depicted.

2 - Robust Long Term Planning of Municipal Budgets
Christian Fritze, Matthias Amen

The German budget law requires municipalities to sustain their equity. If future losses are expected to reduce the equity about a legally defined value, the municipality has to plan and describe measures to restore budget balancing within a period of at most ten years to prevent debt overload. The questions arise on how municipalities create robust plans over such long term periods considering the specific restrictions of the public sector such as the commitment to satisfy the demand for core services. We present an approach for robust long term planning for municipalities.

3 - The relationship of Cost System Precision and Organizational and Procedural Structures
Jan-Gerrit Heidgen, Stephan Lengsfeld, Arndt Rüdlin

We extend the approach of Labro/Vanhoucke (2007) to analyze the interacting effects of structural and procedural improvements on cost system precision in ABC systems. Firstly, we show that interactions differ when organizational structures are changed after procedural structures are set compared to the inverse scenario. Secondly, improvements on stage II have a larger impact on cost accuracy -compared to those on stage I- only as long as structural errors on the first stage aren't too severe. Thirdly, we provide design-recommendations depending on different initial states of the cost system.

4 - Flexibility in Cost-based Transfer Pricing
Markus Brunner, Peter Schaefer

Cost-based transfer prices are frequently used to guide intra-firm trade and also provide incentives for investment. We investigate whether transfer prices should be fixed ex ante for the long run or adjusted each period when future costs and revenues are uncertain. We find that more flexible transfer prices improve trading decisions in the short run, but cause underinvestment in the long run. Specifically, transfer prices should be fixed if uncertainty about future costs is low, and adjustable if uncertainty is intermediate; with high uncertainty, they should be based on actual costs.

■ TB-44

Tuesday, 10:30-12:00 - Room 218

Additional Educational Activities for OR

Stream: Initiatives for OR Education
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Elise del Rosario*
Chair: *Liudmyla Pavlenko*

1 - Developing OR Application Skills with AIMMS: A Bridge in OR Education
Ovidiu Listes

We share our experiences in training both academics and OR professionals for developing OR application skills using AIMMS. Whether the users are students moving from theory to practice or professionals who need to acquire skills in a short time, AIMMS can contribute to bridging the gap in the OR education. Fast and flexible modeling, powerful solvers and integrated visualization are among the AIMMS features which facilitate learning, create understanding and stimulate further application refinements. While we illustrate these aspects based on several examples, interaction is much appreciated.

2 - An Overview of the Intensive Programme in Optimization and DSS for Supply Chains (Odss.4SC)
Giuseppe Bruno, Ana Amaro, Miguel Casquilho, Albert Corominas, Juan Manuel Garcia Lopez, Andrea Genovese, Carla Henriques, Amaia Lusa, Johan Magnusson, Henrique Matos, Joao Miranda, Ana Paula Barbósa-Póvoa, Susana Relvas, Sergio Rubio

The third edition of the Odss.4SC Erasmus Intensive Programme is taking place in Portalegre, Portugal (6-20 July-2014). Once again, about 40 MSc and PhD students from Engineering and Logistics programmes from many countries are participating. Academics from 8 higher education institutions will be delivering classes; lab sessions are kindly supported by IBM/ILOG. The talk will illustrate the summer school activities and the lessons learned in the former editions (2012, 2013); also, a preliminary evaluation of the triennial project is presented.

3 - Summer School AACIMP: Introducing Operational Research to the Students with Various Backgrounds
Liudmyla Pavlenko, Oksana Dziuba, Alexis Pasichny, Kateryna Pereverza, Dmytro Fishman, Olga Nazarenko, Gerhard-Wilhelm Weber

Operational Research is a truly interdisciplinary field that provides many applied researchers instruments needed for dealing with complexity of real-life problems. Yet for many educators the issue of integrating OR into regular curriculum remains challenging. We propose advanced education and particularly summer schools as a conventional form for testing and developing new approaches towards OR education. This talk aims to present our experience of developing international project Summer School AACIMP in the NTUU "KPI", pointing out its benefits and pitfalls.

4 - Feedback from the field - ILOG in IBM for a smarter planet
Alex Fleischer

(0) We will not deal here with theories and models but only deployed applications. (1) Operations Research is a GPT (General Purpose Technology). We will give here some examples of real-life applications. (2) OR as a way for Sustainable Development: Water, Energy, Transport ... . (3) OR as a long-term practice with applications that will run for decades, what can we learn from IBM Mainframes. (4) What is ahead? - New problems to solve. - Moving from craft-work to industrial practice. - Making the most out of more powerful machines and architectures.

■ TB-45

Tuesday, 10:30-12:00 - Room 219

Geometric Clustering

Stream: Geometric Clustering
Invited session
Chair: *Steffen Borgwardt*
Chair: *Andreas Brieden*
Chair: *Peter Gritzmann*

1 - Partitioning in Polynomial Time via Edge-Complexity
Michal Melamed, Shmuel Onn

The shaped partition problem deals with partitioning n given items among p players, so that player i gets b_i items. Each player has an integer utility matrix with columns representing the items' utility under d criteria, providing the player with a utility vector per partition. The goal is to find a partition that maximizes a convex objective function on these vectors' sum. It was shown that for fixed d and p this problem has a polynomial time algorithm. We show that for small valued utilities, it can be solved in polynomial time even for variable p by using its feasible set edge-complexity.

2 - A Balanced k-Means Algorithm for Weighted Point Sets
Steffen Borgwardt, Andreas Brieden, Peter Gritzmann

We generalize the popular k-means method to handle weighted point sets and prescribed lower and upper bounds on the cluster sizes. Our algorithm replaces the assignment step of k-means by the computation of a weight-balanced least-squares assignment, which we model as a linear program over a special polytope. The optimal vertices correspond to clusterings that allow strongly feasible power diagrams. We use this connection to devise a worst-case bound on the number of iterations of our algorithm, which is similar to the known upper bound for k-means - despite our more powerful framework.

3 - Tabu Search and GRASP for the Capacitated Clustering Problem
Anna Martínez-Gavara, Vicente Campos, Micael Gallego, Manuel Laguna, Rafael Marti

Our problem consists of forming a given number of clusters from a set of elements in such a way that the sum of the weights of the elements in each cluster is within some capacity limits, and the sum of the benefits between the pairs of elements in the same cluster is maximized. A GRASP with VNS has been recently proposed by Deng and Bard (2011). We propose a tabu search and several GRASP. They are based on different neighborhoods, including a new one, not previously proposed for the CCP, in which we implement a one-for-two swapping. We also hybridized both methodologies for improved outcomes.

4 - Three Distinctive Models for Multicriteria Clustering
Yves De Smet

In multicriteria decision aid, many authors have been interested in assigning objects to predefined groups. This is referred as the sorting problematic. More recently, they have also investigated how clustering techniques could be extended to this specific context. The goal of this presentation is to summarize three recent clustering techniques: a method for partially ordered clustering based on binary matrices, an exact method for ordered clustering based on ordinal properties of preferences and an extension of the PROMETHEE II method for ordered clustering.

Tuesday, 12:15-13:45

■ TC-50

Tuesday, 12:15-13:45 - Plenaries room

Plenary Session J. Barceló

Stream: Plenary Sessions
Keynote session
Chair: *Nelson Maculan*

1 - Analytics and the Art of Modeling
Jaume Barceló

This lecture could have as subtitle "Was Johannes Kepler a precursor of Analytics? Models constitute a key tool to achieve a deep understanding on how complex systems behave, models have been central to building the body of knowledge that we understand as "Science'. Since its origins Operations Research has claimed to be considered a scientific discipline and, as such, rooted in the model building process. A process that epistemologically is schematically represented by the methodological chain: factslawstheories. Kepler's quest for an interpretation of Brahe's astronomical observations in terms of a model, his laws of the orbital motion of planets, is a well known example of the paradigm of modern science. Since then we have learned that reality is more complex than we thought, it is uncertain and dynamic in both, probabilistic and chaotic terms. The technological evolution is supplying quality data in unprecedented amounts, and this has forced us to develop the appropriate methods to deal with them, but this only means that the methodological chain of knowledge discovering is now richer with respect to our capabilities of analyzing the facts, and therefore opens the door to deeper chances of finding laws and formulating explanatory theories. The search for Higgs Boson, frequently presented as an archetype of Analytics process, is essentially supported by the same epistemological principles that Kepler's work. I would like to devote my lecture to make some remarks on these similarities and, in doing this, highlight the relationships in the frameworks of the theme of this conference: The Art of Modeling.

Tuesday, 14:00-15:30

■ TD-01

Tuesday, 14:00-15:30 - Room 118

Railway Scheduling

Stream: Railway and Metro Transportation
Invited session
Chair:
Chair:
Chair: *Jacint Szabo*

1 - Generating Delivery Commitments from Train Operators' Applications
Sara Gestrelius, Martin Aronsson, Malin Forsgren

Despite the traffic situation being unique for every day of operation, a train should always run according to the train path finalised in the yearly train plan in Sweden. We propose that only timings that are important to the train operators, called delivery commitments, should be finalised rather than entire train paths. Then the timetable could be optimized for every unique day, while operators still get the information they need to provide their service. In this talk we present our initial work on methods for generating delivery commitments from the operators' applications.

2 - Optimizing Railway System Performance by Kronecker Algebra
Mark Volcic

We present an optimization algorithm for railway systems in terms of punctuality and energy consumption. By applying Kronecker Algebra, a graph is created representing all train movements, where conflicts can be easily found. The graph can be reduced to the relevant nodes for train synchronization. The reduced graph is used to determine all possible combinations of routes of all trains. The optimal driving strategy for each train is calculated and the best result will be taken as the overall result. The algorithm is implemented in Ada and designed to run on multi-core CPUs.

3 - Re-optimization of Rolling Stock Rotations
Thomas Schlechte, Ralf Borndörfer, Markus Reuther

The Rolling Stock Rotation Problem is to schedule rail vehicles in order to cover timetabled trips by a cost optimal set of vehicle rotations. The problem integrates several facets of railway optimization, i.e., vehicle composition, maintenance constraints, and regularity aspects. In industrial applications existing schedules often have to be re-optimized to integrate timetable changes or construction sites. We present an integrated modeling and algorithmic approach for this task as well as computational results for industrial problem instances of DB Fernverkehr AG.

4 - An Efficient Macroscopic Railway System Simulator
Jean Damay, Adrien Boillot

To assess the quality of an existing or hypothetic entire railway system, we have devised and built a software tool that simulates at a macroscopic level the operational production of its trains over the network. The main research contribution consists in taking into account several types of railway resource constraints (rolling-stock / crew) and delays (congestion, speed limitations, background noise…) at specific and relevant discrete events of the simulation. Service and production KPIs are provided at the end of (and during) the simulation, and may be visualized over time and space.

■ TD-02

Tuesday, 14:00-15:30 - Room 111

Cross-docking and Warehouse Operations Optimtization

Stream: Vehicle Routing
Invited session
Chair: *Felix Brandt*

1 - Lagrangean Relaxation for the Cross-dock Door Assignment Problem
Wael Nassief, Ivan Contreras, Rami Asad

In this talk we study a Cross-dock door assignment problem in which the assignment of strip doors to incoming trucks and stack doors to outgoing trucks is to be determined, with the objective of minimizing the material handling cost. We present a strong mixed integer programming formulation that is embedded into a Lagrangean relaxation (LR) that exploits the structure of the problem to obtain bounds on the optimal solution value. A primal heuristic is adopted at some iterations of the LR to obtain high quality feasible solutions. Numerical results on a set of benchmark instances are reported.

2 - A Comparison of Heuristics for the Order Batching and the Picker Routing Problem in Manual Order Picking Systems
André Scholz

Order picking is a warehouse function dealing with the retrieval of articles from their storage location in order to satisfy a given demand specified by customer orders. When solving the order batching problem, a given set of customer orders has to be grouped into feasible picking orders such that the total length of all picker tours is minimized. The length of each picker tour is determined by using a given routing strategy. In this paper, it is investigated if the solution quality can be improved by combining heuristics for the order batching problem with more complex routing strategies.

3 - A Multi-Temperature Truck Layout and Loading Problem
Felix Brandt, Anne Meyer

In this work we consider a vehicle layout and loading problem arising in convenience product delivery to stores by using multi-temperature vehicles with reconfigurable walls. We want to find a feasible wall setup and loading pattern, which results in an unloading sequence with a minimum number of reshuffles. We present a MIP model capturing the layout constraints as well as the reshuffling aspects of the problem. We give an overview of our experiments using real world data from our industrial partner PTV group. Our results show that there are significant time savings achievable.

4 - A decision support system to optimize material handling at cross-docking terminals
Pierre Baptiste, Mohammad Yousef Maknoon, Miguel Anjos

The main challenge in cross-docking terminals is to reduce the material handling cost due to its intense operation on internal transshipment. The material handling cost depends on products double handling and traveling distance within doors. Previous scheduling models consider a single factor as a measurement to optimize material handling decisions. In this study, we consider a holistic view and propose a mathematical programming framework to schedule cross-docking operations with respect to its operational restrictions.

■ TD-03

Tuesday, 14:00-15:30 - Room 001

Airline Planning

Stream: Aviation
Invited session
Chair: *Sakae Nagaoka*

1 - Optimizing Time-Dependent Arrival Rates for Truck Handling Operations at an Air Cargo Terminal
Axel Franz, Raik Stolletz

Truck arrivals at air cargo terminals are typically of time-dependent and stochastic nature. Mechanisms such as terminal appointment systems aim at smoothing demand by shifting arrivals from peak to off-peak periods. Using a time-dependent queueing model, we provide a methodology to evaluate and optimize truck arrival patterns at air cargo terminals. Our optimization approach is based on the stationary backlog-carryover approach to analyze the system's performance. The model's objective is to minimize total waiting times with the time-dependent arrival rates as decision variables.

2 - Effect of Pricing on Fleet Assignment with Itinerary-Based Demands
Yasemin Kalafatoglu, Taner Bilgic

This research investigates the influence of itinerary pricing and network effects on fleeting decisions. It has been shown that itinerary fares have a significant effect on choices of customers and thus on itinerary demands. Using real data from a Turkish airline, the Itinerary-based Fleet Assignment Model (IFAM), an MIP model for fleet assignment that incorporates itinerary-level demands, is solved. Different pricing scenarios based on the data are considered. Results show that fleeting decisions and passenger spills are strongly related to itinerary pricing.

3 - Pair-wise Resilience Index based on the Miss Distance and Time to the Closest Point of Approach
Sakae Nagaoka, Mark Brown

In airspace planning, safety indices which can be derived from aircraft trajectory data are needed to assess airspace complexity. One such index, Resilience, reflects the air traffic management system capability to respond to a safety significant event without increasing the likelihood of more such events. The index does not use speed information, so ignores overtaking situations. Therefore we propose an index that takes into account the miss distance and time to closest point of approach for each pair of aircraft. This paper briefly gives the mathematical model and some calculated examples.

■ TD-04

Tuesday, 14:00-15:30 - Room 119

Best Practices in Traffic Simulation

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Monica Menendez*

1 - Validation of Traffic Simulation Models: Are we Looking in the Right Direction?
Jordi Casas, Vincenzo Punzo, Marcello Montanino

The process of checking to what extent the model replicates reality, also referred as validation, is a remarkably challenging task in the traffic field, given the complexity and the highly stochastic nature of traffic. In this paper, statistical techniques applied in other fields are reviewed and compared to the current practice in traffic simulation. In particular, the customary assumption of fixed demand in the designs of experiment, usually adopted to run replications in traffic simulation, is questioned. The paper analyses the implications of neglecting uncertainty in traffic demand.

2 - HBS-compliant Capacity Analysis using VISSIM
Peter Vortisch

Simulation is often used as an alternative to the analytical methods of highway capacity guidelines. But MOEs given in the guidelines and produced by simulation are not always comparable. In our project, we developed methods to use VISSIM in compliance with the HBS, the German HCM. This includes parameter sets to calibrate VISSIM to the capacities given in the HBS for standard network elements and guidance how to extract MOEs from VISSIM that can be compared to the MOEs the HBS is based on, especially how to measure capacity in a HBS-compliant way.

3 - Sensitivity Analysis: A Valuable Tool in Traffic Model Calibration
Monica Menendez, Qiao Ge, Biagio Ciuffo

Sensitivity Analysis (SA) can aid in finding the influential parameters of a model. Here we develop an efficient SA method for traffic simulation models, especially those that are high dimensional and computationally expensive. Its application is illustrated with a case study. Results show that the accuracy of this method is similar to that of the variance-based SA in identifying the influential parameters and their ranks, but the computation cost is much lower. Hence, it is recommended as a standard SA method for traffic simulation models and other complex models in the scientific community.

4 - Meaningful Quantification of Traffic and Pedestrian Flow Model Accuracy
Femke van Wageningen-Kessels, Serge Hoogendoorn, Winnie Daamen

Errors of road traffic or pedestrian flow models are quantified using accuracy measures. Often used measures such as root mean square error or absolute percentage error of predicted velocities or densities are not informative of the type of error. However, it is important to know, for example, whether the overcrowding is predicted at the wrong time or location or whether the actual traffic velocities show more discontinuities than the predicted ones. We propose accuracy measures that quantify meaningful errors in (one-dimensional) road traffic and (two-dimensional) pedestrian flows models.

■ TD-05

Tuesday, 14:00-15:30 - Room 002

Maritime Routing and Scheduling 1

Stream: Maritime Transportation
Invited session
Chair: *Kjetil Fagerholt*

1 - OR Applications in the Maritime Industry
Trond A. V. Johnsen

Over the last decades, the number of scientific publications addressing use of OR to solve maritime planning problems has increased significantly. This again has in the recent years led to the development of several decision support models and systems applied by the maritime industry. In this paper, a set of OR applications in the maritime industry is presented. These examples cover different industry segments and planning levels. Lessons learned from the industrial projects will be presented, and critical factors for a successful industrial implementation discussed.

2 - Development of Containership Services with Transshipments and Deadlines
Mico Kurilic

Our model builds liner routes and schedules for cargo with deadlines and transshipments. It tries to meet the deadlines and to minimize costs of operating ships and cargo handling. It iteratively builds routes, deploys ships, and assigns cargo to the ships. Decisions about port calls and cargo transshipments are based on sailing times, possible cargo consolidations and deadlines. At every step, the model selects the cargo with early deadline and with minimum incremental costs of assigning it to a scheduled ship. If needed, a new service is added to the schedule until all cargo is assigned.

3 - A Decision Support Tool for Liner Shipping Network Design
Berit Dangaard Brouer, Guy Desaulniers

Liner shipping companies adapt to new market situations and fleet decisions by redesigning and adjusting existing services. We present a decision support tool, which is able to incrementally adjust an existing network to new market situations. The underlying algorithm is a matheuristic using an integer program to define insertions and removals of port calls from designated services to improve performance and cost of the overall network. We present a case study of the decision support tool optimizing on a designated subset of services within a global liner shipping network.

■ TD-06

Tuesday, 14:00-15:30 - Room 211

Health Care Operations Management

Stream: Logistics in Health Care
Invited session
Chair: *Katja Schimmelpfeng*

1 - A Hierarchical Facility Layout Planning Approach for Large and Complex Hospitals
Stefan Helber

In large and complex hospitals with a high number of departments, transportation processes for patients, personnel, and goods can consume substantial resources and hence induce substantial costs. The allocation of the different departments and wards in the possibly multiple connected hospital buildings determines those costs. Based on the analysis of a very large and complex University Hospital in Hannover, Germany, we develop a hierarchical layout planning approach to propose locations for departments and wards. We describe the models and report numerical results.

2 - A Flexible Approach for Strategic Master Surgery Scheduling
Andreas Fügener, Jens Brunner

This study discusses a master surgery scheduling approach that maximizes hospital revenues under consideration of downstream resources, such as intensive care units or general patient wards. Demand of these resources is modelled by a stochastic patient path model. We discuss models with both fixed and variable resources to determine efficient allocation of capacity. Our approach is tested with real life data from a German university hospital and manages to achieve significant revenue increases.

3 - Clustering Clinical Departments for Wards to Achieve a Prespecified Blocking Probability
Johann Hurink, Theresia van Essen

When the number of available beds in a hospital is limited and fixed, it can be beneficial to cluster several clinical departments such that the probability of not being able to admit a patient is acceptably small. The clusters are then assigned to the available wards such that enough beds are available to guarantee a blocking probability below a prespecified value. We give an exact formulation of the problem and introduce two heuristic solution methods. Furthermore, we present some computational results based on data of a Dutch hospital.

4 - Master Surgical Scheduling Considering Stochastic Surgery Durations
Alexander Kressner, Katja Schimmelpfeng

Operating rooms (OR) are a hospital's most important and expensive resources. Thus hospitals strive to operate ORs at high utilization without jeopardizing patient service. In this context, one of the main challenges is to cope with the natural uncertainty in surgery durations. We consider the problem of scheduling types of elective procedures to ORs over a mid-term planning horizon (Master Surgical Scheduling). The resulting OR-planning model is stochastic and allows to control overtime. We present different linearization approaches of the non-linear base model and further extensions.

■ TD-07

Tuesday, 14:00-15:30 - Room 003

Challenges in Electricity Systems

Stream: Equilibrium Problems in Energy
Invited session
Chair: *Christoph Weber*
Chair: *Olivier Massol*

1 - Capacity Markets in Europe — Assessing the Benefits of Coordinated Mechanisms versus National Appro
Michael Bucksteeg, Christoph Weber

In Europe, there is an on-going debate about the introduction of national vs. internationally coordinated capacity mechanisms We therefore model the impacts of capacity markets in Europe with different levels of coordination between the considered countries. A stochastic partial equilibrium model of the electricity market is used for a quantification of the economic effects. Beforehand we calculate the capacity requirements with a stochastic convolution approach. Thereby, we assume that the probability of a capacity shortage may not exceed a pre-defined security level.

2 - The Impact of Disequilibria in Power Markets
Thomas Kallabis, Christoph Weber

Frequently, energy market models focus on the analysis of equilibria and equilibrium development paths. But the history of competitive electricity markets in Europe is more resembling to a sequence of booms and busts - with currently a bust period. A key reason are the long lead times for construction. By investigating the impacts of deviations from an (anticipated) equilibrium, the relevance of various risk factors for profitability is highlighted. This will contribute to improve investment decision making under uncertainty.

3 - Equilibrium Pricing of Reserve Power
Christoph Weber, Lenja Niesen

With increasing shares of renewable generation, reserve power markets are expected to gain in importance. Competitively organized markets like in Germany are characterized by high prices with considerable fluctuations. Analytical investigations in a partial equilibrium framework reveal however that capacity prices should be rather low if reserve power is auctioned on an hourly basis. Numerical analyses are then used to quantify in a large European electricity market model the impact of different specifications of the reserve power products.

4 - Production Intermittence in Spot Markets
Olivier Massol, Albert Banal Estanol, Augusto Rupérez Micola

This paper analyses the influence of production intermittence on spot markets. We use both game theory and an agent-based simulation approach derived from the Camerer and Ho (1999) behavioral model. Controlling for costs, we find that intermittent technologies yield lower prices when incumbents have individual market power, but higher when they do not have it. This happens when firms are risk-neutral and risk-averse, and also under different intermittence and ownership configurations. Replacing high-cost assets with low-cost ones results in higher prices than letting them co-exist.

■ TD-08

Tuesday, 14:00-15:30 - Room 120

Green Design and Risk Pooling

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Contributed session
Chair: *Andreas Welling*

1 - The Timing of Green Investments under Regime Switching and Ambiguity
Andreas Welling, Elmar Lukas, Stefan Kupfer

The economic success of green investments does not only depend on the uncertain economic development but also on regime switches in the relevant legislation. As a result of political decision-making the latter are assumed to be rather ambiguous than uncertain. We develop a real options model that takes into account economic uncertainty as well as political ambiguity. We calculate the option value of the green investment and derive the optimal investment-timing strategy. Furthermore, we analyze the sole and the combined influence of economic uncertainty and political ambiguity on these topics.

2 - Green Investment Decisions in Battery Technology for Electric Vehicles: The Role of Uncertainty in the Product Life Cycle
Stefan Kupfer, Karsten Kieckhäfer, Elmar Lukas, Thomas Spengler

Electric vehicles play a decisive role in current strategies to green the automotive industry. Since the battery accounts for the highest share of value creation in electric vehicles, make or buy decisions for a specific battery technology are crucial investment decisions for car manufacturers. This paper studies the effect of technology and market uncertainty on the investment decision of car manufacturers in battery technology. Thereby we take into account that the adoption of a new but uncertain technology typically follows a product life cycle commonly neglected in the finance literature.

3 - Discriminated Fee based Incentive Mechanisms for Green Design Products
I-Hsuan Hong

Green design products can enhance the reclaimed value of end-of-life products. This paper examines how different advanced recycling fees affect a manufacturer's green design of products. We apply the Stackelberg model to determe the optimally discriminated advanced recycling fees in the perspective of the government. This study investigates two different mechanism designs to deduce manufacturers designing green products: incentives to manufacturers or subsidies to consumers. Finally, we compare two mechanisms and discuss the pros and cons of these two mechanisms.

4 - Risk Pooling in Commercial Returns by Managing Product Return Period
Muhammad Naiman Jalil, Sadeeqa Shahzad

Retailers typically specify product return period as per return policy. The impact of return period length on product return volumes and their variability is not understood. We analytically show that increasing return period length results in reducing variability of product returns—commonly known as risk pooling. Risk pooling in product returns is structurally different from existing risk pooling examples in literature. Risk pooling in product returns by increasing return period length occurs by prompting a behavioral change in the underlying stochastic sales and return process.

■ TD-09

Tuesday, 14:00-15:30 - Room 121

Modeling and Optimizing Electricity Markets

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Florentina Paraschiv*

1 - Medium-Term Planning for Thermal Electricity Production
Florentina Paraschiv, Raimund Kovacevic

We present a mid-term planning model for thermal power generation which is based on multistage stochastic optimization and involves stochastic electricity spot prices, a mixture of fuels with stochastic prices, the effect of CO2 emission prices and various types of further operating costs. We solve a 1-year planning problem for a fictitious configuration of thermal units, producing against the markets. We use the implemented model to demonstrate the effect of CO2 prices on cumulated emissions and to apply the indifference pricing principle to simple electricity delivery contracts.

2 - Forecasting Electrical Demand in Commercial Buildings through Energy Performance Indicators using Time Series Methods.
Stamatios Paterakis, Evangelos Spiliotis, Vasilis Assimakopoulos

In this study, a methodology for predicting electrical consumption in commercial buildings is proposed. Initially, Time Series forecasting methods are applied on data from sub-sector energy consumption groups of the buildings. In addition, time series of key Energy Performance Indicators are constructed per sector and used as input data for the above methods. In each case, the optimal forecasting model is selected and combinations of these methods are examined for maximized accuracy. Finally, bottom-up, top-down and optimal hierarchical methods are used to obtain the final forecasts.

3 - Electricity Swing Option Pricing by Bilevel Optimzation
Raimund Kovacevic, Georg Pflug

Swing options are an important type of flexible energy delivery contracts. Due to nonstorability and imcompleteness of eletricity markets, electricity swing options are difficult to price by purely financial approaches. We formulate the pricing problem as a bilevel decision problem (Stackelberg game) and present related optimality conditions and solution algorithms.

4 - A Spot-Forward Model for Electricity Prices
Michael Schürle, Florentina Paraschiv

We propose a novel regime-switching approach for modeling electricity spot prices that takes into account the relation between spot and forward prices. Additionally the model is able to reproduce spikes and negative prices. Market prices are based on an observed forward curve. We distinguish between a base regime and an upper as well as a lower spike regime. The model parameters are calibrated using historical hourly price forward curves for EEX Phelix and the dynamics of hourly spot prices. The model is compared with common time series approaches like ARMA and GARCH.

■ TD-10

Tuesday, 14:00-15:30 - Room 122

Decision Support Models for the Energy Industry III

Stream: Optimization Models and Algorithms in Energy Industry
Invited session
Chair: *F.-Javier Heredia*

1 - Stochastic Optimal Generation Bid to Electricity Markets with Emission Risk Constraints
F.-Javier Heredia, Julián Cifuentes Rubiano, Cristina Corchero

This work investigates the influence of the emission reduction rules in the optimal generation bidding strategy to the day-ahead electricity market through the new concept of Conditional Emission at Risk (CEaR). A stochastic programming model is used to determinate the optimal generation bid to the wholesale electricity market that maximizes the long-run profits of the utility abiding by the Iberian Electricity Market and the environmental restrictions set by the Spanish National Emissions Reduction Plan.

2 - Modeling Renewable Generation Sources for Medium-Term Electricity Generation Planning
Laura Marí, Narcis Nabona

Medium-term generation planning is an essential tool for Generation Companies participating in liberalized electricity markets as it permits to predict revenues and to plan next year's fuel procurements. A new model for non-dispatchable renewables, such as wind power and solar photovoltaic generation, is proposed for generation planning using probabilistic methods for load matching taking into account forced outage rates. A stochastic programming framework using quasi-Monte Carlo techniques is developed to model the randomness of wind and of solar photovoltaic power, and of hydro inflows.

3 - Mixed-Integer Linear Programming Models to Solve Optimization Problems of Radial Electrical Distribution Systems
Marcos J. Rider, Rogério dos Reis Gonçalves

This paper presents mixed-integer linear programming (MILP) models to solve: a) operation planning of radial electrical distribution systems (REDS), considering the presence of distributed generators and devices voltage regulators (DVR); b) optimal allocation of DVR in REDS; and c) short-term expansion planning of REDS. All proposed MILP models are equivalent to their respective original models. The proposed models have been implemented in AMPL and solved using the CPLEX. Several test systems were used to show the accuracy of the mathematical models and efficiency of the proposed solution.

4 - Solving Natural-Gas Infrastructure Planning Models with the Branch-and-Fix Coordination Algorithm
Adela Pages Bernaus, Gerardo Perez Valdes, Asgeir Tomasgard

Assessing the expansion of a natural-gas infrastructure can be modeled as a large-scale mixed-integer programming (MIP) problem. To ensure robust and flexible decisions, such model must consider the unavoidable uncertainty of some of the parameters making it a large-scale multi-stage stochastic MIP problem. Decomposition techniques such as the parallelized branch-and-fix coordination algorithm are required to solve realistic problems. In this talk, we will present the infrastructure problem together with the solution algorithm.

■ TD-11

Tuesday, 14:00-15:30 - Room 113

Various New Advances in Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *José Paixão*

1 - A Very Fast Implementation of the Work Function Algorithm based on Network Flows and Flow Cost Reduction
Robert Manger, Tomislav Rudec

We propose a new implementation of the work function algorithm (WFA) for solving the on-line k-server problem, which is based on a simple network flow model and on flow cost reduction. Thanks to a suitable parameter, our new implementation can achieve tradeoff between accuracy and speed, i.e. it can be either exact or approximate. According to the presented experiments, the exact version already assures fast execution, while the approximate version can be an order of magnitude faster. At the same time, the approximate version can still closely mimic the original WFA in terms of serving costs.

2 - Schedules for Marketing Products with Negative Externalities
Xujin Chen, Zhigang Cao, Changjun Wang

With the fast development of social network services, network marketing of products with externalities has been attracting more and more attention from both academia and business. We design polynomial time algorithms that find marketing schedules for products with negative externalities. The goals are two-fold: maximizing the product sale and ensuring consumer regret-free decisions. Our algorithms achieve satisfactory performance guarantees for both profit maximization and regret-proofness. Our work is the first attempt to address these marketing problems from an algorithmic point of view.

3 - Method of Pattern Analysis: New Algorithms
Alexey Myachin

Research is devoted to the aggregated analysis of data in order to obtain high-quality results that give the most extensive view of the investigated objects, their structural components and behavior in time. New analysis algorithms are proposed: a linear pattern classification, ordinal-invariant and diffusion-invariant pattern clustering. Paper describes the main advantages of the proposed methodology to the classical methods of analysis. The proposed methodology is considered by the data of science, education and innovation activity in regions of the Russian Federation.

4 - Vehicle Routing for Solid Waste Collection: A Hybrid Metaheuristic Approach
Antonio Chaves, Eliseu Araújo

The aim of this paper is to present an heuristic for the periodic vehicle routing problem applied to solid waste collection. The solution is a one-week plan of daily routes for the transport of waste from containers to facilities, taking into account the frequency of collection, the road network and the resources available. We present a hybrid method called Clustering Search (CS), that combines metaheuristics and heuristics intensifying the search only in promising areas. A real-world case supported this study. Computational tests show that CS has an improved performance against other methods.

■ TD-12

Tuesday, 14:00-15:30 - Room 004

Difference Equations and Discrete Dynamical Systems

Stream: Continuous and Discontinuous Dynamical Systems
Invited session
Chair: *Ozan Özkan*

1 - The Dynamics of a Difference Equation
İbrahim Yalçınkaya

Difference equations appear naturally as discrete analogues and as numerical solutions of differential equations having applications in physics,biology, economy, etc. Recenlty there has been an increasing interest in the study of global behavior of rational difference equations. Although difference equations are relatively simple in form, it is extremely difficult to understand thoroughly the global behavior of their solutions. In this paper, we investigate the global behavior of a difference equation with non-negative parameters and initial conditions.

2 - On a System of Difference Equations
Abdullah Selçuk Kurbanlı

Recently, there has been great interest in studying difference equation systems. One of the reasons for this is a necessity for some techniques which can be used in investigating equations arising in mathematical models describing real life situations in population biology, economic, probability theory, genetics, psychology etc. In this paper, we investigate the behavior of the solutions of the difference equations systems.

3 - Solving Fractional Vibrational Problem Using Generalized Differential Transform Method
Ummugulsum Cansu, Ozan Özkan, Suat Kurt

In this paper we propose approximate analytical solutions for time fractional vibration equation by using generalized differential transform method. The solution of the equation is obtained in the form of convergent series. The fractional derivatives are described in the Caputo sense. The numerical results show that the approach is easy to implement to fractional vibration equations without any restrictive assumptions. Hence, by this method, the numerical computations are reduced. Finally an examples is solved to illustrate the accurateness and effectiveness of the method.

4 - A Model Based Systems Engineering Framework for Large Scale Enterprise Design and Management
Craig Lawton

Large scale Enterprises are complex systems containing many highly interrelated elements that evolve over time with a high degree of uncertainty. Design and management of efficient Enterprises is a significant challenge for those responsible for Enterprise performance. This paper will present a Model Based Systems Engineering (MBSE) framework for Enterprise modeling, design and management. The framework integrates both traditional systems architectures (SysML, DODAF) as well as simulation (Systems Dynamics). A case study with application to a military enterprise will demonstrate utility.

■ TD-13

Tuesday, 14:00-15:30 - Room 123

Scheduling and Logistics

Stream: Scheduling
Invited session
Chair: *Michal Penn*

1 - The Routing of Sea Buses via Integer Linear Programming: The Case of Bosphorus
Tekiner Kaya

In this paper, since the sea buses' current schedules in Bosphorus/Turkey were developed through past experiences, the main objective of this study was to prepare a model to minimize cost and the number of sea buses performing in Bosphorus. Thus, in order to manage the current order-demand pairs rationally, the problem is formulated as Vehicle Routing Problem with Simultaneous Pick-Ups Deliveries and a mathematical model consisting 65326 variables and 65847 constraints were developed. Results showed that number of used sea buses reduced by %5,9 and sea buses usage ratio improved by %5,18.

2 - Two approaches of scheduling problems in a distribution center with two cranes and interference constraint
Gabriela Naves Maschietto, Martin Gomez Ravetti, De Souza Mauricio

This work deals with the scheduling of jobs on two machines that may interfere each other. This problem often appears at logistic centers, such as warehouses and stockyards. Machinery as cranes and reclaimers, sharing the same rail may interfere in each other jobs. This work is based on a real case at a distribution center of steel coils, where two cranes on the same trail must load a sequence of trucks. We model the problem as a parallel scheduling problem and as a single multiprocessor. Mathematical programming models are proposed and tested for different organization policies of the coils.

3 - Energy efficient scheduling on a Single Machine
Michal Penn, Tal Raviv

Consider the problem of scheduling jobs on a single machine over T units of time. The time horizon [0,T] is divided into electricity tariff intervals of different lengths and tariffs. Each job delivered from the system yields a revenue and the energy cost of processing it is calculated proportionally to the lengths times the electricity tariffs the processing extends over. We consider two problems: Decide on the number of jobs to be produced and their schedule to maximize the total profit (revenue net energy cost).

4 - Scheduling of Identical Parts in Robotic Flow-shop for Different Cell Layouts
Florence Thiard, Nicolas Catusse, Nadia Brauner

Modeling modern manufacturing systems require to take into account transportation resources. Robotic cells consists in a flow-shop setup where transportation of the parts between machines is handled by a robot. We consider cyclic production of identical parts and optimization of the cell's throughput. Most results in the literature concern linear cells and one unit-production cycles; few studies consider other layouts. We study the extension of classical results to circular layout, where the cell's input and output buffers are at the same position.

■ TD-14

Tuesday, 14:00-15:30 - Room 124

DEA in Energy and Water services

Stream: DEA Applications
Contributed session
Chair: *M. Violeta Vargas-Parra*

1 - Evaluation of the Brazilian Electricity Distribution using Network DEA
Lidia Angulo-Meza, Placido Moreno, João Carlos Soares de Mello

Worldwide, DEA has been used to assess the electricity distributors' efficiency. Operational expenditures (OPEX) is the most used input, while energy distributed and number of consumers are the outputs. However, some papers use the network length as a second input, whereas research conducted in Brazil considers the network length as an output. We propose a new 2-stage model in which OPEX is the only input, energy distributed and number of consumers as outputs, and network length is the intermediate variable. Since OPEX is an input to both stages, we use a shared-input Network DEA model.

2 - Monitoring Efficiency and Productivity of Promoters in Wind Energy Sector
Clara Vaz, Ângela Ferreira

A DEA framework is proposed to explore the differences in performance of a set of wind farms, which involves two main promoters in the Portuguese wind energy sector. The study investigates the efficiency of the promoters in maximizing the energy produced from the physical resources and the wind velocity available in each farm. The overall performance of the two promoters is analyzed by comparing their differences in terms of the efficiency spread and productivity between their best-practice frontiers. Results may be used to support decision makers in the establishment of regulation policies.

3 - Measuring the Impact of Energy on Industry through: A DEA Approch
Nadia Kpondjo, Frederic Lantz, Anna Creti

In this paper, we solve the question of productive performance of DMU (Decision Making Unit) of the primary aluminium industry and analyze the impact of external factors such as energy supply on the change of these performances. Our methodology is based on a DEA approach. The key points that make up our contributions are: First: applying recent developments in DEA; Second: analyzing the change in performance of DMU over time; Third: analyzing the impact of external factors on conditional efficiency. We expect a disparity in the efficiencies of DMU with their technology and location.

4 - Water Treatment Plants Efficiency in México
M. Violeta Vargas-Parra, Francisco Vargas, Noemi Haro, Luis Rentería Guerrero

As energy prices increase, environmental concerns highlight the need to improve processes. The aim of this study is to measure the performance of water treatment plants during 2004-2010. The analysis encompasses all plants in the 32 states of Mexico. An input-oriented DEA model for determining an efficient frontier and derive relative positions of water treatment plants over the states, is applied. A ranking in best practices is obtained from this research, evidencing improvement opportunities oriented to cost reduction and environmental improvement throughout resource consumption reduction.

■ TD-15

Tuesday, 14:00-15:30 - Room 125

Strategic Consumer Behavior, Pricing and Customer Choice

Stream: Revenue Management II
Invited session
Chair: *Sumit Kunnumkal*

1 - Quantity Competition in the Presence of Strategic Consumers
Yuri Levin, Mikhail Nediak, Andrei Bazhanov

Oligopolistic retailers sell an undifferentiated limited-lifetime product to strategic consumers. A manufacturer sets the first-period (full) price, while the second-period (clearance) price is determined by Cournot equilibrium. Symmetric pure-strategy equilibria may result in no sales in the periods 1 or 2 (Cournot outcome versus collusion), and sales in both periods with the clearance price above or at the salvage value. Higher strategic behavior can be a benefit for retailers but hurt consumers, higher competition may harm local economy, and strategic behavior may insure against oversupply.

2 - Dynamic Pricing with Reference Price Effects under Heterogeneous Customer Arrivals
Zizhuo Wang

We consider a monopoly selling a single product over a certain horizon. Customers belong to different groups with different arrival patterns. For each customer, his demand depends on the price in this period, as well as the prices he observed in the past. Contrary to the prior literature on pricing with reference effect, we show that under the above assumptions, the optimal price path does not necessarily converge. Instead, it asymptotically converges to a cyclic pricing strategy with provable cycle lengths. Other properties of the optimal prices as well as numerical tests are studied.

3 - New Compact Linear Programming Formulations for Choice Network Revenue Management
Sumit Kunnumkal, Kalyan Talluri

We consider the network RM problem with customer choice and show that the affine relaxation is NP-complete even for a single-segment MNL model. Nevertheless, by analyzing the affine relaxation we derive new compact linear programs that approximates the dynamic programming value function better than choice deterministic LP, provably between the choice deterministic LP value and the affine relaxation, and often coming close to the latter in our numerical experiments.

4 - Pricing Strategies in a Fairness-sensitive Market
Steven Shugan, Jihwan Moon

Overwhelming empirical evidence finds: (1) consumers consider fairness but (2) competitive equilibria occur without considering fairness. Consistent with both findings, we develop pricing strategies with fairness-sensitive consumers. Ostensibly unfair actions are information events that (1) hurt consumers who view them as unfair and (2) deviate from the market norm. We find that adverse cost shocks cause the imposition of unfair fees regardless of whether consumers are fairness-sensitive. However, the transition to that equilibrium depends on whether consumers are fairness.

■ TD-16

Tuesday, 14:00-15:30 - Room 127

Machine Learning Applications in Web Technology

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Takashi Onoda*

1 - Composition of Web Services for Scaling Using Finite States Machines
Nadia Halfoune, Khaled Sellami

The main goal of our work is to ensure a precise composition of Web services. We use business protocols to model the exchanges between the different entities (supplier, consumer, intermediaries). Our work is based on the technology of Web services and the finite state machines to define our approach of services composition. In this work, we present an improvement of an existing algorithm of consumer-server composition. Then, we develop two new algorithms of composition: series composition and parallel composition of Web services.

2 - Big Data - Classification and Optimization Algorithms
Stanislav Sopko

The main focus of paper is to study the effectiveness of different optimization algorithms in an area called big data. The data will be examined using statistical and data mining methods. Optimization takes place both in terms of optimization of classification process, as well as optimization of the work process with the results. Classification and optimization algorithms in this work will be based on a combination of traditional approaches in this sector, but also supported by a series of new approaches based on the theory of artificial intelligence and neural networks.

3 - Automated Radial Basis Function Neural Network Construction for Malicious URL Classification
Dirk Snyman, Tiny Du Toit, Hennie Kruger

Phishing attacks which employ URLs pointing to fraudulent resources are directed at end users in order to steal sensitive or identifying information. Attackers exploit many weaknesses of current methods used to detect malicious URLs. In this study malicious URLs are identified by a new automated RBF neural network construction algorithm. This technique uses an in-sample model selection criterion to determine the best neural network architecture. Example URLs from the Open Directory and Phishtank are utilized to train and test the neural network. Results obtained will be presented.

4 - Semantic Requests in Web Services Search
Abdelmalek Boudries, Amad Mourad, Rabah Kassa

The semantic Web has attracted the attention of many searchers since these last years. It concerns to arrive to an intelligent Web, were the information would be no more stored but translated by computers in order to answer to the users' needs. The semantic Web Services (WS) are situated at the convergence of two important research domains which concerns the internet technology, as the semantic Web and the WS. In this work, we have studied some semantic annotations approaches in the WS contest and we have proposed an annotation method and an algorithm of construction of semantic queries.

■ TD-17

Tuesday, 14:00-15:30 - Room 005

Interior Point Methods for Large-Scale Optimization

Stream: Interior Point Methods and Conic Optimization
Invited session
Chair: *Miguel Anjos*

1 - Inexact Search Directions and Matrix-free Interior Point Method for Quantum Information Problems
Jacek Gondzio

Many large-scale optimization problems cannot be solved with methods which rely on exact directions obtained by factoring matrices. I will argue that second-order methods (including interior point algorithms) which use inexact directions computed by iterative techniques and run in a matrix-free regime offer an attractive alternative. I will address a theoretical issue of how much of inexactness is allowed in directions and support the findings with computational experience of solving some very large optimization problems which arise in quantum mechanics.

2 - BlockIP: An Interior-Point Solver for Block Angular Problems
Jordi Castro, Xavi Jimenez

A new interior-point solver for block angular structures is introduced. It implements an approach based on the solution of normal equations by Cholesky factorizations and preconditioned conjugate gradients (PCG). Some of its features are: it is written in C++, allowing several input formats (C++ interface, extended MPS, AMPL SML); it solves separable convex problems (linear, quadratic and nonlinear); both proximal point and quadratic regularizations are included; normal equation are solved by either Cholesky or Cholesky and PCG. Computational results with some problems will be reported.

3 - Finding a Basis for the Splitting Preconditioner on Interior Point Methods
Aurelio Oliveira, Porfirio Suñagua-Salgado

The splitting preconditioner works well on linear systems arising from interior point methods near a LP solution when the matrices are highly ill-conditioned. It needs a basis computed by a sophisticated rectangular LU factorization. We propose a new approach to find a better conditioned basis computing the standard rectangular LU factorization with partial pivoting of the transpose scaled constraint matrix. Additionally, a penalty parameter is applied in the interior point method to reduce ill-conditioning. Numerical results reveal the new approach better performance on large-scale problems.

4 - Using Hybrid Preconditioners in an IPM for Large Block-Angular Problems
Silvana Bocanegra, Jordi Castro, Aurelio Oliveira

The main computational burden of interior point methods (IPMs) is the solution of linear systems. An IPM for block-angular problems solves these systems by combining Cholesky and a conjugate gradient based on a power series preconditioner for block and linking constraints, respectively. This preconditioner may become inefficient in the last IP iterations. A hybrid approach is proposed: the power series preconditioner is used at the first iterations and a splitting preconditioner based on LU is applied in the last ones. This approach improves the performance and robustness of the IPM.

■ TD-18

Tuesday, 14:00-15:30 - Room 112

New Trends in Evolutionary Multiobjective Optimization

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Mariano Luque*

1 - An Interactive Evolutionary Multiobjective Optimization Method based on the WASF-GA Algorithm
Mariano Luque, Kaisa Miettinen, Ana Belen Ruiz, Rubén Saborido Infantes

We describe an interactive evolutionary algorithm to solve multiobjective optimization problems. It is based on a preference-based evolutionary multiobjective optimization algorithm called WASF-GA. In the interactive version of WASF-GA to be introduced, at each iteration, the decision maker can provide desirable aspiration values and several nondominated objective vectors are generated based on them. They are filtered and shown to the decision maker who has also the option of expressing minimally acceptable values for each objective function in the form of reservation values.

2 - A Hybrid GA and ACS Preemptive Multiobjective Model to Approach a Hydroelectric Dynamic Dispatch
Regiane Silva de Barros, Jéssica Pillon Torralba Fernandes, João Paulo Estrócio, Ieda Hidalgo, Paulo Correia

This paper approaches a hydroelectric dynamic dispatch with hybrid Genetic Algorithm (GA) and Ant Colony System (ACS) tools in a preemptive multiobjective model. It seeks to maximize the plant efficiency and to minimize the units' start-ups and shut-downs. In the first priority, GA solves the 24 hourly static dispatches to provide a set of good solutions (optimal or sub-optimal) in terms of the efficiency. In the second priority, ACS minimizes the shut-downs and start-ups to find optimal Pareto diary paths. This model was successfully applied to a real plant, whose results are discussed.

3 - A Metamodel Assisted NSGA-II Algorithm for Multiobjective Optimization
Karthik Sindhya

Industrial multiobjective optimization problems often involve objective and constraint functions, which are very computationally expensive to evaluate. Evolutionary multiobjective optimization algorithms like NSGA-II are often used to handle multiobjective optimization problems, are not suitable for computationally expensive problems as they require calculation of objective and constraint functions of a population of solutions over a large number of generations. In this paper we augment NSGA-II algorithm with a metamodel in order to be better able to handle computationally expensive problems.

4 - Solving Two-Stage Stochastic Integer Linear Programming with Multiple Objective
Salima Amrouche

In this paper, we present a new method of multiobjective two-stage stochastic integer linear programming MOSILP cosidering the parameters of linear objective functions and some linear constraints as discrete random variables with known probability distribution. To solve the stated problem, first we remove the randomness of the problem and formulate an equivalent deterministic multiobjective integer linear programming model MOILP. Then an optimal solution of LP whose objective is a positive combination of the criteria, with respect to the first-stage constraints and existing feasibility.

■ TD-19

Tuesday, 14:00-15:30 - Room 128

Retail Demand Planning

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Winfried Steiner*

1 - Product Line Pricing and Design for Aspirational Products with Multiple Customer Segments
Udatta Palekar

We consider the problem of determining the optimal pricing for a product line where the products are vertically differentiated and customers choose the best product that fits within their budget. Customers are grouped into segments based on minimum quality requirements of products they will purchase. We focus on two-customer segments and study the optimal pricing problem and the problem of adding or dropping products from the line. We also present numeric results based on our algorithms.

2 - A Comparison of Different Types of Probit Models for Conjoint Segmentation
Friederike Paetz, Winfried Steiner

Finite Mixture (FM) Choice Models so far do not account for dependencies between alternatives. We propose a new FM-MNP model that considers such different pairwise similarities. To analyze whether the independence assumption is as restrictive as it seems, we contrast the FM-MNP model to its nested version, the FM-IP model, which assumes independence. In a simulation study we compare these models w.r.t. parameter recovery, fit and prediction. While incorporating dependencies pays off for parameter recovery and unpenalized model fit, the models are comparable with regard to forecasting accuracy.

3 - Association Rules Based on Tree-Building Technique in Market Basket Analysis
Marijana Zekic-Susac, Adela Has

As a data mining method, association rules have been used in marketing and retail management to reveal which products are frequently purchased together or sequentially by the same customer. This paper investigates the efficiency of association rules based on the tree-building technique in case with a large number of items. A real dataset was collected from a major Croatian supermarket, and association rules generated with two different item-grouping strategies were analyzed. The selection of interesting rules is then performed by integrating objective measures and expert knowledge.

4 - Optimal Diapers Production Using Simplex Method
Zaid Montenegro, Jose Luis Chavez - Hurtado, Humberto Palos Delgadillo

SCA is a leading global hygiene and forest products company that develops and produces sustainable personal care, tissue and forest products. In Guadalajara, Mexico, there is an area of the company dedicated to produce baby care products, focusing especially in producing diapers. This work shows the results of a consultancy made for SCA Guadalajara which aimed to optimize production of diapers for different brands in order to maximize company profits by taking into account different constrains (product demand, available resources, production capacity, etc.) and solved using simplex method.

■ TD-20

Tuesday, 14:00-15:30 - Room 129

Power System Design and Operation

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Asgeir Tomasgard*

1 - Wind Power, Congestion Management and the Variability of Power Prices
Mette Bjørndal, Jonas Andersson, Endre Bjørndal, Linda Rud

New interconnectors and added intermittent generation capacity will expose the Nordic market to more variability. While price variations from uncorrelated wind power production may cancel out, variability may be enhanced due to the network topology and capacity. This has implications for congestion management. In a model of the Nordic electricity market and its transmission system, we study implications of spot market volatility given various scenarios of wind power and transmission investment, using different methods of congestion management.

2 - Congestion Management by Dispatch or Redispatch: Flexibility Costs and Stochastic Effects
Endre Bjørndal, Mette Bjørndal, Asgeir Tomasgard, Kjetil Midthun

Several European electricity spot markets use simplified congestion management methods such as uniform or zonal pricing, and redispatch is necessary to achieve a feasible flow. Bjørndal et al. (2013) discussed the effects of flexibility costs in a deterministic setting. We extend their model to include stochastic effects, e.g., caused by intermittent renewables, and we apply our model to the Nordic power market. We discuss the combined effect of uncertainty and flexibility costs for different choices with respect to congestion management method.

3 - Reliability in the Power System Modeled in a Multi-Stage Stochastic Mixed Integer Programming Model
Michael Pascal Simonsen Nielsen

Contributions from this article are that it takes the characteristics of the power system into account at different stages, which gives a more realistic presentation of the welfare aspects to be gained by an optimal operation/ dispatch of the power system. This article is utilizing a Multi-Stage Stochastic Mixed Integer Programming Model that handles uncertainty in a flexible and practical way. The method applied relies on state-of-the-art modeling within this field, but the method applied in this article is extended by using decomposition.

4 - Estimation of Stochastic Frontier Cost Efficiency for Companies in the Electricity Distribution Sector in Brazil
João Silveira, Julio Siluk, Simone Naimer

This paper presents the estimation of a cost efficiency stochastic frontier panel for a sample of the Brazilian electricity distribution sector, using in the main function explanatory variables of average operational cost of the companies, such as average salary, cost of energy purchased and volume of energy supplied. In the equation of inefficiency is tested the average duration of the supply interruption per year in hours (DEC) and the average frequency of the supply interruption per year (FEC), as well as the productivity in MWhs sold by employee.

■ TD-21

Tuesday, 14:00-15:30 - Room 006

ORCCS1

Stream: OR Consultancy and Case Studies
Invited session
Chair: *Sue Merchant*

1 - Optimizing Collection Routes for Bottle Banks
Jeroen Belien, Philippe De Bruecker, Simon De Jaeger, Liesje De Boeck

This paper presents an integrative optimization-simulation approach for optimizing the collection routes for bottle banks. A bottle bank is a large container into which the public may throw glass bottles for recycling. The objective is to minimize the collection time while avoiding containers becoming full. Our model has been used to determine the return on investment of providing the containers with filling level sensors and to compare flexible routes with fixed, cyclic routes. Discussions with the client about implementing the results will also be covered.

2 - Optimal Department Locations Determination and Workforce Schedule in Textile Industry
Sila Halulu, Engin Bayturk, Fadime Üney-Yüksektepe

This study involves the biggest textile store chain in Turkey which has many stores in seventeen countries. Currently, one IT department in Turkey covers all stores. Since stores are located in different time zones, it is difficult to manage stores' problems from single location. The company wants to open new IT departments in different locations. The study aims to decide the optimal locations of the new IT departments, to assign the number of workers for each and determine the work hour schedule of the workers. Discussions with the client about implementing the results will also be covered.

3 - A Predictive Analytics Approach for Demand Forecasting in the Process Industry
Benjamin Priese, Robert Blackburn, Kristina Lurz, Rainer Göb, Inga-Lena Darkow

Anticipating demand changes is critical in the process industry with high capacity utilization. The developed solution is based on a new predictive analytics approach and sophisticated information technology, which allows combining company data and economic information specifically matched to the market environment of product segments. The approach systematically selects the best information for a business outlook. Based on data from the global chemical company BASF, first empirical results show that our approach significantly outperforms statistical approaches based on historical demand data.

4 - Learning from OR Practice
John Ranyard, Robert Fildes

The IFORS sponsored global survey of OR practice, fully reported at the last IFORS conference but summarised here, has enabled several key challenges for the OR community to be explored. These include addressing the long-acknowledged gap between theoretical research and the needs of practitioners and examining the extent to which the scope of OR has been influenced by problem structuring methods (soft OR) and the burgeoning business analytics movement. The response to these challenges is critical to the future of OR, in particular how it is practiced.

■ TD-22

Tuesday, 14:00-15:30 - Room 007

Game Theory Applications in Supply Chains

Stream: Game Theory and Operations Management
Invited session
Chair: *Eda Kemahlioglu-Ziya*

1 - On Using Incentives to Induce Reliable Supply: The Interplay of Supply Risk, Bargaining Power, and Process Design
Woonam Hwang, Nitin Bakshi, Victor DeMiguel

Supply risk can be mitigated through the supplier's effort, but effort is often not contractible in decentralized supply chains. We investigate how contractual incentives may be used to induce reliable supply, and how it is influenced by the interplay of the type of supply risk, the balance of bargaining power, and the allocation of decision rights in the procurement process. We find that a simple wholesale-price contract can often generate high efficiency. Moreover, multitask moral hazard can actually mitigate the problem of incentive alignment, generally resulting in higher efficiency.

2 - Can You Be Too Fast? Assortment Competition and Supply Chain Responsiveness
Victor Martínez de Albéniz, Gurhan Kok

In industries where customer needs quickly change, retailers can postpone their assortment decisions if they are quick enough. We study here how assortment competition depends on the postponement capabilities of retailers. We develop a stylized model where two retailers choose their assortment breadth either before or after market characteristics are revealed.

3 - Setting the Right Incentives for Global Planning and Operations
Ulas Ozen, Marco Slikker, Henk Norde

We consider a firm selling a group of products that require the same production technology and share resources through multiple regional business units. The demand in each region is stochastic and best observed by the regional units. The firm is engaged in global planning and manufacturing activities and relies on the regional units' forecasts. In this research, we are studying incentive mechanisms that induce the business units to reveal their private information truthfully and work hard.

4 - Contracting for Capacity under Renegotiation: Partner Preferences and the Value of Anticipating Renegotiation
Eda Kemahlioglu-Ziya

This paper studies contract renegotiation in a stylized supply chain model. Two original equipment manufacturers (OEMs) sign fixed-quantity contracts with a contract manufacturer (CM) prior to demand realization. Contract renegotiation after demand realization allows the OEMs to use capacity that is more or less than what they contracted for. We assume that the extra profit due to efficient allocation of capacity is allocated to the supply chain parties according to the egalitarian rule and investigate when an OEM's expected post-renegotiation profit is maximized.

■ TD-23

Tuesday, 14:00-15:30 - Room 008

Behavioural Operations and Supply-Chain Management

Stream: Behavioural Operational Research
Invited session
Chair: *Hajnalka Vaagen*

1 - Workers to Job Allocation — Case Study of Central Europe Countries
Peter Horvát, Miroslav Štefánik

In this paper we present results based on EU Labour Force Survey microdata. We analyze the decisions of individuals on the combination of economic sector and occupation where they accept employment. These decisions determine the allocation of supply of labour on the labour market. Two groups of factors are identified: individual (gender, age, education, and region), market (wage, unemployment, dynamic of employment). We explore these factors using a multinomial logit model. The data allow us to compare the contributions of particular factors to individuals' decisions between countries.

2 - Simulation and Experimental Analysis of Pull-Type Ordering Methods
Javier Pereira, Fernando Paredes, Claudio Lavin, Luis Contreras-Huerta, Claudio Fuentes

Ordering methods are simulated under an AR(1) demand processes when a supply chain model is considered. Three criteria are computed and aggregated on diverse scenarios: the stage's amplification, average inventory and backlog levels. Pull-type ordering methods have better results than push-type procedures. An experiment is developed with twelve individuals who are instructed to use a pull-type policy. The high amplification and average inventory levels observed show that people persistently tends to prospective behaviour implementing re-order and push methods, but introducing serious bias.

3 - Social Preconditions for Operational Excellence in Engineer-to-Order Dynamic Systems — The Context of Norwegian Offshore Shipbuilding
Hajnalka Vaagen, Jan Emblemsvag

The aim is to build understanding on the inner network mechanisms and human factors that drive operational excellence in engineer-to-order dynamic systems: from the structural- to the cognitive dimension. Understanding is built by the triangulation of social network analysis and behavioral studies, within the context of shipbuilding engineering planning. Besides establishing the true informal network structures, explicit discussions are expected on how micro level behavior (like job rotation, motivation) influences macro level operations (like outfitting flexibility offered to customers.

■ TD-24

Tuesday, 14:00-15:30 - Room 212

Operations Finance Interface 1

Stream: Operations Finance Interface
Invited session
Chair: *Burak Kazaz*

1 - Supply Chain Network Structure and Firm Performance
Jing Wu, John Birge

The complexity and opacity of the network of interconnections among firms and their supply chains inhibits understanding of the impact of management decisions concerning the boundaries of the firm and the number and intensity of its relationships with suppliers and customers. Using recently available data on the relationships of public US firms, we investigate the effects of supply chain connections on firm performance as reflected in stock returns. We find that supply chain structure is closely related to firm returns at two levels, first from direct connection and second from centrality.

2 - Pre-shipment Financing: Credit Capacities and Supply Chain Consequences
Anne Lange, Fehmi Tanrisever, Matthew Reindorp

We study a supply chain where a wealthy retailer buys from a debt-constrained supplier who cannot internally finance his entire production operations. The retailer commits to a minimum purchase quantity to facilitate pre-shipment financing, which enables the supplier to extend his debt capacity and thereby also his production level. In equilibrium, we illustrate that the retailer has an interest to collaborate with a financially strong supplier. In contrast, we find that the supplier may be at a disadvantage when doing business with a highly creditworthy retailer.

3 - Multinational Newsvendor Networks: On the Profit-Shifting Option of Multi-Plant Sourcing
Gerd J. Hahn, David Francas, Shailesh Kulkarni

We extend the classical newsvendor networks approach to a setting with taxes and a profit-shifting mechanism. Optimal cost allocations, transfer prices, capacity, and production levels are determined for a multinational company that serves one domestic market under stochastic demand with a secondary sourcing option in a low-tax country. While shifting the disposable income to the low-tax country is (obviously) optimal, the capacity investment strategy has two distinct forms (single vs. dual-sourcing) depending on the cost parameters. A numerical example illustrates our analytical findings.

■ TD-25

Tuesday, 14:00-15:30 - Room 009

Patterns Detection in Very Large Datasets

Stream: Data Mining
Invited session
Chair: *Bart Baesens*

1 - A Social Network Approach to Identifying Key Police Suspects using Data Mining
Fredy Troncoso, Richard Weber

The analysis of criminal groups through social networks has been a key element in police analysis. A commonly used approach is the evaluation of the nodes importance and its application has been appropriate where the links between individuals are the only information available. This work propose an effective evaluator of the nodes importance in a network composed of suspect individuals, considering the criminal propensity of each individual. This evaluator, called Social Network Criminal Capacity Evaluator (SNCCE), outperformed alternative evaluators that are commonly used in network analysis.

2 - Finding Cliques in Large Fraudulent Networks: Theory and Insights

Véronique Van Vlasselaer, Leman Akoglu, Tina Eliassi-Rad, Bart Baesens

Given a bipartite graph consisting of people and activities, can we find groups of persons frequently involved in the same activities? Moreover, given that some activities are fraudulent, are we able to identify those groups of persons that are frequently involved in the same crimes. This study concerns the detection of fraudulent clique structures in a social security context. Using row- and column reordering techniques and simultaneously spreading fraud through the network, our approach successfully succeeds to find cross-associations, as well as to assign a fraud score to each clique.

3 - Detecting Collusion-Based Occupational Fraud in Business Processes

Filip Caron, Jan Vanthienen, Bart Baesens

According to the Association of Certified Fraud Examiners, an organization loses on average about 5% of its revenue to occupational fraud. Collusion allows perpetrators to more easily circumvent anti-fraud controls, resulting in a median loss that is twice the loss of a single perpetrator scheme. While collusion remains hard to prove, event logs of process-aware information systems can assist in uncovering highly unusual interaction patterns. Based on the transaction data in the logs, materiality based metrics can be defined for selecting the optimal fraction of potential fraud issues.

4 - Optimization Techniques in Astronomy

Mauricio Solar, Rodrigo Gregorio

In the context of ChiVO (www.chivo.cl) used for search of ALMA data, processing tools and image analysis to detect and classify astronomical structures are developed. We will show an algorithm to identify and classify astronomical structures at different scales using the wavelet transform (WT) in 2D images. WT provides a matrix to decompose it into several images of different scales. Identifying objects in WT is, given a scale, isolate structures. Then a classification algorithm is applied to recognize the structures and incorporate them into an astronomical catalog.

■ TD-26

Tuesday, 14:00-15:30 - Room 010

Fuzzy Systems

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session
Chair: *Pavel Holeček*

1 - Multiple-criteria Fuzzy Evaluation in FuzzME - Recent Development

Pavel Holeček, Jana Talasova

FuzzME is a software tool for multiple-criteria fuzzy evaluation. The vast number of supported methods (fuzzy weighted average, fuzzy OWA operator, fuzzified WOWA operator, fuzzified discrete Choquet integral, and fuzzy expert system) makes it incomparable to any other fuzzy decision-making support system. This presentation will summarize the recent development of the software and the theoretical results used in it. Specifically, possible transitions between the various aggregation operators and methods of deriving their parameters from the parameters of the original operator will be studied.

2 - SPRINT SMEs: A Fuzzy Linguistic 2-Tuple Recommendation Approach for Allocating human Resources in Software Projects

Vassilis Gerogiannis, Pandelis Ipsilandis

Assignment of human resources to the activities of a software project is a decision that is based on subjective/vague evaluation for the required skills and the capabilities of available resources. We suggest content-based recommendation to handle this imprecise information. The 2-tuple fuzzy linguistic model is used to adequately represent and evaluate skills' ratings. The development of the approach was co-financed by the EU Social Fund and Greek national funds through the Operational Program "Education & Lifelong Learning" of the National Strategic Reference Framework (ARCHIMEDES III).

3 - Direct Search methods to optimize Indoor Location Using Fuzzy Logic

Aldina Correia, Pedro Mestre, João Matias, Carlos Serôdio, Carlos Serôdio

Optimization problems in areas such as engineering are characterized by the fact that objective and constraints functions are non-smooth and/or their derivatives are not know. Therefore, optimization methods based on derivatives cannot be used and direct search methods must be an alternative. In this work these methods were used to tune the Fuzzy Logic parameters of the membership functions used in the location systems as well as the weights of the rules used in the on-line phase of Fingerprinting location method, minimizing the value of the precision.

■ TD-27

Tuesday, 14:00-15:30 - Room 213

Contracts, Auctions, Upgrade Timing, and Reverse Supply Chain Management

Stream: Operations/Marketing Interface
Invited session
Chair: *Samar Mukhopadhyay*
Chair: *Petr Fiala*

1 - Buyback Contract and Price Postponement in a Decentralized Supply Chain with Additive and Price-Dependent Demand

Weixin Shang

We study a decentralized supply chain with one supplier offering buy-back contract to one retailer who postpones retail pricing decision after demand realization. We find some mild conditions on demand distribution that guarantee the existence of a unique equilibrium when demand is additive in uncertainty. We discuss the impact of buyback contract on operational decisions and supply chain performance. Different from the game with multiplicative demand, the equilibrium buyback ratio, profit allocation ratio between supply chain members and the channel efficiency depend on demand distribution.

2 - The Timing of Product Upgrades with Brand Loyalty and Demand Aggregation

Sam Kirshner, Yuri Levin, Mikhail Nediak

This work examines how brand loyalty impacts the timing of product upgrades in industries with stochastic improvements in technology. Loyalty is shown to be an important determinant of the upgrade decision, since it enables a firm to aggregate demand for a future product release. Modeling the upgrade problem as a Markov Decision Process, we prove the optimality of a threshold policy based on the concept of demand aggregation. Numerical experiments are used to examine the behavior of the threshold policy and profitability for varying degrees of brand loyalty in different market conditions.

3 - Supply Network Coordination by Auctions

Petr Fiala

A structure of supply networks is composed from layers of potential suppliers, producers, distributors, retailers, customers. The units are interconnected by material, financial, information and decisional flows. Developing coordination can significantly improve the efficiency of supply networks and provide a way to ensure competitive advantage. Auctions are important market mechanisms for dynamic pricing and allocation of goods and services. We propose coordination of supply networks by multi-dimensional auctions. Mathematical models and solutions of the coordination process are presented.

■ TD-28

Tuesday, 14:00-15:30 - Room 130

International Outreach and Implicit Expectations in OR

Stream: International Aspects of OR: Cooperation — Coordination — Communication
Invited session

Chair: *Graham Rand*
Chair: *Jakob Krarup*
Chair: *Ulrike Reisach*
Chair: *Gerhard-Wilhelm Weber*

1 - Extending the Boundaries of IFORS
Jakob Krarup

A talented scientist, a group of scientists, a group of groups, a club, a national society, a group of national societies, an international federation: embarking from "Blackett's Circus" on the eve of WWII this is what led to the birth of IFORS in 1959. Today, 55 years after, new groups have emerged outside the IFORS community, amongst others in Africa. How are they identified? How to find ways to include them? No conclusive answer is provided whereas some initial approaches are accounted for.

2 - Discovering and Dealing with Intercultural Issues in Operational Research
Ulrike Reisach

OR as the development and application of scientific methods to improve decision making is useful for all challenges and countries throughout this world. But different cultures influence the way problems are perceived and decisions are taken. Local conditions have shaped people's experiences, expectations and behavior — not only in private life but also in the way of dealing with complex problems relevant to industry and society. A previous analysis and reflection on the societies, their history and implicit values and assumptions, helps to implement OR successfully.

3 - Pro Bono OR
Graham Rand

The Operational Research Society recently appointed a O.R. Pro Bono Manager. This scheme provides free O.R. support to Third Sector organisations (mainly charities) in the UK and is carried out by O.R. professionals. How projects and volunteers are found and matched will be described. The advantages for the organisations, for the ORS and for the volunteers will be explained, as well as some of the difficulties faced. Examples will be given of completed projects, as well as similar work carried out in Uganda and for a charity involved with street children.

■ TD-29

Tuesday, 14:00-15:30 - Room 011

Multiple Criteria Decision Making and Optimization 4

Stream: Multiple-Criteria Decision Making and Optimization
Contributed session

Chair: *Jelena Stankovic*

1 - Elicitation of Criteria Importance Weights with the Simos Method: A Robustness Concern
Eleftherios Siskos, Nikos Tsotsolas, Yannis Siskos

In MCDA, the Simos method is considered as an effective tool to assess criteria importance weights. However, the method's input data, required by a decision maker, do not insure a single weighting vector. This paper shows that solutions of both original and revised Simos procedures are vectors of a non-empty convex polyhedron. A set of robustness analysis techniques is proposed to help analysts and decision makers in fixing a single set of criteria weights or in applying robust rules based on multiple acceptable sets of weights. Results should be considered as complementary to Simos method.

2 - Dynamic MCDA with PROMETHEE and GAIA
Bertrand Mareschal

Most MCDA methods are limited to static data evaluated at a single given time. However many decision or evaluation problems involve time-dependent data and multiple time periods. We propose to extend the PROMETHEE-GAIA methodology to that case. Different types of dynamic problematics are considered and several practical extensions are implemented in the Visual PROMETHEE software including predictive PROMETHEE rankings and a dynamic version of the GAIA analysis. Numerical examples are used to illustrate these extensions.

3 - What Social Choice Rules Could be Simplified to Scoring Rules?
Yuliya Veselova

We consider social choice rules satisfying anonymity, neutrality, and consistency axioms. These rules are called composite scoring rules, since they could be represented via composition of simple scoring rules (Young 1975). We show how a composite scoring rule is simplified to a simple scoring rule for any given number of voters and alternatives. This simplification provides a benefit in time complexity, what is important in group decision making with large number of alternatives or voters. However, it is compensated by losses in space complexity in some particular cases.

4 - Fuzzy AHP application for improving BFC SEE model
Jelena Stankovic, Sasa Drezgic, Zarko Popovic

Business Friendly Certification (BFC) is a process that is conducted in the countries of South-Eastern Europe in aim improve local business environment. The mathematical background of BFC is multi-criteria model with 12 criteria. The subject of this paper is to analyze the attitudes of the business communities about the relevance and importance of these criteria. Research will be carried out at the urban level in the cities in Serbia and Croatia, with emphasis on the analysis of regional differences in the perception of criteria importance. In the analysis will be used fuzzy AHP method.

■ TD-30

Tuesday, 14:00-15:30 - Room 012

Location-Allocation Models

Stream: Allocation Problems in Game Theory
Invited session

Chair: *Lina Mallozzi*

1 - Mathematical Models for a Location- Allocation Problem of Traffic Flow Capturing Facilities
Yoichi Shimakawa, Hirotaka Takahashi, Hiroyuki Goto

Practical mathematical models are formulated for a location-allocation problem for the facilities that capture the traffic flow. It is an optimization problem that maximizes the total flow captured by locating facilities on the road link. The main feature is that the traffic flow can be captured commonly even in the case that some facilities are located on the route. We assume several routes between the origin and destination. We formulate the optimization problems in terms of total traveler kilometer and the number of O-D pairs. Using GIS, we study some results of the numerical simulations.

2 - Maxmin Allocation of Homogeneous Goods: The Three Players Case
Lucia Milone, Marco Dall'Aglio, Camilla Di Luca

We consider the maxmin equitable allocation of a finite number of homogeneous divisible items among three players with idiosyncratic preferences. We characterize the optimal allocations and develop an algorithm for its search. Both goals are obtained considering two important structures from fair division theory: the partition range and the Radon-Nikodym set.

3 - On the Problem of Optimally Locating Facilities and Allocating Customers to Facilities
Egidio D'Amato, Elia Daniele, Lina Mallozzi

A two-stage optimization model is proposed to find the optimal location of new facilities and also the optimal partition of a market area. In this location-allocation problem the social planner minimizes the social costs, i.e., the fixed costs plus the waiting time costs, taking into account that citizens are partitioned according to minimizing the capacity acquisition costs plus the distribution costs. The solution of the bilevel problem gives the optimal facility location. Theoretical and computational results are presented in a planar region.

4 - A Game Theoretical Model of Sensor Devices Placement in a Planar Region
Lina Mallozzi, Egidio D'Amato, Elia Daniele

In this paper a noncooperative game theoretical model for the experimental design problem is presented. The design variables are the coordinates of points in a region of the plane, similar to a facility location problem. The optimal solution gives the values of the experiment variables and corresponds to a Nash equilibrium solution of a suitable game. We study an application of the model to the problem of locating a given number of cosmic wave receivers on a bounded region. Theoretical and computational results are presented for this location problem.

■ TD-31
Tuesday, 14:00-15:30 - Room 013

Security Decision Processes

Stream: Decision Processes
Invited session
Chair: *Javier Cano*

1 - An Adversarial Risk Analysis Approach to Fraud Detection
Javier Cano, David Rios-Insua

Risk analysis provides a methodology aimed at mitigating the negative effects of threats that may harm the performance of a system. Adversarial risk analysis expands the methodology focusing on threats coming from intelligent intentional adversaries. In this paper, we provide a an approach combining risk analysis and adversarial risk analysis to determine best security portfolios when dealing with fraud detection in relation with access to a physical paid facility.

2 - Cibersecurity Decision and Risk Management Process
José Antonio Rubio Blanco, David Rios-Insua

The purpose of this work is to consider the influence and impact of all the elements related with the cibersecurity decision cycle, especially regarding computer system and critical infrastructure. We discuss the fundamental points for cibersecurity, critical infrastructure protection and decision-making cycles, taking into account aspects of cyber deterrence and cyber threat intelligence. We build a framework for strategic, tactical and operational approaches to cibersecurity, providing a decision-making model to support the selection of information security controls.

3 - Incident Handling Decision Processes in Oil and Gas Offshore Drilling
Aitor Couce Vieira, Siv Hilde Houmb, Paula deWitte

Incident handling on offshore drilling rigs involves critical activities to respond complex events that may lead to serious consequences. The article provides an analysis of the decision processes and stakeholders involved in such activity, as well as guidelines on how to improve decision-making, command and control structures, information and communication procedures, and coordination with other security activities. The aim is refining incident handling procedures to avoid failures, to enable a more coordinated and traceable incident handling, and — the ultimate goal — to minimize risk.

4 - Potential Trade-offs of Different Financing and Regulatory Structures for Airport Security in Europe
Woohyun Shim, Fabio Massacci, Julian Williams

Recently, many security regulations that require increased expenditures have been enacted in the aviation industry. These regulations have different regulatory (i.e., customized vs. one-size-fits-all) and financing rules (i.e., centralized vs. decentralized). However, the trade-offs between these rules has not been studied well. This study reviews various alternative financing and regulatory rules for airport security in Europe, and discuss the potential trade-offs of these using a simple conceptual model.

■ TD-32
Tuesday, 14:00-15:30 - Room 014

Information Systems

Stream: Data Mining, Knowledge Discovery and Artificial Intelligence
Contributed session
Chair: *Laura Turrini*

1 - Assessing Financial Incentives for Energy Policy-Making
Yulia Malitskaia, Barry OSullivan

The EU FP7-funded ePolicy project (http://epolicy-project.eu), Grant 288147, aims to provide a system to support the policy decision-making process. The support system represents a global multi-objective optimization framework that takes into account several categories of explicitly-defined requirements and the effects of financial incentives on promoting photo-voltaic (PV) panel installations. This paper presents an analytical model for quantifying the feed-in tariff policy derived from a composite econometric and data-mining approach analyzing multiple PV systems in several Italian regions.

2 - Towards Immune Genetic Algorithm for Composition of Web Services with Constraints
Khaled Sellami, Djamal Dris

Web service is a promising technology that allows dynamic composability, however how to achieve this is one of the current research challenges. The purpose of this work is to present an approach for web services composition based on genetic algorithm which focuses on two aspects in order to find the optimal solution; (1) the functional aspect by considering the semantic description of the web service, and (2) the non- functional aspect by considering the values of QoS of the service components. The use of a vaccine during the evolution provides heuristic information.

3 - Simulation as a key element of advisory system in construction engineering
Aneta Konczak, Jerzy Paslawski

An important role of simulation in support of production planning processes in the construction sector are presented. Simulation is a key element of hybrid advisory system, including various methods: analogy based on similarity of cyclical construction processes executed in similar conditions, abductive and deductive approach, and mentioned simulation. An implementation of this advisory system in ready-mix concrete delivery is presented as case study.

■ TD-33
Tuesday, 14:00-15:30 - Room 015

Defence and Security Applications III

Stream: Defence and Security Applications
Invited session
Chair: *Ana Isabel Barros*

1 - Optimizing Adversary Aircraft Fleet Composition and Employment
Robert Dell, Ryan McLaughlin, Matthew Carlyle

This talk presents an integer-linear program (ILP) to plan adversary aircraft fleet composition and employment to best satisfy the US Navy's annual adversary training demands over a 20-year horizon. Subject to annual budgets and other rules on aircraft use, the ILP prescribes sorties by aircraft type as well as yearly upgrades to the fleet, including procurement of new aircraft, procurement of performance enhancing upgrades, and retirement of older aircraft. ILP solutions to numerous real-world excursions suggest that training can be improved while simultaneously reducing operating costs.

2 - Optimal Scheduling of Canadian Armed Forces Search and Rescue Response Posture
Bohdan Kaluzny

The Canadian Armed Forces provide search and rescue (SAR) response for incidents involving aircraft and vessels in an area covering over 18 million square kilometres. SAR squadrons maintain a response posture defined as the ability to be airborne within a stated time period: either 30 minutes (RP30) or 2 hours. Time on RP30 is limited due to resource constraints. A mixed-integer linear program was formulated to determine optimal schedules aligning time on RP30 to historical SAR incident times. We present the mathematical formulation and related data visualization and optimization results.

3 - A Routing Problem of UAVs by Mission-Adapted Mathematical Programming
Ryusuke Hohzaki, Shunya Nakamura

An unmanned aerial vehicle (UAV) plays an important role for reconnaissance and intelligence use. It is a good tool to search for moving targets on the ground as well as in the sea. We propose mathematical programming methods, LP and DP, to solve a routing problem of the UAVs. We adopt adequate criteria for the problem, corresponding to the reconnaissance and the intelligence mission of the UAV. In our methods, we revise the scenarios of the target movement by Bayes' theorem and take account of the limited motion of the fixed-wing UAV.

4 - The Multiple Traveling Salesmen Problem with Moving Targets
Anke Stieber, Armin Fügenschuh

The multiple weapons to multiple targets assignment problem can be seen as a multiple traveling salesmen problem with moving targets, where the weapons correspond to the salesmen, and the targets to the cities. Our approach is not based on restrictions to the movement of the targets. A discretization of time leads to large-scale integer linear programming (ILP) problems, that need to be solved in very short time. Computational studies on test problems demonstrate what problem sizes can be handled, and how much solutions from a fast and simple first come, first served heuristic can be improved.

■ TD-34

Tuesday, 14:00-15:30 - Room 016

Risk Analysis and Assessment

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Jean-Luc Prigent*

1 - Correlation Across Latent Variables in Credit Risk Models: A Direct Inference from Default Rates
Fernando Moreira

The correlation across latent variables assumed to drive defaults is a key parameter in the credit risk model used by financial regulators. We point out some inconsistencies in this approach and suggest the use of a more coherent measure in this context (the tetrachoric correlation coefficient). We show that the number of loans in the portfolios and their default rates are sufficient to estimate the correlations. Our results support empirical findings in other studies based on different approaches. The technique suggested here can be easily implemented by practitioners and regulators.

2 - A Generalization of Cornish Fischer Formula to Compute VaR: Evidence on Real Estate Data
Charles-Olivier Amedee-Manesme

This paper proposes to better modeled infrequently published returns indices. Infrequent returns are common in alternative investments such as art, wine or real estate where transactions are characterized by their heterogeneity, their low number or their illiquidity. Using a derivation of the Cornish Fischer expansion, the proposed approach allows to better estimate the true distribution. The proposed model is applied on real estate databases. The approach is relevant for fund or risk managers.

3 - On the Debt Capacity of Growth and Decay Options
Jean-Luc Prigent, Nourdine Letifi

This paper focuses on the impact of debt on the optimal policy for investment and hiring. We extend the model introduced by Tserlukevich (2008) by first adding another key control variable, namely the employment level, second by considering a no longer perpetual debt. We detail and analyze the optimal strategies, by using results about singular stochastic optimal control with triggered solutions. The novelty of our approach is based on the combination of optimal firm management with the valuation proposed by Merton (1974).

4 - Scoring Method of Enterprise Risk Management
Juthamon Sithipolvanichgul, Jake Ansell

The main objective of this paper is to propose Enterprise Risk Management (ERM) scoring method from integrating well-implemented ERM components where contribution measurement can be standardized by constructing a sample of firms from all public listed firms in Thailand and classified level of ERM adoption. Stepwise regression model is used to find relationship of ERM implementation level and Tobin's Q. There are positive significant different between ERM and firm value. Finally, not only financial companies will advantage implementation of ERM but also non-financial companies as well.

■ TD-35

Tuesday, 14:00-15:30 - Room 131

Game Theory with Applications III

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Yasushi Masuda*

1 - Comparison of Discrete Fixed Point Theorems by a Bimatrix Game
Hidefumi Kawasaki

There are three types of discrete fixed point theorems: type (C) deals with contraction mappings, type (M) deals with monotone mappings, and type (B) is based on Brouwer's fixed point theorem. In this talk, we mainly deal with types (M) and (B), and make a comparison of them by a bimatrix game. We will show that the simplicial decomposition of the convex hull of the domain of the mapping is important for analyzing type (B).

2 - Optimal Licensing for Incumbent Innovator in Differentiated Product Markets
Masashi Umezawa, Tatsuya Kitagawa, Yasushi Masuda

We investigate a two-part tariff licensing contract that enables an incumbent innovator to license the technology for a new product to a potential rival, who may alternatively develop a compatible technology for an imperfectly substitutable product. We identify the optimal two-part tariff licensing contract based on the development cost incurred by the rival, the market parameter, and the substitution coefficient.

3 - Game Theoretic User Equilibrium in a Congestion-Prone System with Priority
Yasushi Masuda, Akira Tsuji

We consider a stylized congestion-prone system of multiple resources where a fixed number of priority passes are allocated to each customer, and demonstrate that a priority system could be an effective method of congestion control even when customers are homogeneous. We prove that there exists an equilibrium of customers' behavior. In particular, the system without priority has a unique equilibrium. Numerical examples show that the proposed priority system is effective. Furthermore with a proper number of priority passes the equilibrium sometimes achieves the first best solution.

■ TD-36

Tuesday, 14:00-15:30 - Room 132

Forest Management for Biodiversity

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Mustapha Ohimmou*

1 - Towards the Development of a Spatially Explicit Management Model to Protect the Fisher (Martes Pennanti) in an Industrial Forest in California
Richard Church, Matthew Niblett, Klaus Barber

The fisher (Martes Pennanti) is a small weasel that is one of the key species of concern in forest management in California. A viable home range territory of a female fisher needs high canopy cover in approximately 70% of the area, as well as a number of scattered large structural trees and snags. It is necessary to model canopy and structures within unit areas no larger than 40 acres in size, where a typical home range is comprised of 60 or more planning units. In this paper, we propose a new spatial optimization model to optimize harvesting activities while protecting the fisher.

2 - Production Possibility Frontiers for Energy Wood, Timber Production and Biological Diversity in North Karelia, Finland
Mikko Kurttila, Leena Kärkkäinen, Olli Salminen

A large-scale planning system was used to define production possibilities for energy wood, timber production and biodiversity. The results were reported through production possibility frontiers. They indicate that rather high amounts of energy wood can be harvested with minor impact on the studied variables. Energy wood harvesting from thinning stands is supportive to timber production. Energy wood removals from young stands cause minor effects on variables related to biodiversity. Economically sound production of energy wood is connected to harvesting operations of other forest industries.

3 - Wood Allocation and Selection of Forest Harvest Areas - How to Consider Spatial Dispersion and Sustainable Forest Management Policies?
Mustapha Ohimmou, Azdeh Mobtaker, Mikael Rönnqvist, Marc Paquet

The tactical planning in forest management involves the selection of harvest areas over a horizon of several years and allocates them to mills to fulfill certain demand. Several optimization criteria must be included to achieve sustainable forest management policies. Both government and industry face these questions and need decision support system to enable efficient plans. In this paper, we address this wood allocation problem and the selection of harvest areas while taking into account spatial dispersion Sustainable Forest Management Policies in a case study in crown land in Canada.

■ TD-37

Tuesday, 14:00-15:30 - Room 017

Multicriteria Decision Making in Humanitarian Logistics

Stream: Multiobjective Optimization
Invited session
Chair:
Chair: *F. Javier Martin-Campo*

1 - A Multicriteria Proposal for a Humanitarian Logistics Problem: An Integral Approach
Julian Molina, Christopher Mejía-Argueta, Juan Gaytán, Rafael Caballero, 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 multicriteria (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 by a case study in Mexico.

2 - Metaheuristics for a Multi-Criteria Humanitarian Aid Distribution Problem
José María Ferrer, M. Teresa Ortuño, Gregorio Tirado

Planning the delivery of humanitarian aid involves several factors such as cost, operation time, equity of the distribution, reliability of the itineraries, security, etc., which lead to a complex multi-criteria optimization problem. In this work a metaheuristic inspired on a GRASP (Greedy Randomized Adaptive Local Search Procedure) methodology is presented to solve this problem. The proposed method guides the construction of solutions prioritizing the elements that provide larger local improvements as well as those that were part of the best solutions obtained previously.

3 - A Decomposition-based Heuristic for Optimizing Post-Disaster Relief
Christophe Duhamel, Andréa Cynthia Santos, Daniel Brasil

We consider the problem of setting up post-disaster distribution centers and supplies delivery to the population over a given time period. Financial, operational and human restrictions limit both the centers opening schedule and the distribution. We present a non-linear model and we propose a mathematical decomposition where the primary variables (centers opening dates) are addressed by NOMAD solver while the distribution is computed by heuristics and a VND local search. Our approach is calibrated on several instances and scenarios, and evaluated on a realistic instance.

4 - Interactive Decision Making Approach for Selecting an Evacuation Plan
Juan Gaytán, Javier Garcia-Gutierrez

Given the multi-criteria nature faced in the humanitarian logistics context, there is the issue of providing a quick solution adding the good judgment and expertise of the decision maker. Formal and evolutionary approaches exist to identify promissory solutions at the Pareto front as well as providing interaction with the decision maker to end up with a best compromise. We present a fast-solved interactive multi-criteria procedure that starts from a knee point of the Pareto front and a local guided search.

■ TD-38

Tuesday, 14:00-15:30 - Room 214

Proximal and Splitting Algorithms

Stream: Convex Optimization Methods and Applications
Invited session
Chair: *Xiaoming Yuan*

1 - On the Extension of ADMM for Separable Convex Programming and Beyond: From Variational Inequality Perspective
Xiaoming Yuan

The direct extension of the alternating direction method of multipliers (ADMM) for a multi-block separable convex minimization model is not necessarily convergent. We propose a prototype algorithm that can preserve completely the numerical advantages of the direct extension of ADMM but with guaranteed convergence. A unified and easily checkable condition to ensure the convergence of this prototype algorithm is given. Based on this prototype algorithm, we also propose a class of specific ADMM-based algorithms. The analysis is conducted in the variational inequality context.

2 - A Proximal Point Algorithm Using an Asymmetric Linear Term
Deren Han

In this paper, we propose a new PPA with asymmetric proximal term. For a given iteration, the next iteration is generated by solving a PPA-like subproblem, which is similar to that in the classical PPAs. The less restrictions on the proximal term provides us the possibility of designing some efficient splitting algorithms, taking into account the original problems' special structures. Moreover, discarding the correction step can help us keep the favorable properties of the iteration generated by PPA-like subproblems.

3 - Smoothing Proximal Gradient Methods for a Class of Nonsmooth Convex Minimization Problems
Sanming Liu

Inspired by various applications, we propose a novel optimization algorithm for minimizing a convex objective which decomposes into three parts: a smooth part, a simple non-smooth Lipschitz part, and a simple non-smooth non-Lipschitz part. We use a time variant smoothing strategy that allows us to obtain a guarantee that does not depend on knowing in advance the total number of iterations nor a bound on the domain.

■ TD-39

Tuesday, 14:00-15:30 - Room 018

Algorithms for Large-Scale 0-1 Linear and Quadratic Programming Problems

Stream: Discrete and Global Optimization
Invited session
Chair: *Jitamitra Desai*

1 - An Improved RLT-based Mechanism for Solving Nonconvex 0-1 Quadratic Programs
Jitamitra Desai

There are several well-known convexification methods for solving nonconvex quadratically constrained quadratic programs (QCQPs). We introduce a new class of cutting planes that we refer to as minimum triangle inequalities (MINTI). Motivated by these MINTI cuts, an improved version of the RLT-based branch-and-bound algorithm is presented for solving nonconvex 0-1 QCQPs.

2 - On Augmented Lagrangian Duality In Integer Programming
Andrew Eberhard, Natashia Boland

We consider the augmented Lagrangian dual for integer programming, and provide a primal characterization of the resulting bound. As a corollary, we obtain proof that the augmented Lagrangian is a strong dual for integer programming. We are able to show that the penalty parameter applied to the augmented Lagrangian term may be placed at a fixed, large value and still obtain strong duality for pure integer programs. Some potential avenue of application of these results are discussed.

3 - Integer Bilevel Quadratic Fractional and Quadratic Programming Problem
Nacera Maachou, Mustapha Moulai

The purpose of this paper is to find the integer solution for the bilevel quadratic fractional/quadratic programming problem (BQFP) in which the leader's objective is quadratic fractional and the follower's objective is quadratic. Applying the Kuhn-Tucker conditions at the lower level, the (BQFP) is converted to a quadrtaic fractional programming problem with complementarity constraints. A related bilevel linear fractional/quadratic problem problem (BLFP) is constructed in order to obtain an integer optimal solution of a (BQFP).

4 - C-GRASP for Mixed Integer Global Optimization
Joao Lauro D. Faco', Mauricio Resende, Ricardo Silva

Continuous GRASP (C-GRASP) is based on the guidelines of the greedy randomized adaptive search metaheuristic procedure (GRASP) of Feo & Resende (1989, 1995) to find optimal or near optimal solutions to constrained global optimization programming problems (Hirsch et al., 2007). We adapt C-GRASP to handle both discrete and continuous variables. The linear or nonlinear constraints as well as the variable integrality constraints are incorporated in the objective function using a penalty term. We present results of computational experiments with hard mixed integer nonlinear programming problems.

■ TD-40

Tuesday, 14:00-15:30 - Room 019

Innovations in Meta-Analytics I

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair: *Fred Glover*
Chair: *Manuel Laguna*
Chair: *Gary Kochenberger*

1 - Variable Association Networks for Identifying Patterns in 0-1 Integer Programs
Shunji Umetani

The latest MIP solvers have become to solve many real instances optimally in recent years. However, many large and/or hard MIP instances still remain because of little hope to close large gap between lower and upper bounds by the standard mathematical programming methods. To overcome this, we incorporate a data mining technique into an efficient local search algorithm, in which we construct variable association networks that identify promising pairs of flipping variables in the large neighborhood search.

2 - A Two-Stage Population-Based Approach with Learning Mechanisms
Eduardo Lalla Ruiz, Christopher Expósito Izquierdo, Belen Melian Batista, Marcos Moreno-Vega

In this work, we propose a two-stage population-based approach to solve optimization problems. Our approach exploits the information obtained from preliminary tests in order to learn and tune up its own components. During the first stage, a pre-search process that consists of conducting analytical tests regarding different search components of the algorithm is performed. In the second stage, the collected data regarding the performance of each search component is analyzed and used to determine which components are promising to enhance the overall algorithm behaviour through the search process.

3 - SAT-DM: Satisfiability Data Mining for Classification Problems
Vincent Gardeux, Lars Magnus Hvattum, Fred Glover

SAT-DM is a new classification method that generates a representative set of binary inequalities for each class. The inequalities are feasible solutions to a special variant of a satisfiability problem. A new sample is assigned to the class whose inequalities are the less violated. Although primarily designed for handling binary attributes, SAT-DM has been extended to any representation using a binarization method, inspired by the IDEAL algorithm. SAT-DM belongs to the class of Meta-Analytics procedures, joining metaheuristics with the field of analytics to enhance machine learning processes.

4 - Meta-Analytics for Improved Heuristic Search in Combinatorial Spaces
Manuel Laguna, Abraham Duarte, Rafael Marti, Anna Martínez-Gavara

Metaheuristics are typically configured and implemented as a set of search strategies that are chosen a-priori by following general methodological principles and context information. Programming by Optimization (PbO) is a noteworthy exception, where design choices are delayed and the task of determining the algorithmic configuration for a class of problems is viewed as an optimization problem. We propose applying data meta-analytics to discover search strategies that could be more effective than design choices that are either hard-coded or given as alternatives in frameworks such as PbO.

■ TD-41

Tuesday, 14:00-15:30 - Room 216

Enterprise-wide Optimization

Stream: Simulation-Optimization in Logistics & Production
Invited session
Chair: *Carlos A. Mendez*

1 - Optimal Operation of a Petrol Refinery Hydrogen Network
Elena Gomez, Gloria Gutiérrez, Daniel Sarabia, Gloria Gutierrez, Sergio Mármol, José Miguel Sola, Rafael González

Hydrogen H2 is an expensive utility employed in many refinery processes which has gained increasing importance in the economic balance. A model-based optimization tool for decision support has been developed for on-line optimal operation of a petrol refinery network involving 18 plants, aiming at a better H2 redistribution from producer to consumer plants under given constraints. The system suffers from important uncertainties, using measurements and data reconciliation methods for reliable estimation of all process variables combined with plant-wide optimization to minimize operating costs.

2 - Development of a Multi-Objective Optimization Model for the Integrated Management of Internal and External Production Resources
Javier Silvente, Antonio Espuña

This work addresses the integrated management of external (materials, energy/water management) and internal resources (equipment units, manpower) within the operation of a production plant, to determine the production strategy to best fit a specified demand, optimizing the use of resources through their integration and through the adaptation of their consumption to their availability. This objective is met using an extended mathematical formulation of the traditional integration approach to consider a generic view of common resources. Acknowledgements: DPI2012-37154-C02-01 and BES-2010-036099

3 - A Large Neighbourhood Search Combined with Monte-Carlo Simulation for Coping with Airlines Operational Disruptions
Daniel Guimarans, Pol Arias, Miguel Mujica Mota

We propose a methodology combining simulation and optimisation to tackle operational disruptions in the airline industry and increase solutions' resilience. Operational disruptions are defined as a deviation from originally planned operations and cause significant overheads to airlines. By introducing Monte-Carlo simulation methods within the solution acceptance mechanism in a Large Neighbourhood Search process, we can guide search towards more robust solutions. Advantages of our proposed methodology will be assessed by different case studies based on real data.

4 - Improvements in Multi-Objective Optimization for Supply Chain Design Problem
Gonzalo Guillen Gonsalbez, Pedro Jesús Copado Méndez

In the recent past, supply chain management (SCM) and enterprise-wide optimization (EWO) have been devoted to extend the boundaries of the analysis in order to capture a broader range of business practices. Our work addresses the multi-objective optimization (MOO) of supply chains (SCs) of enrivonmentally friendly fuels. In particular, we present a comparison between four e-constraint based strategies that expedite the overall search of optimal solutions in a smart manner by eliminating redundant criteria. The performance of these strategies is assessed by means of the hypervolume indicator.

■ TD-42

Tuesday, 14:00-15:30 - Room 215

OR in Systemic Risk, Credit Risk and Rating

Stream: Big Data Analytics
Invited session
Chair: *Kasirga Yildirak*
Chair: *Mariana Funes*

1 - Assessing the Effects of Spanish Financial Sector Restructuring on Branch Rivalry
Martí Sagarra, Cecilio Mar Molinero, Frank M.T.A. Busing, Josep Rialp

Spanish banks have been heavily affected by the banking crisis that began in 2008. Many of them, especially the Cajas, had to merge with other institutions or had to be rescued. We address the question of up to what point the nature of competition in this sector has changed as a result of the crisis. Our measure of interfirm rivalry is based on a geographical proximity measure that we calculate for the years 2008 and 2012. The technical approach is based on multidimensional unfolding, a methodology which allows us to represent the asymmetric nature of such rivalry through statistical maps.

2 - Credit Scoring Model with Additional Regression Parameters Taken from the Social Networks
Nataliya Soldatyuk, Michal Cerny

We present an experimental study of a credit scoring model based on logistic regression where public data from social networks are included as additional regression parameters. The main finding is that including of the social network data in the model can significantly affect the predictive power of the model. Though this is a case study only, it exposes that publicly available data from the social networks have an impact on the debtor-creditor relationship between a (potential) client and a bank.

3 - Assessing Developing Countries Creditworthiness Using the UTADIS Multicriteria Analysis Method
Mariana Funes, José Vargas

Since the globalization of capital markets, a higher number of developing countries governments are borrowing in international bond markets. It is important to have information that allows differentiating good and bad credit quality countries. This application involves the creditworthiness assessment of 98 developing countries previously classified in 9 ordered groups according to the implementation of an unsupervised classification method. Using UTADIS an additive utility function was developed that reproduced the classification with satisfactory results in terms of the classification error.

■ TD-43

Tuesday, 14:00-15:30 - Room 217

Data Mining, Statistics and Reliability Theory

Stream: Computational Statistics
Invited session
Chair: *Pakize Taylan*
Chair:
Chair: *Coşkun Kuş*

1 - Maximum Margin Multiple Kernel Clustering by Semi-infinite Optimization
Sureyya Ozogur-Akyuz, Gulnur Seichanoglou

Maximum margin clustering (MMC) has recently become efficient method in machine learning communities. As in the classification problems, choice of the kernel function affects the success of MMC. In this study, multiple kernel learning is adapted to MMC by using semi-infinite optimization. Kernel coefficients are constrained to L1 norm to produce a sparse solution while the weight vectors are penalized to L2 norm. Optimality conditions are analyzed for semi-infinite problem derived from maximum margin multiple kernel clustering model.

2 - New Solution Methods for the Mean Shift Outlier Model by M-Estimation Based on the Tikhonov Regularizaton and LASSO
Pakize Taylan, Burcu Bilgiç, Fatma Yerlikaya Ozkurt

In statistical research, regression models base on data, play a central role; one of these models is the linear regression model. However, this model may give misleading results when data contain outliers. We deal with the outliers problem in linear regression using the Mean Shift Outlier Model (MSOM) and providing a new solution for it by M-estimation based on the Tikhonov regularization problem and LASSO. We treat it using convex optimization techniques, permitting the use of interior point methods. We present numerical examples and we compare performance measures for our new solutions.

3 - Point and Interval Estimation for Weibull Regression Model under Progressive Type-II Censoring
Coşkun Kuş, İsmail Kınacı, Tony Ng

In this paper, the maximum likelihood estimators and Fisher information and asymptotic variance-covariance matrix based on progressive censoring schemes are obtained for Weibull regression model. Some simulation study are performed to investigate the bias', variances and MSEs of estimators. The coverage probabilities of approximate confidence intervals based on MLE are also considered. Finally, conclusions and discussions are provided.

4 - A Simulation Study to Compare the Estimators for Several Discrete Distributions Under Type I Censoring
Yunus Akdoğan, Tony Ng, Coşkun Kuş, İsmail Kınacı

In this study, Discerete Chen distribution is considered. Maximum likelihood, proportion, least squares and moment estimators based on type I censored sample are obtained. These estimates ara also compared via Monte Carlo simulation study. Some numerical examples are also provided.

■ TD-44

Tuesday, 14:00-15:30 - Room 218

OR Promotion among Academia, Businesses, Governments, etc.

Stream: Initiatives for OR Education
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Liudmyla Pavlenko*
Chair: *Elise del Rosario*

1 - Modeling Population Dynamics with Markov Chains and Logistic Regression in Industrial Engineering Faculty
Erick Orozco

This paper models the population dynamics of industrial engineering students using a stochastic process as a Markov chain and a generalized linear model and the multinomial logistic regression. The results obtained are useful for decision making in college, because, generate results desertion, retention and transfer students, which makes the strategy of academic support programs more effective. Also a cost model presented sets goals for admission of students, in order to use economies of scale and make academic programs more sustainable, in a dynamic environment such as the Colombian economy.

2 - Developing the Quantitative Curriculum in Business and Accounting
Jon Warwick, Anna Howard

Teaching Business decision support methods requires careful consideration of both what to teach and how to teach it. This paper summarises previous research into curriculum development issues for students in UK HE studying Business and Accountancy courses. Employers require that such courses ultimately deliver the correct blend of advanced techniques and core skills but studies have found that this is not always the case. Further, supporting and developing sometimes basic quantitative skills in diverse student cohorts presents particular pedagogic challenges and these are also discussed.

3 - The Modelling as Art for Sustainable Development of World (Fundamental Aspects in Engineering Education from the Viewpoint of a Nonlinear Analysts - OR)
Lyudmila Kuzmina

Research is devoted to Fundamentals of Modeling, Higher Engineering Education problems. Modeling is Art, connected with level/quality of Knowledge in areas of natural sciences, multidisciplinarity, with problems in training-teaching of specialists in complex engineering domains. The principles of subject teaching are discussed, which lead to activating/governing methods for engineering education in all areas. Modeling of systems thinking/system dynamics, applied to multidisciplinary objects, support a sustainable world. "The owning Knowledge, own the World' (Bernard Shaw)

4 - Is Big Data the New Sputnik? An Analysis of the Skills Gap in the Analytics Job Market
Michael Mortenson, Stewart Robinson, Neil Doherty

Whilst many recent reports highlight a perceived shortage of candidates with training in analytics, this has not detailed certain aspects. Specifically, it is unclear which skills are lacking and, as the training of STEM subjects and graduates has been debated since the launch of Sputnik in the 1950s, whether such shortages are indeed a new phenomenon. To address this issue, analyses of quantitative data and a series of interviews with practitioners working in analytics are presented. The results create a better understanding of analytics and suggest new directions for education and training.

■ TD-45

Tuesday, 14:00-15:30 - Room 219

Sustainable Development

Stream: Sustainable Development
Invited session
Chair: *Zenonas Turskis*
Chair: *Tatjana Vilutiene*

1 - Strategy Modelling for Hotel Facilities Management
Rasa Apanaviciene, Silvija Kapočien, Nerijus Varnas, Ala Dauglien

In many countries hotels represent a significant part of real estate sector. Hotel competitiveness is influenced by effective business as well as rational facility management solutions that allow reducing overhead and direct operating costs. While analysing external/internal factors and peculiarities of facilities management process, a theoretical model for hotel facilities management solutions was developed, that combines market, service supply chain, facilities management efficiency criteria, as well as economic, expert and multicriteria evaluation methods.

2 - Integrated Group Fuzzy Multi-Criteria and Cost-Effective Model for Selection of Facility Management Services for Commercial Premises
Zenonas Turskis, Edmundas Kazimieras Zavadskas, Tatjana Vilutiene, Natalija Lepkova

This paper analyses the work peculiarities of facility management companies' in a fuzzy market situation. There is a developed fuzzy multi-criteria group decision making model for similar problems solution, taking into account cost-effective management. The case study presents the selection of rational set of the facilities management services applying the weighted cost-effectiveness analysis together with the fuzzy multi-criteria decision making method ARAS. Such an analysis supports objective decision making: options considered in an objective way provide support for the final decision.

3 - Quality Management Improvement in Road and Highway Engineering
Jerzy Paslawski, Tomasz Rudnicki

Quality assurance is a critical problem in road and highway engineering. A new approach implemented in the last time is presented. An open market, a new network of quality laboratory and a ranking list of contractors are key elements of this conception. A value management and six sigma are discussed as steps for the future. Some case studies (acoustic screens, park & ride parking, quality ranking list) for illustration of implementation procedures are presented.

4 - Markov Switching Applied to the Evolution of GDP of Argentina, Brasil, Colombia and Mexico, 1950 to 2004
Alfredo Russo, Hernan Ferrari, Carlos Martinez, Juan Ledesma

Using the annual GDP series for Latin America countries (1950-2008) in constant dollars of year 2000, we have calculated the transition probabilities for each Hidden Markov matrix and the respective mean times for each regime since 1950 to 2008. Inter annual percent variations of GDP's for each country are used to simplify calculations. Parameters have been calculated using the Maximum Likelihood method. A first calculation has encompassed the whole period of 54 years and a second one encompassed periods of 10 years to verify time dependency of transition probabilities.

Tuesday, 16:00-17:30

■ TE-01

Tuesday, 16:00-17:30 - Room 118

Robustness and Maintenance of Vehicles and Infra

Stream: Railway and Metro Transportation
Invited session
Chair: *Ángel Marín*

1 - Long-Term Planning of Railway Track Maintenance
François Ramond, Bathilde Vasselle

For security reasons, maintenance has to be performed on railway tracks, making some portions of them unavailable during operations. For a given number of maintenance operations, maximum track availability is achieved by combining operations into single "track possessions". We consider the associated scheduling problem where operational constraints have to be taken into account to minimize the number of required possessions as well as the distance travel by maintenance machines on the network. We present some results showing that significant gains can be achieved by optimization techniques.

2 - Interactive Rolling-Horizon Scheduling of Depot Visits and Condition based Maintenance Tasks
Bob Huisman, Cees Witteveen

The majority of train maintenance tasks is condition based. When needed, vehicles have to visit maintenance depots within predetermined time windows. We propose schedules for depot visits and maintenance tasks taking into account the availability of routing options while respecting job deadlines. The method proposed solves the problem to optimality in polynomial time and offers real-time interaction with human planners. When used in a rolling horizon scenario with a dynamic environment it enables the user to control economic optimality versus plan stability in a time-efficient way.

3 - Optimal Scheduling of Aircrafts' Engines Repair Process
Isabel Cristina Lopes, Eliana Costa e Silva, J. Orestes Cerdeira

We address a real world scheduling problem concerning the repair process of aircrafts' engines by TAP Maintenance and Engineering (TAP-ME), which is the maintenance, repair and overhaul organization of the Portuguese leading airline. A MILP model, based on the flexible job shop scheduling, to determine the optimal sequencing of tasks within workstations, minimizing the total weighted tardiness, is presented. The model was tested on a real instance provided by TAP-ME from a regular working week and also on benchmarking instances available in literature.

4 - Scheduling of the train operation by a double track railroad while segments are closed.
Nail Khusnullin, Alexander Lazarev

We consider a problem, namely, the optimal scheduling of the train operation by a double- track railroad when one of the segments is under repair works. It is necessary for the set of trains available at the stations to determine time-scheduling and destination routing by railways in order to minimize one of the regular objective function. We suggest an exact algorithm. The idea suggested may be used for chosing the time period when the closing segments are economically profitable.

■ TE-02

Tuesday, 16:00-17:30 - Room 111

Vehicle Routing Applications

Stream: Vehicle Routing
Invited session
Chair: *Refail Kasimbeyli*

1 - The Blended Milk Collection Problem using Collection Points
Germán Paredes-Belmar, Andres Bronfman, Armin Lüer-Villagra, Vladimir Marianov

We present the blended milk collection problem using milk collection centers. Different qualities of milk are collected from farms, using a heterogeneous truck fleet. Each farm produces single quality milk. Milk is blended in the trucks, and the blend takes the quality of its lower quality component. Collecting milk form the farthest farms could have high costs, so collection centers are located for farthest farms. Trucks visit some of the farms and the milk collection centers, to which the remaining farmers have brought their milk. A model is presented and solved using Branch and Cut.

2 - Hybrid Metaheuristic for the Vehicle Routing and Scheduling Problem Featuring Perishability and Capacity Restrictions
Verena Schmid, Alvaro Raul Espitia Rueda

We present a model for a setting to arise in the context of milk collection. Besides dealing with a perishable product, some customers may only be accessed by vehicles below a maximum weight. Additionally the capacity of the processing plant is limited. To solve the problem we decomposed it in 2 parts: a metaheuristic is responsible for finding promising routing. Any solution may then be post-processed ensuring feasibility with respect to the plant's capacity and the product's life time. We are able to provide favorable results for this problem variant, as well as for benchmark instances.

3 - A Two - Objective Mixed Integer Mathematical Model for the Capacitated Vehicle Routing Problem
Melis Alpaslan, Refail Kasimbeyli

In this study, the capacitated vehicle routing problem with different types of vehicles is considered where each type has different number of vehicles. To analyze different cases, a single objective and a two-objective mathematical models are developed. The single objective mathematical model deals with minimizing the total route costs while the two-objective mathematical model also minimizes the total number of vehicle types used. To calculate efficient points of the second model, different scalarization methods are applied. Both models are demonstrated on test problems.

4 - Vehicle Routing and Scheduling with Cross-dock
Mohammad Yousef Maknoon, Pierre Baptiste, Gilbert Laporte

Vehicle routing with cross-dock is a generalization of well-studied vehicle routing problem in which truck loads need to be synchronized. In this problem, a set of request has to be transferred from an origin to a destination via cross-dock. Previous studies consider no restriction on capability of cross-dock on processing trucks which leads to infeasible plan. In this problem, we investigate the case in which cross-docks have limited capacity. We present an adoptive large neighborhood search to solve the problem.

■ TE-03

Tuesday, 16:00-17:30 - Room 001

Continuous Location (contributed)

Stream: Location
Invited session
Chair: *Tsutomu Suzuki*

1 - Continuous Multifacility Ordered Median Location Problems
Víctor Blanco, Justo Puerto, Safae EL Haj Ben Ali

We propose a general methodology for solving a broad class of continuous, multifacility location problems, in any dimension and with l_tau-norms proposing two different methodologies: 1) by a new second order cone mixed integer programming formulation and 2) by formulating a sequence of semidefinite programs that converges to the solution of the problem; each of these relaxed problems solvable with SDP solvers in polynomial time. We apply dimensionality reductions of the problems by sparsity and symmetry in order to be able to solve larger problems.

2 - A Modelling Framework for Solving Restricted Planar Location Problems with Forbidden Regions Using Phi-Object
Murat Oguz, Tolga Bektas, Julia Bennell, Joerg Fliege

We develop a general modelling framework for the planar location problem with arbitrarily shaped forbidden regions, where the regions are modelled using phi-objects. We show that the proposed modelling framework can be applied to both the median and centre problems. All instances from the literature on this problem type are modelled with this framework and solved to optimality. We also introduce and solve a multi-facility problem instance derived from an archipelago. This problem is more complex than any instance described in the literature.

3 - Cyclic Dynamics of Demand Distribution and Facility Location
Tsutomu Suzuki

Traditional facility location models yields optimal locations of facilities, usually taking accessibility of users into account. Thus the optimal location changes corresponding to changes in demand distribution. This paper provides a spatiotemporal facility location model under cyclic dynamics of demand distribution. The model shows that the larger range of fluctuation forces us frequent relocation of facilities, and that the expensive relocation cost requires saving relocation, on the contrary.

■ TE-04

Tuesday, 16:00-17:30 - Room 119

Urban Traffic Control

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Jack Haddad*
Chair:

1 - Robust Signal-Controlled Road Network Design with Equilibrium Flow
Suh-Wen Chiou

A robust design of signal-controlled road networked (RONET) system is considered with uncertain travel demand. A bi-level min-max model is constructed and travel delay can be reduced. A trust-region cutting plane projection approach (TCPP) is proposed to effectively solve this problem. A computationally tractable solution scheme is presented and numerical computations are conducted. Computational results indicate that the proposed solution scheme TCPP can substantially enhance greater system performance for RONET when compared to other alternatives while incurring less computational efforts.

2 - Optimizing Traffic Signals and its Consequences for Traffic in Surrounding Areas
Martin Strehler, Dominik Grether, Theresa Thunig

The optimization of green waves between signalized intersections is a challenging task as static traffic assignment cannot capture the dynamics required to model the problem. This work presents a cyclically time-expanded network flow model for optimizing traffic signals and traffic assignment simultaneously. Optimization results are applied to a real-world scenario for the city of Cottbus, Germany and tested with the multi-agent traffic simulation tool MATSim. The impact of the optimized signals on the city traffic and the surrounding rural areas is analyzed in detail.

3 - Analyzing the Shape of the Macroscopic Fundamental Diagram on Grid Urban Networks for Urban Planning Purposes
Javier Ortigosa, Monica Menendez

In this paper we emulate the dynamics of traffic in three urban grid networks: two way streets, one way streets, and two way streets with prohibited left turns. We pay particular attention to the shape (e.g. height, width, area) of the Macroscopic Fundamental Diagrams (MFD) obtained. We believe that the characteristics of the MFD can also reveal properties of the network to support urban planning and land use policies in urban areas. Hence, we analyze in detail this relationship between urban form and MFD shape and we discuss which should be the optimal MFD shape in an urban network.

4 - A Time-budget Surplus Maximisation Three-objective User Equilibrium Model
Judith Y. T. Wang, Matthias Ehrgott

We propose a three-objective user equilibrium (UE), considering the three most important factors influencing route choice behaviour in a road network: travel time, travel time reliability and monetary cost. We introduce time-budget surplus (TBS) defined as the maximum travel time budget minus the actual time budget required for a desired level of travel time reliability. At equilibrium, for each origin-destination pair, all individuals are travelling on the path with the highest TBS value among all the efficient paths. This becomes a time-budget surplus maximisation three-objective UE model.

■ TE-05

Tuesday, 16:00-17:30 - Room 002

Optimization in Liner Shipping 1

Stream: Maritime Transportation
Invited session
Chair: *Berit Dangaard Brouer*

1 - Scheduling of Connections in a Liner Shipping Network Reducing Bunker Consumption while Minimizing Transit Times
Line Reinhardt, Christian Edinger Munk Plum, David Pisinger, Mikkel M. Sigurd

Every couple of years a liner shipping company may do major changes to the design of the network implementing new strategies to capture market shares in upcoming markets. Given a network the scheduling can be optimized. The scheduling of the network concerns the speed and berthing times so that transfers are short and the transit time for the demands are satisfied. We have developed two models for scheduling minimizing bunker fuel consumption while still satisfying the connection and transit time restrictions of the demand. Results from the two models are presented and compared.

2 - Liner Shipping Network Design with Transit Times
David Pisinger, Berit Dangaard Brouer, Christian Vad Karsten

The liner shipping network design problem is concerned with the design of a set of cyclic routes for container vessels to transport multiple commodities. We will present a reformulation of the reference model from Brouer et al. (2013) to consider transit times for each individual commodity as there is an inherent trade of between the design and speed of the services (and thus the realized costs) and a competitive transit time for each commodity in the network.

3 - Feasibility of Shuttle Services in Liner Shipping Networks
Judith Mulder, Rommert Dekker

The growth in container trade has led to substantial increases in ship sizes, introducing diseconomies of scale in ports. On the other hand, larger ships benefit from economies of scale at sea. This raises the question whether container ships should reduce the number of port calls on a string. In this research, we will investigate whether a shuttle service between two ports is to be anticipated. Thereto, a mixed-integer programming model to determine the joint cargo and ship allocation problem is solved with a shuttle service included in the initial network.

4 - Solving the Liner Shipping Network Design Problem using Branch-and-Price
Kristian Thun, Henrik Andersson, Marielle Christiansen, Magnus Stålhane

We solve the network design problem in liner shipping to optimality using a branch-and-price algorithm. The subproblem of finding new routes is solved using a set of simple heuristics, more advanced meta-heuristics/matheuristics, and finally an MIP formulation. We present a path flow model, discuss the quality of various route-generating procedures, and show results from applying our method to benchmark instances.

■ TE-06

Tuesday, 16:00-17:30 - Room 211

Stochastic Modeling in Health Care

Stream: Logistics in Health Care
Invited session
Chair: *Jerrold May*
Chair: *Shannon Harris*

1 - On Forecasting Outcomes of a Binary Time Series
Shannon Harris, Jerrold May

We consider forecasting the next outcome of a binary process generated by human behavior, based only on a limited number of its most recent historical values. The forecast probability is generated using a linear function whose coefficients are assumed to degrade exponentially through time. We illustrate our approach using data from patients' attendance and non-attendance at VA outpatient clinics.

2 - RFID-enabled Modeling and Analysis of Care Coordination in Ambulatory Care
Rema Padman, Yi-Chin Lin

Care coordination, a process to manage dependencies between clinicians who provide care to a patient, has been proposed as a critical and challenging step in improving care delivery and health outcomes. In this study, we formulate a Markov decision process model to identify best practice plans that improve care coordination and evaluate it using a novel data collection strategy that employs RFID technology. 389 office visit records associated with 327 unique patients and 12 clinicians and staff, collected over a 2-month period, are used to instantiate our models and identify optimal policies.

3 - Modeling Non-punctual Patients in an Outpatient Clinic
Luis Vargas, Jerrold May

Outpatient scheduling papers found in the literature, deal with patients who are punctual. Those who consider the possibility of patients not being punctual do not provide strategies to schedule early and late arrivals within the developing daily schedule. We consider three types of patients, early, on time and late arrivals. All information about patients arrivals and service time is probabilistic. We develop scheduling rules for each type of patient to decide who should be serviced next when the patients do not arrive in the order in which they were scheduled.

■ TE-07

Tuesday, 16:00-17:30 - Room 003

Dynamical Models in Sustainable Development I

Stream: Dynamical Models in Sustainable Development
Invited session
Chair: *Francois Guerrin*

1 - Sustainability Performance of Energy Supply Chains
Patricia Rogetzer

A conceptual model of energy supply chains from the perspectives of electric utility companies and consumers of electricity will be discussed. To improve the carbon footprint, greenhouse gas emissions (GHG) from the generation of purchased energy (Scope 2) are considered. For a transparent disclosure of sustainability measures taken in this context, companies increasingly comply with regulatory dynamics following the reporting guidelines of the worldwide standard GRI (Global Reporting Initiative). In this talk, sustainable operational practices of Austrian energy suppliers are illustrated.

2 - System-Dynamics Analysis of the Belgian Energy Transition After the Nuclear Shut-Down
Pierre Kunsch

The nuclear phase-out law has been passed in 2003 in Belgium for closing down between 2015 and 2025 nuclear power plants (NPPs) producing today more than 50% of the domestic electricity. Green parties argue that the phase-out would be stimulating renewable energy sources. A system-dynamics model brings rational elements to the passionate debate, more pertinent than ever after the Fukushima disaster in March 2011. It appears that the nuclear phase-out according to the foreseen schedule would benefit by priority to fossil energy sources.

3 - Long-Term Sustainable Optimal Management of Multispecies Stochastic Fisheries
Diwakar Poudel, Leif Sandal, Stein Ivar Steinshamn, Sturla Kvamsdal

Multispecies management accounts for a number of species and their physical, biological, and economic interactions. This increases complexity in understanding stock dynamics and optimal catch. To address the issue of identifying optimal catch of stochastic multi stocks, we have formulated and applied a time-continuous stochastic model. The model, applied in prey-predator ecosystem, contributes to sustainable yet optimal management of multispecies fisheries. The findings suggest that the optimal catch for stochastic stocks in a multispecies ecosystem is different from the deterministic catch.

4 - Simulation Modelling of Human Activities in Agricultural Production Systems
Francois Guerrin

Simulation modelling allows one to assess management scenarios of agricultural systems. Beyond representing biophysical processes (material flows stemming from crops, animals and the environment) it is also crucial in such models to account for the farming activities to which they are tightly coupled. With this aim, it will be presented the representational features enabling human action to be simulated according to its two dimensions: time (based on Systems Dynamics) and space (based on Multi-Agent Systems). Integrating both approaches in a coherent modelling framework will be outlined.

■ TE-08

Tuesday, 16:00-17:30 - Room 120

Carbon Footprint and Climate

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Contributed session
Chair: *Jan Kersting*

1 - Institutional Level, FDI and Pollution Tax
Salvador Sandoval, Rafael Salvador Espinosa

This work develops a model of environmental economics with corruption, to determine the optimal institutional level that should allow the government to achieve economic balance of the country under an oligopolistic pattern of FDI. In addttion, it calculates the optimal pollution tax, the values of which are derived from a series of strategic environmental policies that aim to maximize the welfare of the domestic country, involving consumers, producers, government and the dishonest agents working in the public sector. The model includes such variables in a function of social welfare.

2 - Methodology of the Carbon Footprint in the Logistics Business Operations Applied for Food Manufacturing Companies
Juan Bermeo, Jaime Calderon

In recent years, we heard repeatedly about climate change, generated by emissions of greenhouse gases to the environment as a result of human activities. This has created concern in companies, taking them to measure the greenhouse gases emissions. This allow to the company known as negatively impacting the environment for the greenhouse gases generation. Under this new scenario, was developed a methodology and a reference model for food manufacturing companies allowing in a friendly way identify the elements, make an inventory and measure the basic criteria of the carbon footprint.

3 - Cooperation of Climate Clubs
Jan Kersting

In the search for a solution to the global climate change problem and in light of the slow process under the UNFCCC, more attention has recently been paid to the activities of "climate clubs", smaller consortia of countries like the G20 or the Major Economies Forum. We analyse the question of whether a stable cooperative outcome in these non-global fora exists. Therefore, we apply the concept of a subgame of a cooperative game to the setup of Chander and Tulkens (1997) and show how the existence of a core allocation in the subgame depends on damage and abatement cost parameters.

4 - Sensor and Controller on Bio-diesel Fuel Market for Eco-efficient Policy Making
Noriaki Koide, Koji Okuhara

In this research, authentication systems for waste cooking oil (WCO) collection and bio-diesel fuel production and mathematical model are proposed to support the policymaking on environmental issues. Implemented systems visualize the BDF and WCO flow as sensor. We propose a system model describing the BDF production, human perceived price for WCO collection and BDF use in a city. We discuss a balance between environmental impact and consumer behavior. Using this model, we support the policymaking for the collection of WCO and selling price of BDF while minimizing the impacts as a controller.

■ TE-09

Tuesday, 16:00-17:30 - Room 121

Decision Dependent Stochastic Problems and Day-Ahead Forecasting in Energy

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Georg Pflug*

1 - Decision Dependent Stochastic Optimization Problems
Georg Pflug

We consider a decision problem, where the decision influences the probability distributions of the stochastic parameters. Several methods of dealing with this problem are known and we review some of them. Then we present a solution method which is based on the notion of measure-valued derivatives. An application to a decision problem in Energy is given.

2 - A Trust-Region Approach for Optimization under Decision-Dependent Uncertainty
Eric Laas-Nesbitt

We present an algorithmic framework for optimizing stochastic systems with decision-dependent uncertainty. Our approach adapts trust-region methods from deterministic optimization, using the measure-theoretic differentiation concept known as measure-valued differentiation to compute derivatives by simulation. Convergence results will be demonstrated and the method will be illustrated computationally. Applications to energy will be discussed.

3 - Forecasting one Day-ahead Household Natural Gas Consumption with Differently Sized Moving Datasets using Multiple Linear Regression
Mustafa Akpinar, Nejat Yumusak

In our work, one day ahead forecasting household natural gas consumption is studied with differently sized data. Six models are prepared for this purpose. Each model is named with the number of weeks included, meteorological data, subscriber amount and holidays. Forecasts have been made for the year 2012. For every new day, the rearmost realized day is removed from the dataset and the last realized day is added. Multiple linear regression is applied on the data sets differentiating everyday. The fourth model included past four weeks and shows the lowest mean absolute percentage error.

4 - New Approaches to Day Ahead Electricity Price Forecasting: MARS and CMARS Models
Gerhard-Wilhelm Weber, Ayse Özmen, Miray Hanım Yıldırım

High volatility, high frequency and multiple seasonality structures of the electricity prices are required a short-term and assumption-free forecasting. Therefore, we used two approaches, multivariate adaptive regression splines (MARS) and conic multivariate adaptive regression splines (CMARS), to forecast day-ahead electricity prices. MARS and CMARS model complex relationship between variables even for large data sets without long training progress. These methods are compared with previous studies by using Spanish electricity market data and yield similar results.

■ TE-10

Tuesday, 16:00-17:30 - Room 122

Energy Management and Modelling

Stream: Optimization Models and Algorithms in Energy Industry
Contributed session
Chair: *Mel Devine*

1 - Techno Economic Model for Adopting Cogeneration or Conventional Steam Boiler throughout Natural Gas Penetration
Matan Shnaiderman

This research provides techno-economic model for resolving the dilemma of adopting cogeneration system or converting diesel steam boilers burners to natural gas. The profitability of cogeneration plant depends on energy prices (electricity & natural gas), capital cost, operational strategy and maintenance costs. Optimized design and operational method of cogeneration can cause major differences between significant energy saving and economic investment disaster. Using stochastic dynamic programming, we solve this problem.

2 - PRIMES-TREMOVE: A Transport Sector Model for Long-Term Energy-Economy-Environment Planning for EU
Pelopidas Siskos

PRIMES-TREMOVE is an EU energy economic transport model combining modeling of microeconomic behaviors concerning distribution of passenger and freight mobility across transport modes and vehicle types until 2050. The model is policy and technology rich, while implementing an economic modeling approach. The model solves a complex dynamic equilibrium problem with equilibrium constraints using a mixed complementarity programming algorithm. Policy assessment illustrations are drawn from recent model use in the preparation of the White Paper on Transport in 2011 by the European Commission.

3 - Incorporating Risk Aversion into the Specification of Efficient Renewable Energy Feed-in Tariffs
Mel Devine, Niall Farrell, William Lee

Many governments incentivise renewable energy generation by offering Renewable Energy Feed-in Tariffs (REFITs). This work compares the efficiency of a number of REFITs to identify under what conditions a given design may be preferred. This preference is identified by incorporating both investor and policymaker exposure to risk into the decision to implement a given tariff. The interactions between policymakers and investors are modelled using a bi-level nonlinear stochastic optimisation model. This talk shall present the methodologies employed, findings obtained to date, and further works.

■ TE-11

Tuesday, 16:00-17:30 - Room 113

Advances in Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Silvano Martello*
Chair: *Paolo Toth*

1 - The Biobjective Capacitated m-Ring Star Problem
Herminia I. Calvete, Carmen Galé, Jose A. Iranzo

The problem consists of finding a set of m simple cycles (rings) through a subset of nodes of a network. Each ring contains the depot, a number of customers and some transition points. The customers not in any ring are allocated to nodes in the rings. The rings must be node-disjoint and are limited by their capacity. The aim is to minimize the ring cost (due to the ring links) and the allocation cost. A hybrid evolutionary algorithm is proposed to approximate the Pareto front. Chromosomes provide the nodes in the rings. Feasible solutions of the problem are constructed by using heuristics.

2 - A Branch-and-Bound Method for Box Constrained Integer Polynomial Optimization
Claudia D'Ambrosio, Christoph Buchheim

We consider the problem of minimizing an arbitrary polynomial subject to box and integrality constraints. We propose a new class of under-estimators composed of separable functions of the original variables and use it within branch-and-bound scheme to easily and quickly compute lower bounds. Computational results on randomly generated instances show good performance with respect to the ones of different open-source solvers like Couenne, Gloptipoly, and SCIP.

3 - Models and Algorithms for Packing into the Smallest Square
Silvano Martello, Michele Monaci

We consider the problem of determining the smallest square into which a given set of rectangular items can be packed without overlapping. We present an ILP model, an exact approach based on iterated execution of a two-dimensional packing algorithm, and a randomized metaheuristic. Such approaches are valid both for the case where the rectangles have fixed orientation and the case where they can be rotated by 90 degrees. We evaluate the average performance of the proposed approaches on a large benchmark, for both cases above, and for the special case where the items are squares.

4 - Generalized Intersection Cuts from Orthant Interval Sets
Egon Balas

A new convexification paradigm for mixed integer programming (Balas and Margot 2011) intersects the extended edges of the LP polyhedron with the boundaries of several lattice-free convex sets, and uses the resulting intersection points to generate deep cuts in a non-recursive fashion. In this context, valid cuts can also be generated from certain nonconvex lattice-free sets. Given two parallel k-dimensional positive orthants with origins at opposite vertices of the unit cube, the interval between them is such a nonconvex lattice-free set.

■ TE-12

Tuesday, 16:00-17:30 - Room 004

Preemptive Project Scheduling and Resource Leveling

Stream: Project Management and Scheduling
Invited session
Chair: *Jürgen Zimmermann*
Chair: *Julia Rieck*

1 - A Column-Generation Approach to Lower Bounds for Resource Leveling Problems
Christoph Schwindt, Tobias Paetz

We present a method for computing tight lower bounds on the optimum objective function value of resource leveling problems arising in project management and production scheduling. We consider leveling criteria which can be expressed as linear functions in the execution times of the precedence order's antichains. The problem can be stated as a huge LP with side constraints, whose LP relaxation is amenable to column generation. The pricing problem corresponds to a convex-weight stable set problem on a comparability graph. We report on computational experience on test sets from literature.

2 - Models and Bounds for Preemptive Project Scheduling with Generalized Precedence Relationships
Tobias Paetz, Christoph Schwindt

We study a resource-constrained project scheduling problem where activities can be interrupted at any point in time and generalized precedence relationships between activities have to be taken into account. A novel MILP formulation is presented, which encodes a schedule as a sequence of time intervals with associated sets of activities that are in progress during the respective interval. We report on the results of an experimental performance analysis comparing upper bounds obtained by the MILP model and a priority-rule based method with lower bounds that arise from solving an LP relaxation.

3 - Mathematical Formulations for RCPSP/max-cal
Stefan Kreter, Jürgen Zimmermann

In this talk we extend the RCPSP/max by the concept of calendars. This problem is denoted by RCPSP/max-cal. Many practicians argue that calendars have to be taken into account when considering real-life project scheduling problems because resources like manpower or machines are not available in some time periods. We will present different MIP formulations for the RCPSP/max-cal that are based on time-indexed binary decision variables, methods to reduce the number of decision variables, and the results of an extensive performance study.

4 - MILP Models for Resource Leveling Problems
Julia Rieck, Jürgen Zimmermann

We consider project scheduling problems subject to general temporal constraints, where the utilization of a set of renewable resources has to be smoothed over the planning horizon. In particular, we consider the classical resource leveling problem, where the variation in resource utilization during project execution is to be minimized, and the overload problem, where costs are incurred if a given threshold is exceeded. For both problems, new MILP models and domain-reducing preprocessing techniques are presented. Furthermore, CPLEX is used to solve instances with up to 50 activities.

■ TE-13

Tuesday, 16:00-17:30 - Room 123

Handling Uncertainty in Scheduling and Lot-Sizing 1

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*
Chair: *Mikhail Y. Kovalyov*

1 - A Unified Modeling Approach for the Static-Dynamic Uncertainty Strategy in Stochastic Lot-Sizing
Roberto Rossi, Onur A. Kilic, Armagan Tarim

We develop mixed-integer linear programming models to compute near-optimal policy parameters for the non-stationary stochastic lot sizing problem under Bookbinder and Tan's static-dynamic uncertainty strategy. Our models build on piecewise linear upper and lower bounds of the first order loss function. We discuss formulations in which the quality of service is captured by means of backorder penalty costs as well as non-stockout probability and fill rate constraints. These models can be easily adapted to operate in settings in which unmet demand is backordered or lost.

2 - A General Lotsizing and Scheduling Problem with Stochastic Product Returns
Guillaume Amand, Yasemin Arda

We consider a multi-product capacitated lotsizing and scheduling problem with sequence-dependent setups and stochastic product returns. The returned products accumulate in an input inventory and can be sold as new items after a remanufacturing process. The deterministic demand of end items can also be satisfied through a manufacturing process that is fed by an unlimited source of raw materials. An approximate dynamic algorithm is developed to solve both single-item and multi-items cases.

3 - Feasibility and Optimality Conditions for Setup Schedule in Uncertain Manufacturing Systems Depend on the Interplay between Setup Logistics and Perturbation Flow
Jean-Pierre Kenne, Vladimir Polotski, Ali Gharbi

The failure-prone manufacturing system producing two products and requiring setups for changing the mode is considered. Various hypotheses about the interactions between failure-repair process and setup logistics were previously used in the literature without clarifications of possible consequences. Both feasibility and optimality conditions are developed and shown to be dependent on the adopted hypothesis. Optimality conditions in the form of Hamilton-Jacobi-Bellman equations are obtained. Solutions of HJB equations obtained numerically are compared and matched with underlying hypotheses.

4 - Optimal Lot-Sizing with Deterioration and Price Management
Natalia Stepanova, Anna Kitaeva

We consider single-product and single-period lot-sizing problem. The demand is a steady process with a random batch size. Two models are presented: 1) at the end of the inventory cycle T the remaining product needs to be disposal; and 2) the product is to be completely used prior to time T, and the demand's intensity depends on the price, remaining time and inventory. We use a diffusion approximation to the inventory level process. In case 1) we also obtain the procedure for statistical estimation of the required parameters and design the adaptive algorithm for multi-period lot-sizing model.

■ TE-14

Tuesday, 16:00-17:30 - Room 124

DEA Developments

Stream: DEA Applications
Contributed session
Chair: *Jens Leth Hougaard*

1 - Piece-Wise Linear Cost Efficiency Evaluation
Zohreh Moghaddas, Farhad Hosseinzadeh Lotfi, Mohsen Vaez-Ghasemi

Following the concept of Cost Efficiency, input and Output quantity data as well as exact knowledge of input prices at each decision making units are required. In real-life markets the input prices are not exactly defined for the DMUs. In this paper we emphasize that the fixed prices assumption can not reflect the reality of situations because markets will force lower prices if greater amounts of a product are purchased. This means discounts are automatically considered. Thus, some modifications in the CE model have been made to consider the situations of real life markets.

2 - Multi-Directional Program Efficiency: The Case of Lithuanian Family Farms
Tomas Balezentis, Mette Asmild, Aiste Galnaityte, Jens Leth Hougaard, Irena Krisciukaitiene

The agricultural sector is important in both economic and social terms, because it provides inputs for food industry and supports the rural population. Therefore, it is important to develop new methodologies which can support effective policy making. This paper suggests using Multi-directional Efficiency Analysis (MEA, see Asmild et al., 2003) in connection with estimation of so-called program efficiency (Charnes et al., 1981). The proposed methodology is applied to analyse farm level data on Lithuanian family farms.

3 - Likelihood Ranking of Decision Making Units
Markku Kallio, Merja Halme

For DMUs, we assume that the input-output vectors are a random sample of a given probability distribution. For efficiency analysis of the DMUs, we employ common prices for all DMUs and choose them based on maximum likelihood estimates. We define the profit based ranking criterion for each DMU by the likelihood that the random profit is at most the profit of that DMU. Return based ranking is defined similarly. We compare both profit and return based ranking methods with conventional DEA methods using five field studies.

4 - Technological Superiority
Jens Leth Hougaard, Mette Asmild

We develop a theoretical framework for analyzing technological possibilities. We consider fundamental properties of technology indexes and demonstrate that previous approaches violate a central axiom dubbed monotonicity in possibilities. From the axiomatic analysis emerge two canonical types of indexes: one based on the volume, and one based on the cardinality of the dominance set. We define a binary superiority relation where both types of indexes have to point in the same direction before concluding that one subset is superior to another.

■ TE-15

Tuesday, 16:00-17:30 - Room 125

Revenue Management with Advertising Applications

Stream: Revenue Management II
Invited session
Chair: *John Turner*

1 - Optimizing Online Advertising Budget Allocation across Multiple Placements
Jian Yang, Pengyuan Wang

Big online advertisers are typically faced with a challenging problem in campaign management: how to allocate advertising budget across multiple placements in order to maximize Return on Investment (ROI). We develop a Multi-Touch Attribution (MTA) methodology based on both observation and experimentation to measure ad effectiveness across multiple placements. The MTA empowers a simulator that provides advertisers with what-if analysis for budget allocation. We also build an optimization model using the MTA results to maximize the total ad effectiveness for advertisers, and hence their ROI.

2 - A Class of Nonlinear Allocation Problems with Heterogeneous Substitution
Huaxia Rui, De Liu, Andrew Whinston

We study the problem of efficiently allocating multiple types of goods (workloads) to multiple agents when different types of goods (workloads) are substitutable and the rates of substitutation differ across agents. We derive theoretical properties of such problems that enable us to design an extremely fast algorithm called SIMS for solving such problems. We expect the SIMS algorithm to work well for real-time applications with time-constrained allocation problems such as the allocation of online advertisement.

3 - The Least Cost Influence Problem
Rui Zhang, Dilek Gunnec, S. Raghavan

We analyze the diffusion process of a product over a social network while incentives are provided to the individuals. Such catalysation addresses the trade-off of minimizing the amount of incentives given and reaching a greater number of buyers. This problem is NP-Hard for general networks. However, we show that it is polynomially-solvable on tree networks under the assumption that all neighbors of a node exert equal influence. Next, we propose a totally unimodular integer programming formulation based on the insight that the influence propagation network must be a directed acyclic graph.

4 - Foundations of Social Network Ad Optimization
John Turner

We introduce revenue optimization models for placing ads in social networks, motivated by the connectivity structure of the underlying graph. We discuss some pros and cons of the underlying models, and illustrate our approach using real social graphs.

■ TE-16

Tuesday, 16:00-17:30 - Room 127

Model Selection Methods

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Ivan Reyer*

1 - Multimodelling and Object Selection for Banking Credit Scoring
Alexander Aduenko, Vadim Strijov

To construct a bank credit scoring model one must select a set of informative objects (client records) to get the unbiased estimation of the model parameters. This set must have no outliers. The authors propose an object selection algorithm for mixture of regression models. It is based on analysis of the covariance matrix for the parameters estimations. The computational experiment shows statistical significance of the classification quality improvement. The algorithm is illustrated with the cash loans and heart disease data sets.

2 - Comparison of Different Clustering Algorithms Based PCF Classifiers
Emre Çimen, Gurkan Ozturk

In this study we dealt with generating different clustering algorithms based polyhedral conic classifiers. The main purpose of using clustering algorithms to generate PCF based classifiers is to determine the number of PCF's and divide the sets to the smaller parts. By this way stronger classifiers can be constructed. Expectation Maximization (EM) and k-Means based algorithms are implemented and tested on well-known literature test problems.

3 - Multicollinearity: Performance Analysis of Feature Selection Algorithms
Alexandr Katrutsa, Vadim Strijov

We investigate the multicollinearity problem and its influence on the performance of feature selection methods. The paper proposes the testing procedure for feature selection methods. We discuss the criteria for comparing feature selection methods according to their performance when the multicollinearity is present. Feature selection methods are compared according to the other evaluation measures. We propose the method of generating test data sets with different kinds of multicollinearity. Authors conclude about the performance of feature selection methods if the multicollinearity is present.

4 - Data Mining Application with Decision Tree Algorithms for the Evaluation of Personal Loan Customers' Repayment Performances
Aslı Çalış, Ahmet Boyacı, Kasım Baynal

Data mining techniques are used extensively in banking area such as many areas. In this study, conducted in banking sector, it was aimed to analysis of available personal loan customers and estimate potential customers' repayment performances with decision tree is one of the classification methods in data mining. In the study, SPSS Clementine was used as a software of data mining. An application was done with C5.0 and C&RT algorithms for evaluation of personal loan customers and the results were compared.

■ TE-17

Tuesday, 16:00-17:30 - Room 005

Conic Optimization and Applications

Stream: Interior Point Methods and Conic Optimization
Invited session
Chair: *Tamás Terlaky*

1 - Hierarchical Cuts to Strengthen Semidefinite Relaxations of NP-hard Graph Problems

Miguel Anjos, Elspeth Adams, Franz Rendl, Angelika Wiegele

The max-cut problem can be closely approximated using the basic semidefinite relaxation iteratively refined by adding valid inequalities. We propose a projection polytope as a new way to improve the relaxations. These cuts are based on requiring the solution to be valid for smaller cut polytopes. Finding new cuts creates a hierarchy that iteratively tightens the semidefinite relaxation in a controlled manner. Theoretical and computational results will be presented.

2 - Specialized Interior Point Methods for Classes of Random Network Problems

Stefano Nasini, Jordi Castro

The application of optimization based methods in the field of random graphs represents a novel research area. We consider linear optimization (LO) models of different random graphs and provide procedures to generate empirical probability distributions of network features. Those distributions entail the generation of thousands of networks verifying specific constraints. By exploiting the matrix structure of the resulting LO problems, it is possible to use a specialized interior-point method for block-angular problems. Computational results support the high efficiency of the proposed methods.

3 - A Feasible Direction Algorithm for Nonlinear Second-Order Cone Optimization Problems

Miguel Carrasco, Alfredo Canelas, Julio López

In this work we present a new feasible direction algorithm for solving smooth nonlinear second-order cone programs. These problems consist of minimizing a nonlinear differentiable objective function subject to nonlinear second-order cone constraints. Given an interior point of the feasible set the proposed approach computes a feasible and descent direction for the objective function. The search direction is computed by using a similar formulation to the FDIPA algorithm for nonlinear programming. We prove global convergence to stationary points of the minimization problem.

■ TE-18

Tuesday, 16:00-17:30 - Room 112

Nonconvex Multiobjective Optimization I

Stream: Multiobjective Optimization - Theory, Methods and Applications

Invited session

Chair: *Julius Zilinskas*

Chair: *Panos Pardalos*

1 - On Optimal Algorithms for Multi-Objective Global Optimization

Antanas Zilinskas

Theoretical assessment of the efficiency of algorithms for multi-objective global optimization is difficult. Best algorithms can be constructed only for specific classes of problems. In the present paper, worst case optimal algorithms for univariate Lipschitz functions are considered. Alternatively, the one variable multi-objective optimization algorithm, which is on the average optimal with respect to a statistical model, is considered. The applicability of the developed algorithms for construction of algorithms of multivariate multi-objective problems is discussed.

2 - A Deterministic Method to Solve Constrained Multi-objective Optimization

Mikhail Posypkin, Yuri Evtushenko

In the talk we precisely define the notion of an approximate solution with the given accuracy for constrained multiobjective optimization problems. Then we present a deterministic method for obtaining an approximate solution in a finite number of steps under quite natural restrictions on objectives and constraints. The constraints and objectives are allowed to be non-linear and non-convex. The talk also discusses some implementation issues and practical applications of the proposed method.

3 - Nonlinear Multi-Objective Constrained Optimization: Using Second Order Approximation of Pareto Frontier Local Geometry in Descent-Diffusion Approach

Alexis Pospelov, Fedor Gubarev

Local geometry of the Pareto front allows building efficient algorithms to discover the frontier. However, in many applications it's not sufficient to use only linear approximations to optimal variety. In this work we propose to use second-order local approximation to the Pareto frontier. Within the descent-diffusion algorithm, presented in supplementary talk, our approach allows efficient discovery of Pareto frontier even in problems with singular Hessians, where linear approximations perform poorly because of large number of very small steps.

4 - Exact Solutions of the Cell Formation Problem in Group Technology

Julius Zilinskas, Boris Goldengorin, Panos Pardalos

The Cell Formation Problem (CFP) aims at identification of groups of machines to form manufacturing cells. The objective function of CFP is to minimize the intercell moves (exceptional elements in the block-diagonalized matrix) and within-cell load violation. In this talk we present our exact branch-and-bound algorithms to solve the CFP. We report our computational study for solving some benchmark instances of CFP available on either Internet or other publications. Our comparative analysis shows that our branch-and-bound algorithms are competitive with many other counterparts.

■ TE-19

Tuesday, 16:00-17:30 - Room 128

Inventory Planning II

Stream: Demand and Supply Planning in Consumer Goods and Retailing

Contributed session

Chair: *Edward Fox*

1 - Joint Optimization of Maintenance and Spare Part Inventory Policies

Z. Pelin Bayindir, Pinar Bulbul, Ismail Serdar Bakal

In this study, we consider maintenance planning and spare part inventory planning problem simultaneously. Our main focus is the joint optimization of preventive replacement and spare part inventory management. We propose an exact dynamic programming algorithm and several heuristics for a finite planning horizon situation. In a computational study the heuristics are compared against the optimal solutions.

2 - An Enhanced Model for Integrated Replenishment and Transportation Problem in a Dynamic Demand Environment

He-Yau Kang, Amy H. I. Lee, Li-Hao Huang

This research considers an integrated replenishment and transportation problem, and the objective is to minimize total costs under the requirement that no inventory shortage is allowed in the system. The integrated replenishment and transportation problem is formulated as a mixed integer programming model. An efficient genetic algorithm model is constructed for solving large-scale lot-sizing problems. The results demonstrate that the proposed two models are effective and accurate tools for determining the replenishment of high-tech industries from multiple suppliers for multi-periods.

3 - Inventory Models with Non-Stationary Transition Probabilities to Determine the Optimal Mix of Owned and Rented Items

Leonardo Epstein, Eduardo González-Császár

Inventory models with rental items help plan operations that involve rental items, such as trucks to ship containers or telephone lines to carry calls. A service provider who plans to buy an inventory of items for rental may find that the cost of the number of items to buy is too high to meet demand with certainty. Thus a smaller inventory, insufficient to meet demand, may be preferable if the service provider can obtain items by renting them from another provider. Typically, rented items have a larger operational cost than owned items, but do not require the investment to purchase them.

4 - A General Approximation to the Distribution of Count Data with Applications to Inventory Modeling
Edward Fox

We derive a general approximation to the distribution of count data based on the first two moments of the underlying interarrival distribution. The resulting variant of the BISA distribution is similar to the lognormal, but fits simulated and empirical data better than the lognormal in many applications. Moreover, although the BISA can be fit to count data, it can also be fit directly to interarrival data. In numerical experiments involving dynamic inventory models, we compare the BISA distribution to other commonly-used distributions and show that it leads to improved stocking decisions.

■ TE-20

Tuesday, 16:00-17:30 - Room 129

Stochastic Optimization in Energy Infrastructure Planning

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Yueyue Fan*

1 - A Stochastic Programming Model for Renewable Energy Infrastructure Planning Considering Oligopolistic Competition
Yueyue Fan

This paper presents a mathematical model that supports renewable energy infrastructure planning under uncertainties. The interdependency between different stakeholders in the system is captured in an energy supply chain network. Competition between different renewable energy investors, who compete for resources, transmission capacities, and demand markets, is modeled using variational inequalities. Creative solution algorithm is developed by establishing similarity between the energy problem and the traffic network equilibrium problem that has been well studied in transportation literature.

2 - Impact of Electricity Pricing Policy on the Investment of Renewable Energy
Safak Yucel, Gurhan Kok, Kevin Shang

We study the effect of time-based pricing policies on renewable energy investment. In contrast with the expectations of policy makers, we show that flat (time-invariant) pricing policy leads to a higher level of renewable energy investment for utility firms and independent power producers.

3 - Stochastic Project Scheduling for Wind Farm Installation
Diclehan Tezcaner Ozturk, Euan Barlow, Kerem Akartunali, Matthew Revie, Sandy Day, Evangelos Boulougouris

The installation process of an offshore wind farm involves several tasks to be scheduled in advance. However, planned schedules are affected by many external uncertainties such as weather conditions and vessel availability. In this study, we develop a stochastic rolling horizon optimisation model to plan the installation schedule, where the installation process is based on the input from three industry partners. Our model yields a robust project schedule considering all the uncertainties and revises the schedule at predetermined times to minimise the deviation from the baseline schedule.

■ TE-21

Tuesday, 16:00-17:30 - Room 006

Lessons from Industrial Collaboration

Stream: OR Consultancy and Case Studies
Invited session
Chair: *John Ranyard*

1 - Simulation Tools for Railway Planning
Ricardo Garcia-Rodenas, Jose Luis Espinosa-Aranda

This work presents the experience in the collaboration between the UCLM, UPM and US universities of Spain and RENFE (the main Spanish railway provider) participating in the PT-2007-003-08CCPP project granted by the Ministry of Development of Spain. This collaboration led to successful results developing various models, research papers and software tools focused on the robust planning and the management of railway transport in case of emergencies, but failed in the final objective of implementing all this new knowledge in the railway company for reasons outside of control of the research group.

2 - Gas Transport Network Simulation and Optimization
Ángel Manuel González Rueda, Alfredo Bermúdez, Julio González-Díaz, Francisco José González-Diéguez

Reganosa is a company that manages a regasification plant into the Spanish gas transport network and, thus, its main function is to supply natural gas to the network. It is important to manage the gas network in an efficient way to minimize the consumption in compressor stations. This is one of the main optimization problems that we have studied in this field, typically ensuring the security of supply. We have developed a software, called Ganeso, to solve this kind of problems that has allowed Reganosa to improve its strategic positioning in the gas sector.

3 - Computing Stoichiometric Matrices in Chemical Reactions. An MINLP Problem
Emilio Carrizosa, Rafael Blanquero, M. Asuncion Jimenez-Cordero, Boglárka G.-Tóth

We consider the problem of determining the coefficients of a stoichiometric matrix and rates so that the concentrations of a series of species give a best-possible fit to empirical concentrations. Finding the fit amounts to solving an MINLP, in which nonlinear differential equations appear in the constraints. A heuristic is proposed, and its behavior is tested in benchmark data sets.

4 - Logistic Report on the Location of an Agricultural Processing Plant
María José Ginzo Villamayor, Julio González-Díaz, Balbina Casas-Méndez

Biocen is dedicated to the reuse of wood ash produced by wood industry as organic fertilizers, which are used in forest crops, organic farming and traditional farming. The problem was on finding the place for the plant keeping in mind the transport needs of the wood ashes from the suppliers to the plant and the later distribution of fertilizer to customers. The Weiszfeld algorithm was used to solve the problem. We got a logistic map that provides the optimal location of a production plant based on the location of suppliers and customers of the company Biocen.

■ TE-22

Tuesday, 16:00-17:30 - Room 007

Cooperation and Competition in Operations Management

Stream: Game Theory and Operations Management
Invited session
Chair: *Alf Kimms*
Chair: *Ana Meca*
Chair: *Igor Kozeletskyi*

1 - Retailer Assortment Strategies to Induce Manufacturer Competition
Sebastian Heese, Victor Martínez de Albéniz

We compare different assortment planning strategies that differ in how much information the retailer passes on to the manufacturers. We find that it is usually best to pre-announce the assortment breadth but not to declare which manufacturers are included, as opposed to requesting bids from all candidates selected in the assortment. Compared to the assortment breadth that a centralized system would choose, a retailer that announces just the assortment breadth might benefit from artificially limiting the assortment to increases manufacturer competition.

2 - Quality Gatekeeping at the Retail Level: Implications for the Role of Retailers in Quality Assurance
Mingming Leng

We investigate a manufacturer-retailer channel to explore the role of a retailer in assuring the quality of a manufacturer's product as a quality gatekeeper. We show that any increase in the manufacturer's penalty payment to the retailer may not be helpful in encouraging the manufacturer to decrease his defective rate. The retailer's gatekeeping activity may not induce the manufacturer to reduce his defective rate, which depends on the two firms' relative market powers, their penalty costs incurred when consumers return defects, and their quality control costs.

3 - A Multi-Objective Allocation Problem in the Cooperative Traveling Salesman Problem with Rolling Horizon
Igor Kozeletskyi, Alf Kimms

In this presentation a case of horizontal cooperation among salesmen is considered, where besides the minimization of total costs every salesman aims to maximize his own utility from assigned orders. The goal is to find a stable allocation of costs and orders. We present a game-theoretic approach using the core concept for the allocation problem and a solution procedure for arising optimization problems. The solution procedure is based on methods of multi-objective optimization in combination with mathematical programming techniques and its performance is tested using a computational study.

4 - Revenue in Contests with Many Participants
Arieh Gavious

We show that in a contest with a single prize, the expected effort made by the kth highest valuation participant bounds the sum of the expected efforts made by all of the participants with valuations less than the kth highest valuations.Wealso show that in the limit case of a contest withmprizes, the expected effort made by the kth highest valuation participant when the bidders are risk-neutral is greater than the expected effort in the risk-averse case.

■ TE-23

Tuesday, 16:00-17:30 - Room 008

Analysis of Human Behavioural Data and Knowledge

Stream: Behavioural Operational Research
Invited session
Chair: *Chien-Jung Lai*

1 - A Decision Framework for Using Mood as Context in Recommender Systems
Sanjog Ray

We provide a framework based on two dimensions to help recommendation engine designers select the appropriate domains for integrating mood as contextual data. The two dimensions are time to consume [TTC] and familiarity [FAM] required to effectively consume the product. Both dimensions have two levels high and low, resulting in four quadrants. We propose that only domains that fall into the first quadrant, i.e., where both TTC and FAM is low should use mood as contextual data in their recommendation systems algorithms. We also show results of experiment to validate the framework.

2 - Analysis of Commercial Vehicle Operation Data for Driving Safety Enhancement
Kwang-Jae Kim, Minjun Kim, Chiehyeon Lim, Kyungim Choi, Jinwoo Jeon

Digital tachograph (DTG) is a device installed on a vehicle that records its operation data. The Korean government maintains a database (DB) which contains the operation data of commercial vehicles. We are conducting a research project for driving safety enhancement using this DTG DB. In this presentation, we discuss the analysis of the DB to extract the relationship between driving patterns (such as speed, rapid accelerations and decelerations, breaks on or off) and accident rates. The analysis results can be used in developing service models for driving safety enhancement.

3 - From Community Concerns to Societal Risk Perception
Xijin Tang

In current China social stability is emphasized to develop a harmonious society by the government. A number of social indicators contribute to measure the societal state. Most of them require conducting time-consuming surveys on social attitudes. As search queries, BBS posts and even microblogs reflect the community concerns timely and more truly, we explore to correspond the hot search words, BBS posts or even microblogs with societal risks, and then to measure the on-line societal risk levels every day. Such an approach provides additional measures toward societal states.

4 - Driver Attention for Information Display on Variable Message Signs with Graphics and Texts
Chien-Jung Lai, Chi-Ying Wang

The purposes of this study were to discuss response effect and driver attention for information display and position on Variable Message Signs (VMS) with graphics and texts. A 234 within-subjects design using a simple driving simulator was conducted. The independent variables were Changeable Graphic Sign (CGS) information, VMS information, and position of VMS. The results showed that CGS information, VMS information, and position of VMS were significant for most of the participants' response time, fixation time and fixation frequency.

■ TE-24

Tuesday, 16:00-17:30 - Room 212

Operations Finance Interface 2

Stream: Operations Finance Interface
Invited session
Chair: *Anne Lange*

1 - Analysis of an Artemisia-Based Malaria Medicine Supply Chain
Scott Webster, Burak Kazaz, Prashant Yadav

Artemisinin Combination Therapy, the most effective malaria treatment today, is manufactured from an agriculturally derived starting material. We present a model of the supply chain that captures the effects of such factors as available farm space, manufacturer capacity, farmer's self-interest, volatility in crop yield, and volatility in the malaria medicine market on such measures as the level and volatility of medicine price and supply.

2 - Franchise Contracting with Debt Financing and Bankruptcy Risk
Vlad Babich, Christopher Tang

We study how franchise contract should account for the entrepreneur's financing need, the bankruptcy probability, and bankruptcy costs, using a stochastic dynamic game among the franchisor, the entrepreneur, and the banks. The franchisor chooses contract terms. The entrepreneur dynamically decides when to open a franchise store (obtaining debt financing). The bank determines competitive equilibrium loan rates, accounting for bankruptcy risk. The ramifications of ignoring financing considerations are delays in a store opening and higher entrepreneur's bankruptcy probability.

3 - Wine Futures and Advance Selling under Quality Uncertainty
Burak Kazaz, Tim Noparumpa, Scott Webster

We examine the use of wine futures as a form of operational flexibility to mitigate quality risk in wine production. While aging in the barrel, wine receives a barrel score indicating its potential quality. The winemaker then determines (1) the percentage of its wine to be sold as futures and (2) the price of wine futures. When wine is bottled, it receives another review called a bottle score. Using data from Bordeaux wineries, our study provides insights into how barrel scores, consumer preferences and the winemakers' preferences influence the allocation and pricing decisions.

■ TE-25

Tuesday, 16:00-17:30 - Room 009

Data Mining via Pattern Analysis and Recognition

Stream: Data Mining
Invited session
Chair: *Onur Seref*

1 - Urban Bus Transit Boarding Pattern Analysis and Route Planning for the Disabled
Deniz Türsel Eliiyi, Uğur Eliiyi

We focus on planning exclusive bus routes for the disabled users of a multimodal transportation system, where bus passengers comprise about 66% of the overall 1.5 million average daily boardings. Passenger demand is analyzed via a route-based alighting point estimation model, based on smart card boarding data of the disabled users and their attendants. Trip patterns are investigated for the purpose of determining new fixed routes and their schedules, as well as special fleet capacities of paratransit service requests. Model results are analyzed in comparison with registered passenger database.

2 - Causal Inference with Simultaneous Outlier Detection and Removal
Erhun Kundakcioglu, Mohammad Poursaeidi

This study presents a novel pattern recognition framework where we simultaneously detect and remove outliers, and perform regression. Our goal is to draw causal relations and identify relevant features in cases where outliers are most abundant such as and multiple-instance and time-series data. We propose an integer programming formulation that eliminates effects of outliers on the regression loss function, prove that the problem is NP-Hard, and propose a heuristic solution approach that outperforms available forecasts on a time-series data set.

3 - Rule Mining in Critical Node Detection
Dionne Aleman, Mario Ventresca

The critical node detection problem (CNDP) is the problem of identifying nodes in a graph whose deletion causes the network to be maximally disconnected, and has several applications. While CNDP is NP-Hard, algorithms with reasonable performance exist. However, implementation of CNDP results can be challenging as nodes in the graph may imperfectly represent the real word. We therefore investigate mining CNDP results to obtain rules that can be followed to remove nodes without requiring exact graph structure knowledge. Results are shown for a 5 million-node contact network for vaccine planning.

4 - A Computational Rhetoric Framework for Mining Online Stock Commentaries
Onur Seref, Michelle Seref, Alan Abrahams

We develop a computational rhetoric methodology that combines data mining, machine learning, and natural language processing to analyze rhetorical moves in online stock pitch arguments of players from an online investment game. We derive predictive models to determine a player's stock prediction accuracy and the influence of their stock prediction in their online community. We compare our framework to conventional text mining methods to highlight the contribution of our computational rhetoric approach.

■ TE-26

Tuesday, 16:00-17:30 - Room 010

Nonconvex Nonsmooth Optimization Methods

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Napsu Karmitsa*

1 - A New Bundle Method for Nonsmooth DC Optimization
Kaisa Joki, Napsu Karmitsa, Marko M. Mäkelä

In nonsmooth nonconvex optimization, functions do not need to be differentiable. These types of problems arise for example in computational chemistry and biology. At the moment, bundle methods are considered to be efficient and reliable methods for these problems. I will introduce a new bundle method for the unconstrained nonsmooth nonconvex minimization of a function which can be presented as a difference of two convex functions. The benefit of DC functions is that we can still utilize convex analysis and optimization to some extent. Some numerical experiments will also be presented.

2 - Numerical Methods for Solving Nonsmooth Optimization Problems with Known Structures
Adil Bagirov

In this talk, we present numerical methods for solving nonsmooth nonconvex optimization problems with given structures. These problems include the minimization of difference of (nonsmooth) convex functions and problems where the objective function is represented as a smooth composition of nonsmooth functions. The proposed algorithms use different generalizations of a subdifferential. We report results of numerical experiments using well-known nonsmooth optimization test problems.

3 - Piecewise-Concave Minimization via Nonconvex Bundle Local Searches
Giovanni Giallombardo, Manlio Gaudioso, Giovanna Miglionico

We focus on the numerical solution of minimization problems where the objective function is the maximum over finitely many concave functions, not necessarily differentiable. We present a tailored bundle-like method whose termination at a point satisfying an approximate stationarity condition is guaranteed. Next we discuss on how to embed such a local-search method into heuristic approaches for escaping from local minima, and provide numerical results on some sample problems.

4 - A New Bundle Method for Sparse Problems
Napsu Karmitsa

Many practical optimization problems involve nonsmooth functions with thousands of variables. Fortunately, these functions often have some underlying structure that can be utilized to better solve these problems. In this talk, I describe a new bundle method for large-scale, possible nonconvex, nonsmooth minimization. The method combines the limited memory bundle method with sparse updating of matrices. The preliminary numerical experiments to be presented confirm the effectiveness of the method.

■ TE-27

Tuesday, 16:00-17:30 - Room 213

Pricing Decisions

Stream: Operations/Marketing Interface
Invited session
Chair: *Elif Dogdu*

1 - Strategic Pricing Decisions for Competing Suppliers
Basak Altan, Ali Ekici, Okan Ozener

We study a duopolistic market of capacitated suppliers competing for the business of a single retailer for a single product with a synergy in joint procurement. We study this market under two settings: asymmetric and symmetric information. We show that a supplier might set a "threshold price" to capture the entire market if its per unit fixed ordering cost is sufficiently small. We establish that there exists a joint-order Nash equilibrium only if the suppliers set identical prices low enough to make the retailer order full capacity from both.

2 - Pricing Warranty for Online Retailers
Lei Guan

Nowadays, many online retailers provide extended warranty for 3C products. The price for the extended warranty is according to the length of the warranty. In this article, we study how to pricing the warranty for online retailers by introducing the consumers' choice. We first consider the case that there is only one period of warranty and show the optimal result. Then we extend the basic model by considering two periods or jointly optimizing the retail price and the warranty price. In addition, we provide some numerical experiments to give more insights on our model.

3 - Dynamic Pricing for Perishable Products in the Presence of Customer Behaviour
Elif Dogdu, Derya Eren Akyol

In recent years, there has been an increasing interest in using dynamic pricing policies in various industries, where the capacity is fixed in the short-term and perishable. However, there have been limited studies that consider the impact of purchasing behavior of customers on the seller's pricing decisions. In this study, we review the literature on dynamic pricing in perishable inventory systems and propose a dynamic pricing strategy for inventory management of perishable products. Then, we present the simulation results for different scenarios with different customers behaviour.

4 - A Dynamic Pricing Strategy under Supplier Disruptions
Mualla Gonca Yunusoglu, Derya Eren Akyol, Gokalp Yildiz

In this study, a dynamic pricing strategy is proposed to prevent possible stockouts during supplier disruptions. We consider a single retailer that replenishes its inventory from two vulnerable suppliers. The retailer uses a base stock policy to control its inventory level and a dynamic pricing strategy to effectively satisfy customer demand during disruptions. The effectiveness of the proposed strategy is tested via a simulation model under different cost and disruption scenarios. The results reveal that the proposed pricing strategy performs better compared to static pricing strategy.

■ TE-28

Tuesday, 16:00-17:30 - Room 130

Congestion Games: Dynamics and Algorithms

Stream: Dynamic and Repeated Games
Invited session
Chair: *Cheng Wan*

1 - A Lemke-Like Algorithm for the Multiclass Network Equilibrium Problem
Thomas Pradeau, Frédéric Meunier

We consider a nonatomic congestion game on a connected graph, with several classes of players. Each player wants to go from its origin vertex to its destination vertex at the minimum cost and all players of a given class share the same cost functions on each arc. The computation of an equilibrium in the multiclass case is an open problem for general functions. We consider the case where the cost functions are affine and propose an extension of Lemke's algorithm able to solve this problem. At the same time, it provides a constructive proof of the existence of an equilibrium in this case.

2 - Risk Measures and Shortest Paths in Network Games
Roberto Cominetti, Alfredo Torrico

Modeling risk-aversion in routing games using mean-stdev, VaR and CVaR, has significant drawbacks: high computational complexity, lack of monotonicity, dynamic inconsistency. We show that the only measures that avoid these limitations are the "entropic risk measures". For independent link travel times, entropic-optimal paths reduce to standard shortest paths which can be computed efficiently and allow to study atomic and non-atomic routing games. We discuss some open questions on travel time correlations, heterogeneity in risk perceptions, and adaptive dynamics.

3 - A Mean-Risk Model for the Stochastic Traffic Assignment Problem
Nicolas Stier-Moses, Evdokia Nikolova

We explore how stochastic travel times and risk aversion transform the traditional traffic assignment problem and its equilibrium concepts. In this setting, even computing user best responses has unknown complexity. This talk focuses on equilibrium existence and characterization in the settings of infinitesimal vs. atomic users and fixed vs. congestion-dependent variability of travel times. We show that equilibria always exist in most of those combinations. Although paths are necessary to describe them, we see that few paths suffice. Finally, we estimate the cost imposed by risk-aversion.

4 - Dynamics in Composite Congestion Games
Cheng Wan, Sylvain Sorin

In a network composite congestion game, two types of players (nonatomic ones of weight zero and atomic splittable ones with positive weight) coexist. This work considers dynamical aspects, i.e. the evolution of the strategies at disequilibium states. Players adjust strategies in a selfish and myopic way. The evolution of the strategy profile is described by a continuous-time dynamical system. One shows that several dynamics well-known in the framework of population games can well be adapted to this general framework with heterogeneous players. Their asymptotic properties are analysed.

■ TE-29

Tuesday, 16:00-17:30 - Room 011

Multiple Criteria Decision Making and Optimization 5

Stream: Multiple-Criteria Decision Making and Optimization
Contributed session
Chair: *Evangelos Grigoroudis*

1 - Elicitation of a Model of Map Comparison Taking into account Geographic Aspects
Valérie Brison, Marc Pirlot

We have developed several models to help a decision maker to compare maps representing the state of a region at different stages of its evolution. One of these allows taking some geographic aspects into account. This model combines additive value function and expected utility models. In this work, we provide an interactive elicitation process to determine all the parameters of the model. For this purpose, we transpose the method of lotteries comparison. We interpret lotteries as maps and we formulate questions to the decision maker in terms of comparisons of well-chosen maps.

2 - Fuzzy Multi-Criteria Group Decision Making: A Case of Art Students' Placement in Undergraduate Art Programs
V. Alpagut Yavuz

Selecting art students from a number of competing candidates is a decision making process that requires a group of decision makers evaluating a two-stage performance exam. Fuzzy Analytic Hierarchy Process (FAHP) is one of the methods suggested for multi-criteria decision making (MCDM) involving group decisions and fuzziness. In this study, art students' placement process in undergraduate art programs is modeled as MCDM problem and FAHP method is used in determining the decision makers' weights of criteria. Rankings of the candidate students are determined by TOPSIS method.

3 - Towards a Multi-Objective Capital Allocation within Data Centres
Takfarinas Saber, Anthony Ventresque, Xavier Gandibleux, Liam Murphy

Data Centre Capital Allocation is often based on different combinations of distinct objectives, hence it can be defined as a multi-objective optimisation problem. In this paper, we present different techniques for addressing this problem, and an experimental evaluation on different sized data centres. Our results show that PLS provides many localised solutions while NSGA-II provides few solutions, and is sensitive to the quality of the initial set of seed solutions. We propose a modified version of GRASP that addresses these deficits by offering a large number of distinct solutions.

4 - Modeling Additional Information in the MUSA Method: A Robust Extension
Evangelos Grigoroudis, Nikolaos Matsatsinis, Nikolaos Matsatsinis

The MUSA method is a collective preference disaggregation approach following the main principles of ordinal regression analysis under constraints using linear programming techniques. This study presents an extension of the MUSA method based on desired properties of the inferred preference system, as well as additional customer preferences. The main aim of the study is to show how incorporating these additional constraints in the linear program of the original MUSA method, the robustness of the estimated results may be improved.

■ TE-30

Tuesday, 16:00-17:30 - Room 012

Recent Models on Emerging Optimization Problems

Stream: Allocation Problems in Game Theory
Invited session
Chair: *Takako Yamada*

1 - An Ant Colony Optimization Algorithm for the Daily Photograph Selection Problem of Earth Observation Satellites
Sezgin Kilic

This paper proposes an ant colony optimization (ACO) algorithm for the daily photograph selection problem (DPSP) of earth observation satellites (EOSs). DPSP is an NP-hard optimization problem related to management of EOSs. Each photograph related to a customer order generates a profit but not all of the requests can be satisfied due to various constraints. The proposed algorithm inherits the hyper-cube framework of ACO metaheuristic. Realistic instances are used as benchmark problems. Computational results demonstrate that the proposed algorithm is capable of generating competitive solutions.

2 - A Fuzzy-QFD based Mathematical Model for Sustainable Supplier Selection
Zeynep Gergin, Fadime Üney-Yüksektepe, Nur Nazlı Şen, Gökhan Kılıç

This study is an integration of sustainability concept with supplier selection activities in a dairy products manufacturing company. Initially expectations from the suppliers are identified. Then, based on the sustainable supplier selection criteria of related literature, evaluation factors are determined. These factors are correlated with the expectations, and ranked by using Fuzzy-Quality Function Deployment methodology. Finally, the data obtained from the House of Quality is input to a mathematical model, and optimum suppliers with respect to their sustainability performances are proposed.

3 - Characteristic Analysis and Modeling of User Tweet Behavior on a Consumer-Insight Rating Website
Takako Yamada, Masashi Taguchi

We analyzed 170000 tweets data obtained from a web site's (https://www.uranokao.jp) visitors. At this web site, the users are classified into 17 types according to their response patterns to 35 questionnaires where each user type suggests consumer insight.We explored user site access process over 6 months and how users are induced to the website via their follow-follower networks. By observing user tweets, we found a specific user cluster exists in an intensive access-period. Based on our findings, we propose an user influence model on social networks.

■ TE-31

Tuesday, 16:00-17:30 - Room 013

Topics in Decision Processes

Stream: Decision Processes
Invited session
Chair: *Manel Baucells*
Chair: *Antonio Jiménez-Martín*
Chair:

1 - Expected Utility and Narrow Framing
Manel Baucells, Rakesh Sarin

We examine conditions under which monetary decisions made in isolation provide an optimal strategy. We offer a direct proof that only logarithmic utility permits narrow framing in the presence of learning. Without learning but allowing for probabilities to vary from period to period, we provide a direct proof that only CRRA utility is robust to narrow framing. The class of linear risk tolerance, which includes exponential utility, is robust to narrow framing when the payout distribution is identical in all periods and there is no risk of bankruptcy.

2 - Selecting Preventive, Palliative and Fault Transmission Safeguards for Risk Management of Information Systems: A Fuzzy Approach
Antonio Jiménez-Martín, Eloy Vicente, Alfonso Mateos

We focus on the selection of safeguards in fuzzy risk analysis and management for information systems (IS). Preventive, palliative and fault transmission safeguards have to be identified to reduce risks in the IS and a safeguard selection process has to be performed since safeguards have associated costs. The aim could be to select the safeguards that minimize costs while keeping the risk within acceptable levels or minimizing the maximum risk for a given budget. We propose a dynamic programming-based method and the use of metaheuristics to tackle the corresponding optimizations problems.

3 - A Competitive Covering Tour Problem in Disaster Relief
Christian Burkart, Walter Gutjahr, Pamela Nolz

We consider the problem of designing the logistic system for distribution of relief aid in a drought disaster. The beneficiaries do not relocate and walk to distribution centers. A competitive, multi-objective Covering Tour Problem aims at minimizing (i) uncovered demand and (ii) costs. A competitive location model models the beneficiaries decision on where to go to (if at all), so demand can be met in the right places and quantities. We use a genetic algorithm and compare the solutions to the exact Pareto front with the Hypervolume Indicator, using data from Gaza, Mozambique.

4 - Decision making in the chaotic environment of first response to disasters
Kate Hughes

Decision making in chaotic contexts is difficult and requires exploratory investigation for preliminary identification and understanding of the issues before more positivist methods can be employed. This study of decision making supply chain managers takes an interpretivist approach in order to gain contextual understanding of the elements that help - and those that hinder — the ability to make assessments and evaluate action in the emergency phase of disaster management. This information can then be extended for further research using methods that employ quantitative data for analysis.

5 - Decision-Making Social Networks
Ali Abbas

Facebook has shown us that people love to connect with others in a social network. Wikipedia has shown us that people love to offer expertise to help others. This talk presents the learnings obtained from the decision-making social network, Ahoona. We discuss the types of decisions people like to offer help on, and show tag clouds for preferences, uncertainties and alternatives for decisions in our daily lives.

■ TE-32

Tuesday, 16:00-17:30 - Room 014

Data Mining Applications and Applied Probability

Stream: Data Mining, Knowledge Discovery and Artificial Intelligence
Contributed session

Chair: *Rosangela Villwock*
Chair: *David Simchi-Levi*

1 - What Drives Strategic Deviance in a Nascent Industry? Evidence from Big Data
Kyung Min Park, Bokyung Lee

Utilizing big data accumulated on social media such as twitter and blogs, we investigate public opinions on a nascent industry such as daily deal shopping industry. This study demonstrates how the industry level legitimacy and performance feedback-based learning affect the degree of firms' strategic deviance. We describe key properties of industry legitimization and de-legitimization process through analyzing public discourse and social comparison among firms. An analysis of daily deal sites in Korea supports our main theoretical expectations.

2 - Diagnosis and Prediction of Equipment Fault using the Probability Model
Inseok Lee, Sung-Shick Kim, Jun-Geol Baek

To reduce manufacturing cycle time and production costs, predicting the abnormal state of the equipment is highly important. Causes of fault are various and complicated. We defined these hazard factors as each probability model. Through these probability models, we make the probability model to predict and diagnose the equipment fault. To calculate the probability by using the time event data, we propose survival analysis. This method is statistical data analysis by using time until an equipment fault occurs. Throughout the experiment, we expect a better diagnosis and prediction.

3 - How to Use Regression Method Properly
Syed Shahabuddin

Forecasting is a critical tool for making sound futuristic decisions. Forecasters can use time series or regression methods to forecast. Regardless of the method, one must follow the required rules of the method to make an accurate forecast. Unfortunately, some forecasters do not know the rules, ignore the rules, or implement them partially. Thus, most forecasts are inaccurate. Instead of blaming themselves, they blame the method. My paper discusses the required rules associated with regression and shows quantitatively the consequences of ignoring, violating, or partially implementing them.

4 - Dynamic Pricing and Demand Learning for an Online Retailer
David Simchi-Levi

We present an implementation of dynamic pricing strategy for an online retailer. The challenge facing the retailer is that most products have short sales windows and high demand uncertainty. To address this challenge, we develop a two-stage pricing strategy: first, a clustering method identifies several potential demand functions; then, a dynamic pricing algorithm learns demand and adjusts price on the fly. We show a theoretical performance guarantee and numerical experiments of the algorithm.

■ TE-33

Tuesday, 16:00-17:30 - Room 015

Defence and Security Applications IV

Stream: Defence and Security Applications
Invited session

Chair: *Ana Isabel Barros*

1 - The Framework of the Decision-Making Support System for Joint Operations
Chifei Zhou

A new decision-making support system (DMSS) is researched for joint operations. The DMSS is focused on the proceeding of joint operations to support user's decision making process in the large-scales, complex and dynamic environment. The DMSS consists of geographical interfaces, analyses tools and an assistant plan, that helps users solve issues quickly.

2 - Creating Real Time Intelligence
Ana Isabel Barros, Jeroen Wevers, Bob van der Vecht, Hans van Dalen

In order to produce reliable and up to date intelligence in support of current military operations there is a need for (near) real time analysis of threat. This presentation addresses a framework to support intelligence analysts and operators in collecting, processing information from different sources, in order to constantly carry out (near) real time prediction of the likelihood of threats over space and time.

3 - Information Retrieval Customized for Intelligence Collection
Ned Dimitrov

Intelligence processors are faced with a glut of information. Typically, their job consists of sifting through thousands of intelligence reports, to compile the data relevant to their query. We create custom information retrieval algorithms for the intelligence collection setting. Unlike the algorithms used by modern search engines, our algorithms exploit knowledge of the interest, experience, and organization of the user to guide their search for relevant information.

4 - Development of Terrorist Threat Prediction Model in Indonesia by using Bayesian Network
Hilya Arini, Nur Masruroh, Budi Hartono

There are more than 20 terrorist threats from 2002 to 2012 in Indonesia. However, study to build preventive solution to counter terrorist has not been conducted. This study aims to build prediction model of terrorist threat in Indonesia by using Bayesian network. This study finds several significant findings. First, news and the readiness of terrorist group are the most influent factor for conducting terrorist threat. Second, according to several scenarios of the news portion, it can be concluded that the higher positive news proportion, the higher probability of terrorist threat will occur.

■ TE-34

Tuesday, 16:00-17:30 - Room 016

Risk Analysis and Management

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Shin-Yun Wang*

1 - Support Vector Regression for Loss Given Default Modelling
Xiao Yao, Jonathan Crook, Galina Andreeva

In this paper support vector regression models are applied to predict loss given default of corporate bonds, where improvements are proposed to increase predictive accuracy by modifying the SVR methods to account for heterogeneity of bond seniorities. Our paper has the following contributions: At an aggregated level the proposed improved versions of SVR techniques outperform other methods significantly; At a segmented level LS-SVR models show significantly better predictive abilities compared with the other statistical models; Standard transformations of LGD do not improve predictive accuracy.

2 - Modelling Operational Risk Using Skew t-Copulas via Bayesian Inference and Extreme Value Theory
Betty Johanna Garzon Rozo, Jonathan Crook, Fernando Moreira

Operational risk losses are heavy tailed and are likely to be asymmetric and extremely dependent among business lines/event types. We propose a new methodology to assess, in a multivariate way, the asymmetry and extreme dependence between severities, and to calculate the capital for Operational Risk. This methodology simultaneously uses extreme value theory and the skew t-copula. The former to model the loss severities more precisely; the latter to effectively model asymmetry and extreme dependence in high dimensions. The paper analyses an update data set, SAS Global Operational Risk Data.

3 - Comparative Analysis of Multinomial and Multistage Logistic Regression Approaches to Credit Card Holders Behaviour Modelling
Denys Osipenko, Jonathan Crook

Because of the variety of the card holders' behaviour patterns and income sources each consumer account can move to different states. The estimation of the transition probability between status at the account level helps to avoid the memorylessness of the MDP approach. The key question is which approach gives more accurate results: multinomial logistic regression or multistage decision tree with binary logistic regressions. This paper investigates the approaches to credit cards profitability estimation at account level based on multistates conditional probability.

4 - Executive Compensation and Excessive Risk-Taking: A Quantile Regression Analysis
Shin-Yun Wang

We test the relation between firm's risk and executive compensation. Differ from previous studies and examine the relation at the tails of the risk distribution using quantile regression. Traditional analysis of such relation using OLS method reveals only the conditional means of the estimates, which cannot answer the question if executive compensation encourages excessive risk-taking. We also partition firm risk into systematic and idiosyncratic levels as literature suggests that CEO option compensations create incentive to increase systematic risk, but not necessary idiosyncratic risk.

■ TE-35

Tuesday, 16:00-17:30 - Room 131

Airline Optimization

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair:
Chair: *Alexandre Jacquillat*

1 - A Multi-Period Airline Seat Inventory Control Model
Sang Won Kim

Airlines sell similar seats on an air flight at different fares and demand is affected by customer buying behaviors when customers buy other fare class tickets if the originally requested fare were unavailable and wait in anticipation of reopening of the same fare class. We consider an extension of the two-fare, two-period seat inventory allocation model to multi-period, multi-fare airline seat inventory allocation decisions. We develop heuristic models for multi-period, multi-fare airline seat inventory allocation and an efficient computer algorithm to reduce computation time.

2 - Measurement of Efficiency Using Data Envelopment Analysis: An Application in Airline Industry
Burak Keskin, Efehan Ulas, Mert Aktan

The aim of this study is to present an application of Data Envelopment Analysis (DEA) to measure the efficiency of 28 airline companies which are members of the star alliance organization. The first step is to quantify the level of efficiency based on the real data which acquired from the annual reports of airlines and then, the ways to improve the efficiency of their works are recommended for the inefficient ones.

3 - Toward an Equitable and Collaborative Mechanism for Schedule Coordination at Congested US Airports
Alexandre Jacquillat, Vikrant Vaze, Amedeo Odoni

Small scheduling changes could achieve large delay reductions at US airports. But schedule coordination studies do not fully integrate airline scheduling preferences. We solve a tradeoff between reducing delays and satisfying airline preferences. First, we formulate equity constraints to fairly balance schedule changes among airlines. Second, we design a collaborative mechanism between a coordinator and the airlines based on non-monetary transfers. This combines stochastic queue dynamics, a Dynamic Programming model of capacity utilization and an Integer Programming model of flight scheduling.

■ TE-36

Tuesday, 16:00-17:30 - Room 132

Agrifood Industry

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Concepcion Maroto*
Chair: *Javier Ribal*

1 - The Analytical Hierarchy Process in the Choice of Cocoa Post-Harvest Technology in Ecuador
Amparo Baviera-Puig, Lenin Vera-Montenegro, José María Garcia-Alvarez-Coque

We define a cocoa post-harvest technology selection model to assist small producers in Ecuador by using the Analytical Hierarchy Process (AHP) to assess the following criteria: quality, processing cost and technology adoption capability. Although quality is the highest-valued single criterion, it is not necessarily the decisive factor in the selection of the best technology because the high scores attributed to some technologies in the other two criteria offset the quality criterion score. Thus, processing cost and technology adoption are also relevant for small producers.

2 - Old and new diet Formulation Models in the Swine Industry
François Dubeau, Jean-Pierre Dussault, Émilie Joannopoulos, Candido Pomar

We present several new diet formulation models that can be applied to the swine industry. We explain the classic and multiphase feeding models. We introduce two formulations, called respectively fixed and free. The free premix model departs from the traditional linear programming formulation in tackling simultaneously the diet's premix contents and the daily proportions, resulting in a bi-linear formulation. We also present the unfixed energy rate model and show how it is related to the previously presented models. Cost improvements of some new models are presented.

3 - Selecting a Healthy, Environmentally Friendly and Affordable Diet
Javier Ribal, M. Loreto Fenollosa, Purificación García-Segovia, Gabriela Clemente, Neus Sanjuan

Due to the high degree of personal choice, food represents a good opportunity for consumers to influence their personal carbon footprint. However, health, environmental effects and food cost are not always convergent. This study develops a goal programming model to select a 30-day sustainable diet choosing out of 256 daily menus considering nutritional, environmental and economic aspects. The results can make it possible to analyze the trade-offs between these aspects and to quantify how budget constraints can determine an unhealthy or environmentally unfriendly diet.

4 - New Methodology for Evaluating and Classifying Suppliers based on an Outranking Approach
Concepcion Maroto, Dennise Alos, Jordi Cuartero, Salvador Giner, Marina Segura, Baldomero Segura

Establishing the most appropriate relationship with the suppliers is a main issue for companies. We propose a methodology to evaluate suppliers in order to support these decisions. We define specific criteria of the products and those related to the suppliers, as well as their indicators. A criticality index and a strategic index of suppliers have been calculated by using PROMETHEE and AHP. These indices have been implemented in an agrifood company to classify their suppliers according to the most interesting relationship (partners, long term contracts, market policies or elimination).

■ TE-37

Tuesday, 16:00-17:30 - Room 017

Indoor Localization

Stream: Multiobjective Optimization
Invited session
Chair: *Marta Pascoal*
Chair: *José Santos*

1 - Multilateration for Indoor Localization
Ana Rita Pereira, José Augusto Ferreira, José Santos, Manuel António Vicente

Multilateration is a usual technique to localize a mobile device in an indoor environment. In this talk we describe different strategies to deal with multilateration. The use of previous positions of the mobile device to increase the accuracy of this procedure will be also considered. Numerical studies will be presented that lead to a ranking of the different approaches.

2 - Indoor Localization with Multi-Criteria Optimization
José Santos, Pedro Jorge

This communication approaches the problem of locating a mobile device in an indoor environment using the wireless network at disposal, where the most common locating services such as GPS are not available. Several strategies are shown based on a multi-criteria approach, each one aims to solve the problem efficiently. Afterwards, they are compared with a usual localization strategy (the k nearest neighbours algorithm), by presenting some computational results.

3 - Shortest Paths on Indoor Localization
Cátia Santos, Marta Pascoal

Indoor positioning systems are often affected by inaccuracy due to various reasons, like changes in the environment or noise resulting from signal propagation errors. In this talk we address the problem of calculating distance lower bounds between two sites in a building, in order to validate (or discard) consecutive locations of a mobile device identified by localization algorithms. Methods for solving this problem in real time will be discussed and comparative computational results will be reported.

■ TE-38

Tuesday, 16:00-17:30 - Room 214

Regularization Methods

Stream: Convex Optimization Methods and Applications
Invited session
Chair: *Yaxiang Yuan*
Chair: *Xin Liu*

1 - A Gauss-Newton Method for Low-Rank Matrix Approximation
Yin Zhang

Data dimensionality reduction problems typically rely on eigenvalue calculations. For large-scale data, classic eigenvalue algorithms, although well-developed, can become unnecessarily costly. In this work, we propose and analyze a Gauss-Newton method for computing low-dimensional principal subspaces. The algorithm is simple, low-cost and parameter-free. We present theoretical convergence and numerical results showing that the proposed algorithm can be up to several time faster than SVD-based algorithms.

2 - Regularization Methods for Retrieval of Magnetic Parameters with Full Tensor Gradient Data
Yanfei Wang

Retrieval of magnetization parameters using magnetic tensor gradient measurements received attention in recent years. Determination of subsurface properties from the observed potential field measurements is referred to as inversion. Little regularizing inversion results using gradient tensor modeling so far has been reported in the literature. In this paper, we solve the inverse problem of identifying the magnetic parameters with the magnetic gradient tensor data using optimization and regularization theory of ill-posed problems. Numerical experiments are performed.

3 - Acquire More for Less: Applications of Compressive Sensing on Seismic Data Acquisition
Chengbo Li, Charles Mosher, Joel Brewer

Compressive sensing (CS) is a novel sampling methodology representing a paradigm shift from conventional schemes. Conoco Phillips has successively applied CS to seismic data acquisition. The field trial shows significant improvement of the data resolution compared to conventional survey. Simultaneous sources provide us with another novel scheme for acquiring better seismic data more quickly at lower total cost. We rely on inversion procedure to deblend and regularize data. The inversion method we developed is based on the nonmonotone alternating direction method.

■ TE-39

Tuesday, 16:00-17:30 - Room 018

Fuzzy Optimization in Supply Chain Management

Stream: Discrete and Global Optimization
Invited session
Chair:
Chair: *Nimet Yapıcı Pehlivan*

1 - Multi-Criteria Decision Making for Recycling Planning in the Automotive Industry
Abdullah Yıldızbaşı, Turan Paksoy, Hadi Gökçen, Nihat Yüzügüllü

This paper proposes a recycling planning model for automotive shredders to make short-term tactical decisions regarding to what extent to process and to reprocess materials through multiple passes. The mixed-integer programming model determines whether to combine materials for shipment. In addition, the AHP method is used for obtaining the weights of some constraints. The model involves shredding facilities, sorting, transportation, and disposal centers. Finally, accuracy and applicability of the model is illustrated via a hypothetical example.

2 - A Novel Interactive Fuzzy Programming Approach based on MultiMOORA Method for Closed Loop Supply Chain Network Optimization under Fuzzy Environment
Nimet Yapıcı Pehlivan, Ahmet Çalık, Turan Paksoy

This paper presents a novel interactive fuzzy programming approach based on a MultiMOORA method which is a multi-criteria decision making method for closed loop supply chain (CLSC) network optimization under fuzzy environment. The general CLSC network members can be classified into two groups (Zhu et al.2008): (i) forward logistics chain members, including raw material suppliers, manufacturers, retailers, and consumers; (ii) reverse logistics chain members, including consumers, collection centers, recycling centers, and manufacturers or suppliers.

3 - A Closed-Loop Supply Chain Network Design: A New TOPSIS Based Interactive Fuzzy Programming Approach
Ahmet Çalık, Turan Paksoy, Nimet Yapıcı Pehlivan

This paper presents a novel interactive fuzzy programming approach based on crisp and fuzzy TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) for closed-loop supply chain (CLSC) network design problem including manufacturers, suppliers and collection centers. The aim of the proposed problem is the integration of TOPSIS and fuzzy TOPSIS methods into the development stage for usage of Interactive Fuzzy Programming approach. A numerical example is applied and tested for the proposed model

4 - Testing for Non-linear Relationship in Structural Equation Modeling
Ilkay Altindag, Aşır Genç

Structural equation modeling (SEM) is a multivariate statistical method, with the integration of factor analysis and multi-regression analysis. Recently, it is recognized that nonlinear relations among the variables are important in establishing more meaningful and correct models for some complex situations. In this study, we indicate a nonlinear structural equation model which can accommodate covariates in the measurement equation, and nonlinear terms of covariates and exogenous latent variables in the structural equation.

■ TE-40

Tuesday, 16:00-17:30 - Room 019

Innovations in Meta-Analytics II

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair:
Chair: *Michel Vasquez*

1 - A Tabu Search Algorithm for Cohesive Clustering Problems
Buyang Cao, Fred Glover

A Tabu Search algorithm for a new problem class called cohesive clustering which arises in a variety of business applications is presented. The class introduces an objective function to produce clusters as pure as possible, to maximize the similarity of elements in each given cluster. Our algorithm generates clusters of a specified number or can determine this number adaptively — which can be useful for unsupervised data mining. Tabu Search intensification and diversification strategies produce enhanced outcomes and we show the effectiveness of the algorithm by computational experiment.

2 - Distance-Guided Local Search
Daniel Porumbel, Jin-Kao Hao

In Local Search (LS), the concept of distance between solutions has been generally used less often than in other areas (e.g, multimodal evolutionary algorithms, crowding or niching). We present Distance-Guided Local Search (DSLS): a platform of using distances on top of a given LS, so as to avoid unique local optima and global looping (looping among a few distinct local optima). DG-LS has been already implemented on the max-clique problem (vector space) and tests are under considerations for graph coloring (partition space) and an arc-routing formulation (permutation space).

3 - MO-Mine_Clust: A Generic Platform for Multi-Objective Clustering
Clarisse Dhaenens, Laetitia Jourdan, Benjamin Fisset

Clustering is a very popular data mining, which is by nature a multi-objective. Therefore, it seems interesting to provide a generic platform that is able to deal with different combinations of measures and propose several multi-objective algorithms. Such a generic platform could offer the opportunity to compare several of them. The objectives of the platform are: - Propose to use several mono and multi-objective models for clustering, - Execute several multi-objective metaheuristic schemes, - Compare statistically results obtained.

4 - Tabu Search with Global Exploration for Machine Reassignment Problem
Michel Vasquez, Saïd Hanafi, Koji Nonobe, Mutsunori Yagiura, Hideki Hashimoto

We propose a tabu search with global exploration for solving the machine reassignment problem (ROADEF challenge 2012). The exploration uses shift and swap moves and the reverse elimination method, proposed by F. Glover, manages the tabu list to avoid the trap of local optimality. Evaluating the neighborhood of the current solution is cpu time expensive regarding the fact that only one move will be choose at the end. To compute quickly the "best" matching, we use an improved version of the path growing algorithm for weighted matching in graph proposed by Drake and Hougardy.

■ TE-41

Tuesday, 16:00-17:30 - Room 216

Simulation-Optimization in Logistics & Production

Stream: Simulation-Optimization in Logistics & Production
Invited session
Chair: *Albert Ferrer*
Chair: *Angel A. Juan*

1 - Operations Research for Health Care: Simulating Blood Inventory Management
Alex Grasas

Banc de Sang i Teixits (BST) aims to ensure the supply and proper use of blood and tissues in Catalunya. BST manages blood inventory for all hospitals in Catalunya considering that blood has a maximum shelf life (MSL) of 42 days; that is, blood can only be transfused within 42 days after donation. Recent studies have shown, however, that blood in its last week may lose some properties causing rejection problems among patients. In order to improve health care quality, we simulate the blood inventory system at BST to study the impact of reducing the MSL to 35 days.

2 - Algorithm for Bicriteria Scheduling in Parallel Machines with Eligibility
Manuel Mateo, Jacques Teghem, Jordi Camps

The scheduling of parallel machines with eligibility is a very common problem. A set of n jobs has to be scheduled on m parallel machines distributed among p levels. The previous and the following operations also introduce release and delivery times. Particularly, we study the case of p=3. Any machine has the same processing time for a job. We consider two objectives: minimize the makespan and a penalty function if the jobs are not assigned to top machines. The problem is solved considering different kinds of exploration. To check their performance, a computational experience is conducted.

3 - Solving Non-Smooth Flow-Shop Problems with Failure-Risk Penalties Using a Biased Randomized Local Search
Albert Ferrer, Daniel Guimarans, Helena Ramalhinho Lourenco, Angel A. Juan

We present a variant of the flow-shop problem with a non-smooth objective function that takes into account maintenance and operations costs. We propose a randomized Iterated Local Search algorithm that employs non-uniform probability distributions. A biased random behavior is considered in the NEH heuristic to generated initial solutions. The algorithm generates a large number of alternative good solutions without a complex configuration. This characteristic is particular useful in presence of non-smoothness or non-convexity functions.

4 - SimILS: Solving Stochastic Combinatorial Optimization Problems by Combining Iterated Local Search with Simulation
Helena Ramalhinho Lourenco, Angel A. Juan, Alex Grasas

The combination of Simulation with Optimization can be a powerful tool to solve complex decision real problems. One important research area is the combination of Simulation with Heuristics and Metaheuristics, SimHeuristics. In this talk we will describe a special case of the SimHeuristics, the combination of Simulation with the Metaheuristisc known as Iterated Local Search. We will describe the scheme to combine Simulation and ILS and the potential application to Stochastic Combinatorial Optimization Problems.

■ TE-42

Tuesday, 16:00-17:30 - Room 215

Applications in Decision Making & Decision Analysis

Stream: Decision Support Systems
Invited session
Chair: *Fatima Dargam*
Chair: *Shaofeng Liu*

1 - A Decision Support System for Estimating the Scale of Using Renewable Sources of Energy and Storing Electricity in a Regional Electrical Grid
Alexander Belenky

A game-theoretic approach to making decisions on the scale of using renewable sources of energy and storing electricity in a regional electrical grid under both the existing and expected prices for electricity from all the sources of the electric power in the gird is proposed. Solving a game with a finite (more than three) number of players on polyhedra of connected player strategies underlies the decision making process, and the use of proposed verifiable sufficient conditions of equilibria in this game reduces finding the equilibria to solving three auxiliary linear programming problems.

2 - A DSS for Resolving Evaluation of Criteria by Interactive Flexible Elicitation on Supplier Selection Problems
Adiel Teixeira de Almeida, Jonatas Almeida, Adiel Almeida-Filho, Ana Paula Costa

The paper presents a DSS for elicitation of weights of multicriteria additive models. This is one of the most relevant issues in additive models. The tradeoff elicitation procedure is considered to have the strongest theoretical foundation, although experimental studies have found inconsistencies when applying that procedure. The DSS uses the concept of flexible elicitation so as to overcome some concerns about the tradeoff elicitation procedure. The use of the DSS is illustrated by the application on two different supplier selection problems.

3 - Learning Non-Monotonic Preferences, a New Algorithm
Mohammad Ghaderi, Francisco Ruiz, Nuria Agell

Capturing preferential system of the Decision Maker (DM), given a ranking of alternatives, is a challenging research question in preference disaggregation field. UTA methods are well-known in the literature, addressing this question by a linear programming model. In most of the UTA-based methods, a monotonic value function has been applied, which limits the applicability of the method. Non-monotonic UTA-based methodologies, on the other hand, are computationally intensive. In this paper we introduce a faster and simpler model, capable of learning additive non-monotonic utility functions.

4 - Support decision in soccer football
Silvely Néia, Vilma Tachibana, Pedro Castro

The soccer has experienced increased competition among clubs. The sport has become a business and the use of techniques of management is essential for survival of these companies, so globalized . This work uses the variables involving football through statistical techniques, envolving multivariate analysis tools with its techniques of cluster and principal components, and space and descriptive statistics. It is possible to obtain results and numbers that can qualify and quantify the performance of the players individually and collectively, qualify and quantify their performances.

■ TE-43

Tuesday, 16:00-17:30 - Room 217

Data Mining, Economic Models and Games

Stream: Computational Statistics
Invited session
Chair: *Pakize Taylan*

1 - The Application of Data Mining Technique to Bookstore Customer Relation Management
Hong Tau Lee, Sheu-Hua Chen

This research applies data mining technique on the transaction data of book chain-store to figure out the consumers' favorites of the relationship between the categories of books they bought. Different favorite relationships were found in different type of book stores which locates in different districts. Specific promotion activities were provided based on the patterns found. The results show that there have significant advantages of profit, advertisement expense, and consumer's response rate.

2 - Understanding Different Online Gamer Retention Behaviours: A Data Mining Approach
Xin Fu, Yutong Shi, Shun Cai, Di Xu

This work proposes an innovative player segmentation model based on their in-game behaviour data, for the first time, to support player retention analysis. In this manner, the retention behaviour patterns of each player segment would be modelled and analysed respectively. In particular, a new similarity metric (which is driven by player's "stickiness" to the game) and an improved fuzzy K-means clustering algorithm is developed herein to cluster players. The applicability and utility of this work are illustrated by means of experiments that are conducted on a realistic MMORPG dataset.

3 - A Business Intelligence Framework Using Web and Time Series Data Mining for Agriculture-based Markets
Hector Flores, Rene Villalobos

The ability to correctly foresee future events based on historic information is key for any analytical setting. Traditional time series forecasting methods are based on stationary and ergodic assumptions that are often not adept to handle complex market information not adhering to these assumptions. In this study, we aim to develop a framework that incorporates web and time series data mining techniques to identify changing trends and patterns in agriculture-based markets. This framework enhances farmers' decision-making by improving their strategic and tactical planning capabilities.

4 - Truthful Auction Mechanisms for Value-Maximizing Bidders
Salman Fadaei, Martin Bichler

We discuss auction design for bidders which maximize valuations rather than quasi-linear utility functions. We will refer to such bidders as value-maximizing bidders or short value bidders. Examples are markets for TV ads sold by a TV station, where bidders are media agencies who are given a budget by clients describing their value for different allocations. The budgets are considered as sunk cost and they are devoted to a particular campaign or package of slots. The bidder's goal is to win the highest valued package. The environment is different from mechanism design without money.

■ TE-44

Tuesday, 16:00-17:30 - Room 218

Multiobjective Linear Programming

Stream: Multiobjective Linear, Integer, and Combinatorial Optimisation
Invited session
Chair: *Matthias Ehrgott*

1 - Ordered Weighted Average Combinatorial Optimization: Formulations and their Properties
Miguel Angel Pozo, Elena Fernandez, Justo Puerto

In this paper, Ordered Weighted Average optimization problems are studied from a modeling point of view. Alternative integer programming formulations for such problems are presented and their respective domains studied and compared. In addition, their associated polyhedra are studied and some families of facets and new families of valid inequalities presented. The proposed formulations are particularized for two well-known combinatorial optimization problems, namely, shortest path and minimum cost perfect matching, and the results of computational experiments are presented and analyzed.

2 - Primal and Dual Methods for Linear Optimization over the Nondominated Set of a Multi-objective Linear Programme
Zhengliang Liu, Matthias Ehrgott

This article presents two new algorithms for the maximization of a linear function over the nondominated set of a multiobjective linear optimization problem. A primal method is developed based on a revised version of Benson's outer approximation algorithm in objective space. A dual method derived from the dual variant of the outer approximation algorithm is proposed. We compare the two new algorithms with several algorithms from the literature on a set of randomly generated instances.

3 - Multiobjective Column Generation Using Revised Normal Boundary Intersection: An Application to Radiotherapy Treatment Planning Optimization
Kuan-Min Lin, Matthias Ehrgott, Andrea Raith

We propose a column generation (CG) approach to solve multiobjective linear programs. The method implements CG within the revised normal boundary intersection (RNBI) framework to compute a representative set of nondominated points. The CG process adds non-basic variables to the restricted master problem, which move a current objective point towards nondominance. A reference subsimplex optimization method is used to eliminate reference points that lead to infeasibility. Numerical tests on a radiotherapy treatment problem demonstrate the uniformity of the points generated by the CG RNBI method.

4 - Data Envelopment Analysis Without Linear Programming
Matthias Ehrgott, Maryam Hasannasab, Andrea Raith

Data Envelopment Analysis for the efficiency assessment of decision making units (DMUs) traditional requires the solution of one linear programme per DMU. In this paper we investigate data envelopment analysis from a multi-objective optimisation point of view and show that, by applying primal and dual outcome space algorithms for multi-objective linear programming, data envelopment analysis can be performed without solving any linear programmes. We demonstrate the advantage of this technique for practice on a number of DEA instances.

■ TE-45

Tuesday, 16:00-17:30 - Room 219

Analysis of Customer-Based Data

Stream: Business Analytics Optimization and Big Data
Invited session
Chair: *Nuria Agell*

1 - Making Sense of Online Customer Reviews
Alexandra Medina-Borja

Published tourist destination data for the Caribbean Islands and online reviews left by visitors were used to extract customer's online opinions. We used sentiment analysis and semantic orientation to extract the data, and on fuzzy logic to quantify the results into representative metrics of service quality. Triangular fuzzy numbers were used to represent the linguistic scale behind customer online comments that reflect their evaluation of the service. We then use Data Envelopment Analysis (DEA) to quantify the performance of comparable service units.

2 - Group Consensus Mining based on Extended Tournament Matrices
Li-Ching Ma

Group consensus mining is to find out a maximum consensus sequence which is the longest ranking lists of items that the majority agrees with and the minority disagrees with. This study tries to develop a novel approach for group consensus mining problems. First, each decision maker's preferences are transformed into an extended tournament matrix. A rank tracking algorithm is then developed to obtain a maximal consensus sequence. Compared to previous methods, the proposed approach can efficiently discover maximum consensus sequence without generating and filtering lots of candidates.

3 - Exploring the Role of Consensus Measures in Decision Science: An Experience Towards Summarizing Users' Opinions
Nuria Agell, Soumya Banerjee, Monica Casabayó

Internet has changed consumers' decision-making process in several ways. Consumers have the possibility to search for more and better information about products and services. Moreover, consumers are likely to influence other peers; even they do not know them. The aim of this paper is to build a new mining approach which is able to filter customer's feed-back automatically using text summarization. We define a new model, based on two consensus criteria. On the one hand a consensus based on a proximity measure, and on the other hand a consensus based on consumers preferences.

4 - 1 Million Regressions in 30 Seconds: An Airbnb Case Study of Distributed Big Data Mining
Lukasz Dziurzynski

The purpose of this talk is to discuss scalable statistical techniques through case studies of analytics projects at Airbnb. You will learn how to overcome analytical challenges at scale–TB-sized datasets–via concrete examples. We built a daily process that uses browsing activity to predict how likely each user-session is to contact or book. We used collaborative filtering to improve our search-to-book rate. We enhanced our price-suggestions, in particular for the upcoming World Cup in Brazil. This talk will show how Airbnb integrated Mahout, Hive, R, and Python to solve these problems.

Thursday, 8:30-10:00

■ HA-01

Thursday, 8:30-10:00 - Room 118

Scheduling and Rescheduling Railways under a Dynamic Environment

Stream: Railway and Metro Transportation
Invited session
Chair: *Luis Cadarso*

1 - The Influence of Dwell Times on Rail Service Planning
Antonio Placido, Luca D'Acierno, Marilisa Botte, Simone Campora, Bruno Montella

Due to the constant increase in travel demand, rail systems are more and more dense and service providers have the difficult task of planning a timetable which has to be robust and stable. Moreover, in order to increase customers' satisfaction, it is necessary to provide sufficient transport capacity avoiding train and platform congestion and guaranteeing a good level of service quality. To reach this target, in this framework we provide an appropriate timetable evaluation which considers the dynamic effect of dwell time at station on the service in the case of metro networks.

2 - A Fast and Effcient Adaptive Large Neighborhood Search Heuristic for the Passenger Train Timetabling Problem with Dynamic Demand
Eva Barrena, David Canca, Leandro Coelho, Gilbert Laporte

We study the design and optimization of train timetables adapted to a dynamic demand environment. The objective is to minimize the average passenger waiting time at the stations, thus focusing on passenger welfare. We first propose two mathematical programming formulations. We then analyze the properties of the problem before introducing a fast adaptive large neighborhood search metaheuristic in order to solve large instances of the problem within short computation times. The algorithm yields timetables that may not be regular or periodic, but are adjusted to a dynamic demand behavior.

3 - A Macroscopic Railway Timetable Rescheduling Approach for Handling Large Scale Disruptions
Lucas Veelenturf, Martin Kidd, Valentina Cacchiani, Leo Kroon, Paolo Toth

Relatively large daily disruptions require infrastructure managers and railway operators to reschedule their timetables and rolling stock and crew schedules. This research focuses on timetable rescheduling at a macroscopic level. An integer programming model is formulated for solving the timetable rescheduling problem, minimizing the number of cancelled and delayed trains while adhering to infrastructure and rolling stock capacity constraints. The results of the computational tests of the model on the Dutch railway network are promising.

4 - A Model for Readjusting Public Transport Services on Short Time Periods
Esteve Codina, Lídia Montero, Ángel Marín

A mathematical programming model described to assist with the rescheduling of services for a set of auxiliary bus lines (a bus-bridging system) during disruptions of metro and rapid transit lines during a short time period is presented. The model is formulated as a classical event scheduling problem combined with flow balance constraints in order to take into account time-dependent information regarding trip demands between the stations of the auxiliary bus system. Both, the complete version of the model and a conveniently simplified formulation are presented.

■ HA-02

Thursday, 8:30-10:00 - Room 111

Time-dependent Vehicle Routing and Scheduling

Stream: Vehicle Routing
Invited session
Chair: *Christian Bierwirth*

1 - Synchronization in Vehicle Routing Problems — An Overview
Dorota Slawa Mankowska, Christian Bierwirth, Frank Meisel

One of the currently established extensions of the VRP is synchronization of vehicles, which is required if, e.g., two vehicles must visit the same location. In this talk, we present VRPs with synchronization where vehicles can visit a transferring point to exchange cargo without having to go back to the depot for replenishment. Also the temporal aspect is considered, i.e., vehicles that provide cargo must visit a transferring point earlier than receiving vehicles. We present mathematical formulations for different types of synchronization requirements and heuristic solution approaches.

2 - Time Inconsistency of Heuristics in Multi-Period VRP
Alexander Shchegryaev, Victor Zakharov

In our talk we discuss and demonstrate the effect of time inconsistency of vehicle routing plans constructed by some heuristic algorithms in multi-period VRP. Results of evaluating level of the heuristics time inconsistency are presented. An approach and methods to decrease level of heuristics time inconsistency are proposed. To increase level of time consistency of optimal routing plan of grand coalition in multi-period cooperative vehicle routing game and improve values of characteristic function we propose to apply iterative coalition induction algorithm (ICIA).

3 - The Multi-period Collection Scheduling Problem with Balancing Constraints
Cristina Nuñez, Elena Fernandez, Jörg Kalcsics, Stefan Nickel

This periodic collection problem determines the joint visiting calendar of a set of companies to a set of customers minimizing the total number of vehicles. There are storage limitations at the customers and balancing constraints on the total amount collected by the companies. Two alternative collection policies are studied. Linear integer formulations are presented. Numerical experiments show the reduction in number of vehicles when the second collection policy is considered. The difficulty of the problem when balancing constraints are imposed is evidenced. A solution algorithm is proposed.

4 - Column Generation for a Class of Bi-Objective Vehicle Routing Problems
Christian Artigues, Nicolas Jozefowiez, Boadu Mensah Sarpong

We present a generalized column generation scheme to compute bound sets for bi-objective integer linear programs. We also present different strategies for implementing the generalized algorithm and refinements for the case where one of the objectives is a min-max objective. We apply the proposed method to extended formulations for bi-objective vehicle routing problems, such as the bi-objective multi-vehicle covering tour problem. The results show that good lower and upper bounds are obtained in reasonable times if columns are efficiently managed.

■ HA-03

Thursday, 8:30-10:00 - Room 001

Discrete Location and Routing

Stream: Location
Invited session
Chair: *Alfredo Marín*
Chair: *Justo Puerto*

1 - Analysis of the Solution Permutations for the Asymmetric Traveling Salesman Problem
Mercedes Landete, Justo Puerto, Javier Alcaraz, Juan Francisco Monge, Eva M. García-Nové
In this work we consider the situation in which the optimal route, the solution of the Asymmetric Traveling Salesman Problem, needs to be modified because of unexpected events. All the nodes require service but some of them modify their position on the route. Instead of probabilities of failing, each permutation has a penalty and the goal is to minimize the weighted addition of the cost of the permutations of the solution we choose. We present several formulations for the problem and we compare them. Computational experiments illustrate the performance of each formulation.

2 - A Further Study of Location Facilities with Failure Foresight
Inmaculada Espejo, Alfredo Marín, Antonio Manuel Rodriguez-Chia
This work introduces a variation of the classic capacitated p-center problem which takes into consideration the possibility of facility failures due to external disruptions. If the closest center to a given demand point fails, the point must be reallocated to its second closest center. The aim is to minimize the maximum distance between a demand point and its second closest center. Moreover, the capacity of each center must suffice to serve the demand of its closest customers and the demand of the customers that would be assigned to it in case of failure of their first closest center.

3 - A Parallel Implementation of the Volume Algorithm to Solve the p-Median Problem
Mourad Baiou, Francisco Barahona, Jean-Christophe Gay
It is known that solvers like Cplex cannot solve huge instances of the p-median linear relaxation and that it is much appropriate to solve it by method based on Lagrangian relaxation as the volume algorithm. Even if we can solve huge instances with a sequential implementation it remains time consuming, so this is why parallel implementation is evoked. We use a trick in the implementation of the greedy heuristic to provide an upper bound. The trick is to reduce the greedy algorithm to a local search algorithm where a powerful implementation is known and due to Resende and Werneck (AOR, 2007).

4 - The Discrete Ordered Median Problem: A Tour of Perspective
Justo Puerto
This talk presents old and new formulations for the ordered median problem comparing the rationale behind them. In addition, we revisit the application of this type of objective function to different combinatorial objects identifying common properties that help in solving the problems. Preliminary computational results show the powerfulness of this approach to model and solve complex combinatorial problems as ordered median hub-location problems, capacitated ordered median location problems or multiobjective ordered weighted average shortest path problems, among others.

■ HA-04
Thursday, 8:30-10:00 - Room 119

Network Traffic Modelling I

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Nikolas Geroliminis*
Chair:

1 - Extensions of the Macroscopic Fundamental Diagram to Multimodal Traffic
Nicolas Chiabaut
This paper aims to extend the concept of Macroscopic Fundamental Diagram (MFD) to combine different transportation modes. Especially, we propose a unified relationship that account for cars and buses because the classical MFD is not sufficient to capture traffic flow dynamic of a multimodal traffic. The concept of passenger fundamental diagram is introduced. With this new relationship, efficiency of the global transport system, i.e. behaviors of cars and buses, can be assessed. Then, this relationship can be used to identify the optimal domains of applications for different transit strategies.

2 - A Mathematical Proof for the Optimal Perimeter Control Policy at an Urban Region
Jack Haddad, Ilya Ioslovich
Recent works show that a perimeter controller can manipulate transfer flows across a region border to maximize the total exit flow of the urban region. The macroscopic fundamental diagram (MFD) is utilized to model the traffic flow dynamics in the homogenous region. In this paper, we provide the explicit formulation of the optimal feedback control policy and a mathematical proof of optimality. The proof is based on the modified Krotov-Bellman sufficient conditions of optimality, where the upper and lower bounds of state variables are calculated.

3 - Modeling and Control of Large Scale Multimodal Urban Networks
Nikolas Geroliminis, Konstantinos Ampountolas, Nan Zheng
Recent research has studied the properties of a macroscopic fundamental diagram (MFD) for urban areas. The MFD should not be universally expected as high scatter or hysteresis might appear for some type of networks. We investigate if aggregated relationships can describe the performance of urban bi-modal networks with buses and cars sharing the same infrastructure and identify how this performance is influenced by the interactions between modes and the effect of bus stops. We also introduce simple perimeter control strategies to maximize passenger flows.

■ HA-05
Thursday, 8:30-10:00 - Room 002

Maritime Routing and Scheduling 2

Stream: Maritime Transportation
Invited session
Chair: *Henrik Andersson*

1 - A General Short Sea Inventory-Routing Problem
Ahmad Hemmati, Lars Magnus Hvattum, Marielle Christiansen, Gilbert Laporte
In this work a general short sea inventory routing problem is considered. To solve the problem an iterative metaheuristic is proposed based on the idea of converting the inventory-routing problem to a ship routing and scheduling problem. Using inventory limits and production and consumption rates, we generate a set of cargoes with time windows which are be updated based on the information gained during the interaction with an adaptive large neighborhood search which solves the ship routing problem. Computational results will be presented, discussed and compared with exact solutions.

2 - A Branch-and-Cut Method for the Routing and Scheduling of Vessels in a Brazilian Oil Industry
Maria Gabriela Furtado, Pedro Munari, Reinaldo Morabito
We address a pickup and delivery problem faced by a Brazilian industry involving vessels that transport oil from offshore platforms to the terminals. In addition to the standard features of vehicle routing problems we incorporate additional constraints that take into account the requirements of the company. As the resulting mathematical formulation become intractable to be solved by optimization softwares, we propose a mathematical formulation and a branch-and-cut method that exploit special characteristics of the problem. This enables us to solve practical instances in reasonable time.

3 - Exact and Heuristic Methods for Creating Annual Delivery Program for LNG Producer
Mohamed Kais Msakni, Fatih Mutlu
The producer of liquefied natural gas (LNG) has to fulfill the demand of its customers all around the world. This demand is specified in a long-term contract between the producer and the client that has been negotiated in advance and containing windows deliveries and, early/late and over/under delivery fees. The LNG is transported to customer with heterogeneous fleet of vessels that may differ in capacity, speed and operations cost. The goal is to establish an annual delivery program (ADP) for the producer that specifies deliveries for the customers at minimum costs while maximizing revenue.

4 - Order Management in the Brazilian Oil Industry
Henrik Andersson, Martine Hagen, Eirik Fernández Cuesta, Kjetil Fagerholt

The transportation of material, tools and waste to and from platforms is a challenging problem within logistics. In this presentation we look at a problem arising at the platforms in the Campos Basin, outside the coast of Brazil. Today, the system is operated using a set of fixed routes repeated on a weekly schedule. Of special concern is the problem of deciding which orders to load on board the platform supply vessels each departure. We discuss the pros and cons of fixed routes and analyze different ways to make them more flexible.

■ HA-06

Thursday, 8:30-10:00 - Room 211

Network Economics

Stream: Social and Economic Networks
Invited session
Chair: *Azarakhsh Malekian*

1 - The Spread of Epidemics on Random Graphs: A Modified Bass Model for Product Growth in Networks
Vahideh Manshadi, Ramesh Johari, Sidhant Misra

We study the diffusion of innovation and the product adoption process in networks with limited interactions. We model the adoption process by a simple epidemic model, and study the evolution of the epidemic on random k-regular graphs. First, we show that for complete graphs, our model is equivalent to the well-known Bass model. Then we analyze the adoption timing for k-regular random graphs and present the limit results for the time it takes for a fraction of the population to adopt. Further, we provide the timing of early adoptions at finer scales, e.g., logarithmic in the population size.

2 - The Spread of Epidemics on Random Networks: The Effect of Quarantine and Isolation
Azarakhsh Malekian

We introduce a theoretical model of the security investments and network formation and characterize the impact of quarantine and isolation on the spread of infection in the equilibrium.

3 - Trading Networks with Bilateral Contracts
Alex Teytelboym

We consider general networks of bilateral contracts that include supply chains. We show that there exists a stable contract allocations whenever agents' preferences satisfy full substitutability. These stable contract allocations may not be immune to group deviations, efficient, or in the core. We also show that competitive equilibrium exists in these networked markets even in the absence of transferrable utility. The competitive equilibrium contract allocation is also stable.

4 - Mechanism and Network Design with Loss-Exposed Agents
Sasa Pekec, Alexandre Belloni, Changrong Deng

A revenue-maximizing monopolist is selling a good to buyers who face a loss if a rival obtains it. The rivalry is modeled through a network (edge between two buyers who are rivals). We characterize optimal solutions to this joint network optimization & mechanism design problem. The revenue-maximizing rivalry networks are independent of distributional assumptions on buyers' private loss values (with virtuals bounded from zero). The structure of optimal networks depends on whether rivalry is (a)symmetric: optimal undirected networks are rare, yet none are among many optimal directed networks.

■ HA-07

Thursday, 8:30-10:00 - Room 003

Dynamical Models in Sustainable Development II

Stream: Dynamical Models in Sustainable Development
Invited session
Chair: *Jean-Sébastien Tancrez*

1 - Development of a Preliminary Model for the Kinetic Behavior of Main Pollutants in the City of Puebla
Maria Osorio

An analysis of the corresponding behavior of the concentrations of carbon monoxide, sulfur dioxide, nitrogen dioxide and ozone recorded in the database of REMA in Puebla city is described. The correlations between these pollutants are established, and a preliminary kinetic model which represents the evolution of pollutants in a characteristic "average day" is generated. The model consists of three ordinary differential equations which solution is obtained with the Runge-Kutta-Fehlberg procedure in combination with the least-squares values for the kinetic parameters.

2 - Modeling Network Supply and Distribution of Perishable Products using Systems Dynamics
Oscar Mayorga Torres

The following research presents the modeling of the supply network and distribution of perishable products using system dynamics, which took place at Bogota (Colombia), the whip effect for information and product was analyzed along the structural links of the chain: producers, transporters, wholesalers and retailers. The research components conceived reverse logistics and inventory management, incorporated in the analysis of the costs and time delays of the network elements. Finally, formulated policies improvement focused on retailer seeking to minimize the negative impact of time delays.

3 - Improving Pest Control Strategies for Eldana Saccharina Walker
Linke Potgieter, Jan van Vuuren, Desmond Conlong

There has been a global shift towards improving the efficiency of pest control programs such that they are long-term, environmentally friendly and cost-effective. A reaction-diffusion model of Saccharina, an insect indigenous to Africa feeding on sugar crop, population dynamics in a temporally variable and spatially heterogeneous environment has been formulated and utilised to identify cost-efficient control strategies for the insect, which includes the sterile insect technique and harvesting. The model and its use in decision making, as well as numerical results obtained will be presented.

4 - Designing the Supply Chain Network to Reduce Carbon Emissions
Jean-Sébastien Tancrez, Joana M. Comas Marti, Ralf W. Seifert

In this work, our goal is to investigate how companies should modify their supply chain network to cost-effectively reduce their carbon emissions. For this, we propose a supply chain network design model that simultaneously considers the emissions and costs related to both facility location and transport mode decisions, while taking into account the product characteristics (e.g., innovative or functional) through the explicit consideration of demand uncertainty and inventory costs. The model is illustrated using numerical experiments and managerial insights are derived.

■ HA-08

Thursday, 8:30-10:00 - Room 120

Carbon Emissions and Remanufacturing Problems

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Contributed session
Chair: *Matthias Garbs*

1 - The State of Scope 3 Carbon Emissions Reporting in Supply Chains
Charles Corbett, Christian Blanco, Felipe Caro
For most firms, the main opportunities for reducing carbon footprint lie upstream in their supply chain. We use CDP (formerly Carbon Disclosure Project) data on Scope 3 emissions (those embedded in products and services purchased) for 374 US firms to assess to what extent they measure their supply chain carbon footprint. We use the breakdown of emissions into Scope 1, 2 and 3 from Huang et al. (2009) as a benchmark, and estimate that firms who disclose to CDP currently under-report Scope 3 emissions by 492 million tonnes of CO2-e, 60% of their total estimated Scope 3 emissions.

2 - What Online Trading and Web Search Sites Data can tell us about Demand for Remanufactured and used Products?
Marta Jakowczyk, Joao Quariguasi, Andy Gibson, Luk Van Wassenhove
In spite of the interest this topic draws from academics and practitioners alike, little is known about the demand for used and remanufactured products. This paper illustrates how secondary data can be used to fill this important gap in the literature. More specifically, we use data drawn from (i) online search traffic, (ii) product specific data collected from various other online sources and (iii) sales data for remanufactured products to test the hypotheses that overall interest and purchase intention are moderated by product-specific determinants.

3 - Purchase Intention of Spanish Consumer: Results from an Experiment about Remanufactured Laptops
Beatriz Jiménez-Parra, Sergio Rubio, Azucena Vicente-Molina
The aim of this work is analysing the behaviour of consumers of remanufactured products. To this end, we conducted an experimental simulation of a purchase situation, in which potential buyers had to decide which their preferences were, considering original and remanufactured laptops in different price scenarios. The results of this experiment can provide some useful insights regarding the consumer behaviour of remanufactured products, and contribute to the development of new researching issues in the field of the Closed-Loop Supply Chain.

4 - System Dynamic Modelling of Carbon Storage by Wood Products
Matthias Garbs, Jutta Geldermann, Martina Hesse
Wood products as a carbon storage delay the emission of carbon to the atmosphere. The material wood utilization is already increasing in Germany, but it is difficult to estimate the savings of carbon emission. Moreover it is unclear how much a reinforced utilization or an extension of the life span of wood products could increase these savings. Therefore a dynamic model based on system dynamics was been developed to estimate the development of the stored carbon in the future and to analyze different scenarios for Germany.

■ HA-09
Thursday, 8:30-10:00 - Room 121

Dealing with Uncertainty and Renewable Sources in Electricity Markets

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Luis Baringo*

1 - An Affinely Adjustable Robust Optimization Approach to the Operation of Heat and Power Systems
Marco Zugno, Juan Miguel Morales, Henrik Madsen
We consider the short-term operation of heat and power systems comprising heat production units, CHP plants as well as heat storages. This is a multi-stage optimization problem under uncertainty, as heat demand and power prices are unknown at the time of making decisions on the unit commitment and schedules. We cast the problem as a multi-stage robust optimization model where the decision is immune to deviations of the heat consumption within a budgeted uncertainty set. Optimal recourse decisions as functions of the uncertainty are approximated via linear decision rules.

2 - Evaluating the Impacts of Priority Dispatch in the European Electricity Market
Giorgia Oggioni, Frederic Murphy, Yves Smeers
This paper compares the efficiency of the Nodal Pricing and European Market Coupling organizations with and without priority of wind dispatch in the power system. The effects of these two wind policies are measured by developing models that consider cases with different wind penetration levels, existing capacities and endogenous investments, as well as assumptions on the EU-ETS. Our analysis shows that Nodal Pricing is more efficient than Market Coupling independently of the wind policy applied. Priority dispatch may cause the collapse of Market Coupling when wind penetration is very high.

3 - Short-Term Effects of Optimal Wind-Pumped Hydro Storage Energy offers in Day-ahead Electricity Markets
Agustín Alejandro Sánchez de la Nieta López, Javier Contreras, João P. S. Catalão
This paper models an optimal joint offer of wind and pumped hydro storage in a day-ahead market considering the imbalance penalty market. The problem is modeled as a stochastic mixed integer linear one, whose objective function is to maximize the expected profit of the daily operation. In this way two types of offers are analyzed: 1) optimal separate wind and pumped hydro storage offering and 2) optimal single wind-pumped hydro storage offering. A risk measure will be calculated and a case study will be solved to see the solution in terms of imbalances and profits.

4 - Strategic Offering for a Wind Power Producer: An MPEC Approach
Luis Baringo, Antonio J. Conejo
Wind power producers have grown in some jurisdictions to clearly dominant positions in the market. Under this context, we propose a mathematical program with equilibrium constraints (MPEC) approach for the offering strategy of a wind power producer that participates in the day-ahead market, where it behaves as a price-maker, and in the balancing market, where it buys/sells its production deviations. Uncertainties pertaining to wind power production and balancing market prices are represented through a set of scenarios. The model is efficiently solved using available optimization software.

■ HA-10
Thursday, 8:30-10:00 - Room 122

DEA Theory I

Stream: Theoretical Developments in DEA
Invited session
Chair: *Dimitris Despotis*

1 - Solving Small LPs to Determine Productive Efficiencies of Big Data
Wen-Chih Chen
This work presents a computation strategy to determine productive efficiency by solving small-size LP problems. The proposed strategy can "control" the size of problems, e.g., no larger than 100 data points each time, while it maintains the solution quality. The proposed strategy can compute different measures, including radial and non-radial, and different models based on different returns to scale assumptions. The empirical results show that the proposed strategy can converge within a reasonable number of iterations.

2 - Resource Allocation Based on the Global Efficiency and Pure Technical Efficiency
Meng Zhang, Jinchuan Cui
Data envelopment analysis has been successfully used in resource allocation problems. However, there are no allocation models that consider both the global and technical efficiency. Hence, our model aims at maximizing the overall global efficiency of a DMU (Decision Making Units) set while maintaining each DMU's pure technical efficiency. To this purpose, we first discuss the optimal resources required by each DMU. We prove that the DMU with the optimal resources is actually a MPSS (Most Productive Scale Size). Based on this, the allocation model is proposed and illustrated to be effective.

3 - Applied Cost Allocation: The DEA-Aumann-Shapley Approach
Aleksandrs Smilgins, Jens Leth Hougaard, Jens Leth Hougaard

In this paper we use the Aumann-Shapley rule to allocate costs of joint production. Empirical application is often hampered by the two facts: estimation of the cost function and production at non-efficient production costs. We solve the first problem by using convex envelopment of data points. For the second problem we suggest to allocate the inefficiency in proportion to Aumann-Shapley prices. Finally, we show how to overcome problems of infinite Aumann-Shapley prices, which may occur at some specific points of the cost function.

4 - A Study on Two-Stage Network DEA Models with Some Improvements
Gregory Koronakos, Dimitris Despotis

In this paper we provide a critical review of the two-stage network DEA models proposed for the efficiency assessment of serial production processes by spotting a number of drawbacks. We focus on processes that assume external inputs entering exclusively the second stage beyond the intermediate measures. Then we provide adequate modifications that remove the observed deficiencies. We illustrate our models with numerical examples.

■ HA-11

Thursday, 8:30-10:00 - Room 113

Combinatorial Optimization: Applications

Stream: Combinatorial Optimization
Invited session
Chair: *Jan van Vuuren*

1 - The Application of the Economic Order Quantity and Osmosis Methodologies to Self-Organising Traffic Control
Mark Einhorn, Jan van Vuuren, Alewyn Burger

If one considers the green time afforded to an approach of a signalised intersection as a commodity, then it is possible to apply the theory of the Economic Order Quantity model to determine the optimal amount of green time to be "ordered" by each approach as well as when it should be ordered. A second traffic control strategy presented here is inspired by the process of osmosis whereby the intersection acts as a permeable membrane, and the movement of vehicles through the intersection depends on the "osmotic potential" on either side of the intersection.

2 - A Multi-Objective Approach towards Terrain-Dependent Facility Location
Andries Heyns, Jan van Vuuren

The placement of facilities such as radars, watchtowers and solar farms requires careful planning and is done according to very specific facility and terrain-related requirements such as (inter)visibility and solar exposure. When placed in a networked environment (which may include different facility types), multiple terrain-dependent and environmental objectives and additional constraints magnify the model complexity due to the conflicting nature of the objectives. The problem is solved within a generic framework that includes geographical processing and metaheuristic procedures.

3 - Comparing a Nondominated and a Scalarising Solution Approach for a Nonlinear Combinatorial Multiobjective Optimization Problem given a Limited Budget
Evert B. Schlünz, Pavel M. Bokov, Jan van Vuuren

The in-core fuel management optimisation problem refers to a problem of designing fuel assemblies loads for a nuclear reactor core. This problem is typically multiobjective, nonlinear and combinatorial in nature. A limited computational budget is available for optimisation due to expensive function evaluations performed by a reactor core calculation system. We compare a nondominated and a scalarising solution approach, given this limited budget, using the cross-entropy method for optimisation. The motivation behind the approach is discussed, along with our results.

4 - On a Scheduling Problem with Sequence-Dependent Setup Times
Jan van Vuuren, Alewyn Burger

In this talk we consider a scheduling problem in which the setup times for jobs depend on the sequence in which the jobs are performed. We show that the problem can be modelled as the well-known tool switching problem, which is tractable for small instances only. The problem can, however, also be solved rather effectively in heuristic fashion by decomposing it into two subproblems: a job grouping problem (which can be modelled as a unicost set covering problem) and a group sequencing problem (which is a generalisation of the celebrated travelling salesman problem).

■ HA-12

Thursday, 8:30-10:00 - Room 004

Project Scheduling: Applications and Generalizations

Stream: Project Management and Scheduling
Invited session
Chair:
Chair: *Jean-Charles Billaut*

1 - Strategic Construction Planning of Underground Gas and Oil Storages with the Flexible Resource-Constrained Multi Project Scheduling Problem
Torben Schramme, Leena Suhl

The resource-constrained project scheduling problem (RCPSP) with multiple projects and flexible resources was used to model a long-term planning problem for building underground gas and oil storages. We will show how that practical problem was mapped to that extended RCPSP with the start times and durations of activities and the resource allocation per time period as decision variables. A genetic algorithm for solving that model under multiple objectives will be outlined. The talk will be concluded with computational results and an outlook about the general applicability of that method.

2 - Solution Approaches for a Close to Real-World Variable Profile Task Scheduling Problem
Roland Braune, Karl Doerner

We consider a special type of resource constrained project scheduling problem arising from a real world scenario as found in a chemical research laboratory. Resource allocation of a task may vary over time within a predefined range and thus implies non-constant execution duration. Multiple parallel resources are available for processing and the tasks are subject to out-tree precedence constraints with min / max time lags. Given a custom objective function, we propose both a MIP formulation and an advanced list scheduling heuristic for the problem at hand and perform an experimental comparison.

3 - GRASP based Algorithms for Dynamic Job-Shop Scheduling with Sequence-Dependent Setup Times
Fatma Selen Madenoğlu, Adil Baykasoğlu, Alper Hamzadayi

In this study, we consider DJSSP with release dates, due dates, sequence-dependent setup times under machine failure, new job arrival by making use of GRASP. To the best of our knowledge this is the first attempt to use GRASP for the DJSSPs. In GRASP based scheduling procedure, we constructed active schedules by making use of G&T algorithm along with dispatching rules. SA algorithm and a greedy search mechanism are used as local search procedures within GRASP. The results have proven that GRASP based dynamic scheduling algorithm is an effective mechanism and able to handle dynamic scheduling.

4 - A Complete View of the Scheduling Problem of Chemotherapy Production with Expensive and Perishable Raw Materials
Jean-Charles Billaut, Thibault Drevon, Jean-François Tournamille

The production of injectable chemotherapy preparations (requiring expensive and perishable cytotoxic drugs) is presented in details. Objective functions are of two types: one related to tardiness of production and one related to waste of drugs. A greedy heuristic is proposed (figuring the schedule performed by the production center) and a Tabu search. This study is based on a real production context, tested with realist data sets. Results show that the use of the Tabu leads to a significant improvement, with non-negligible impact, both from the patient and from an economic points of view.

■ HA-13

Thursday, 8:30-10:00 - Room 123

Handling Uncertainty in Scheduling and Lot-Sizing 2

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*
Chair: *Mikhail Y. Kovalyov*

1 - Handling Uncertain Demands in the Dynamic Dial-a-Ride Problem
Samuel Deleplanque, Alain Quilliot

The vehicle schedulings in the on demand transportation are made by solving the Dial-a-Ride problem (DARP). This type of problem needs a solution in a very short time once it is adapted to the dynamic context. We refine an insertion algorithm solving the dynamic DARP. It is based on constraint propagation which handles all the time constraints: time windows, the maximum ride and route times. We focus on an Insertability value which takes into account the impact of one insertion on the future ones. We use it on the uncertain demands to allow the possibility for these demands to be inserted.

2 - Analysis of the Role of Price Negotiations and Uncertainty in the Optimization of Coordinated Supply Chains
Kefah Hjaila, Miguel Zamarripa, Antonio Espuña

This work aims to coordinate customers and suppliers SCs, and to apply a Multi-Objective optimization approach to the resulting network considering the uncertain behavior of suppliers and markets (now: internals) associated with their characteristics and policies (pricing, efficiency, internal costs, internal recipes). Pricing and resources availability negotiations will be held to avoid any disruptions in the internal suppliers caused by the uncertain behavior of the internal markets. Acknowledgements: AGAUR FI DGR-2012 and DPI2012-37154-C02-01

3 - A Risk-based Approach to Robust Scheduling of a Single Machine
Marcello Urgo, József Váncza

Robustness in scheduling addresses the capability to devise a schedule with a given level of insensitiveness with respect to the disruptive effects of unexpected events. Facing the uncertainty entails the need of optimizing a mean performance but also being prepared to the rare occurrence of very unfavourable events causing heavy losses. We present a branch-and-bound approach to solve a single machine scheduling problem aiming at optimizing a risk measure related to the distribution of the maximum tardiness. The proposed approach is applied to an industrial case in the machining tools sector.

4 - Solving the FMS Uncertainty by Deadlock Prevention with a Critical Siphon Theory
Johannes Chiang

The main tasks of a FMS include process routing, selection of an operation sequence, etc.. For effective FMS operations, the use of resources among various competing jobs must be carefully controlled. Deadlocks, which are undesirable in a FMS, may occur during its operation, i.e., under uncertainty. For general S3PGR2 is no longer valid, mixed-integer programming (MIP) has to be modified to determine the net is live. The paper develops a Critical Siphon theory and proposes a revised MIP to fix the uncertainty that arose with deadlock.

■ HA-14

Thursday, 8:30-10:00 - Room 124

Advances in Nonlinear Optimization: Theory and Applications I

Stream: Nonlinear Programming
Invited session
Chair: *Goran Lesaja*

1 - Second-Order Methods for Sparse Signal Reconstruction
Kimon Fountoulakis, Jacek Gondzio

In this talk we will discuss efficient second order methods for a family of l1-regularized problems from the field sparse signal reconstruction. The problems include total-variation, l1-analysis and the combinations of those two. Although first-order methods have dominated these fields, we will argue that specialized second order methods offer a viable alternative. We will provide theoretical analysis and computational evidence to illustrate our findings.

2 - An Optimization Approach to Model Selection for Support Vector Regression
Andreas Fischer, Gerd Langensiepen, Nico Strasdat, Klaus Luig, Thorsten Thies

For a good regression quality of Support Vector Regression (SVR) models it is necessary to optimize a set of model parameters. To this end, a bilevel program can be defined, where the upper level minimizes an error on a subset of training samples and the lower level is the SVR model based on the remaining training samples. However, such bilevel problems can become large and are often treated by means of a certain grid search over the model parameters. We suggest an optimization approach leading to tractable problems even for more than 2 parameters. Moreover, performance results are presented.

3 - Improved Full Newton-Step Interior-Point Methods for LO and LCP
Goran Lesaja, Kees Roos

An improved version of an infeasible full Newton-step interior-point method for linear optimization is considered. In the earlier version, each iteration consisted of one infeasibility step and a few centering steps while in this version each iteration consists of only an infeasibility step. This improvement has been achieved by a much tighter estimate of the proximity measure after a feasibility step. However, the best iteration bounds known for these types methods are still achieved. Next, generalizations of the improved method to linear complementarity problems are considered.

4 - Mixed-Integer Bilevel Programming with Upper-Level Decision Variables that Appear at the Lower-Level Objective but Not in Any of the Lower-Level Constraints
George Kozanidis, Eftychia Kostarelou

We consider a class of mixed-integer bilevel programs whose upper-level decision variables appear at the objective of the lower-level problem, but not in any of its constraints. We present a novel methodology for generating valid inequalities to suitable relaxations of these problems, in which the so-called bilevel feasibility of the obtained solution is not guaranteed. We develop an exact cutting plane solution algorithm that utilizes these valid inequalities, and we conclude with experimental results demonstrating its computational capabilities under alternative problem formulations.

■ HA-15

Thursday, 8:30-10:00 - Room 125

Revenue Management Application and Theory

Stream: Revenue Management II
Invited session
Chair: *Darius Walczak*

1 - Challenges in RM & Pricing Optimization of Product-Resource Networks
Darius Walczak

We review optimization challenges in product-resource networks found in revenue management and pricing applications. Average network consists of thousands of products where each product consumes a finite number of resources, and the objective is to select one of several price points for each product so that expected revenue is maximized. Due to dimensionality and stochasticity in the problem, real-life software has to rely on near-optimal controls. We present some of these approaches. We also revisit calculating other business metrics, such as expected demand, for a given solution.

2 - Shaping Demand to Match Anticipated Supply
Anant Balakrishnan, Sifeng Lin, Yusen Xia

Firms can exploit their information on inbound supplies to better match demand with anticipated supply through dynamic pricing. We develop an economic model to address short-run demand shaping decisions for vertically differentiated products, i.e., to determine the prices for high and low quality products in each period so as to dynamically segment the market and maximize profits. We identify properties of the optimal price and sales trajectories, and assess the benefit of dynamic pricing versus myopic or sequential pricing approaches.

3 - An Efficient Pricing Method to Determine the Network Value of Influentials in Social Networks
Evren Guney, Volkan Çakır, Irem Düzdar, Abdullah Ozdemir

Companies use social networks to benefit from word-of-mouth marketing by influentials. Most of the previous studies focus on how to maximize the number of individuals reached starting from an initial set of influentials. However, many companies are focused on the total revenue. Hence, a modified objective function that maximizes total revenue, instead of the number of individuals, is proposed. An efficient pricing method to determine the network value of customers is developed and influence maximization is studied from the aspect of revenue maximization and tested on certain real-life data.

4 - A Model for Competition in Network Revenue Management
Nishant Mishra

We study a model of competition in network revenue management where multiple risk-averse players compete to satisfy uncertain consumer demand. For a linear inverse demand function, and for a symmetric game, we can come-up with closed form expressions for equilibrium quantities and prices, and we also establish some monotonicity properties. We then numerically study asymmetric competition to generate further insights. For instance, we find that asymmetry with respect to risk aversion has the same effect as higher demand uncertainty for the more risk averse competitor.

■ HA-16

Thursday, 8:30-10:00 - Room 127

Categorical Data Analysis and Preference Aggregation

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Michael Doumpos*

1 - Partial Orders Combining for the Object Ranking Problem
Mikhail Kuznetsov, Vadim Strijov

We propose a new method for the ordinal-scaled object ranking problem. The method is based on the combining of partial orders corresponding to the ordinal features. Every partial order is described with a positive cone in the object space. We construct the solution of the object ranking problem as the projection to a superposition of the cones. To restrict model complexity and prevent overfitting we reduce dimension of the superposition and select most informative features. The proposed method is illustrated with the problem of the IUCN Red List monotonic categorization.

2 - An Interactive Approach for Multicriteria Selection Problem
Anil Kaya, Ozgur Ozpeynirci, Selin Ozpeynirci

In this study, we work on multiple criteria selection problem. We assume a quasiconcave utility function that represents the preferences of the decision maker (DM). We generate convex cones based on the pairwise comparisons of DM. Then, we build a mathematical model to determine the minimum number of pairwise comparisons required to eliminate all alternatives but the best one. Using the properties of the optimal cones and the pairwise comparisons, we develop an interactive algorithm. We conduct computational experiments on randomly generated instances.

3 - Data-Driven Robustness Analysis for MCDA Preference Disaggregation Approaches
Michael Doumpos, Constantin Zopounidis

Preference disaggregation (PD) is involved with inferring multicriteria decision models from decision examples. The robustness of models and recommendations obtained through PD methods, has attracted much interest. Previous research has mostly focused on uncertainties related to preferential parameters of decision models. In the context of PD, however, the data used to infer the model also affect the robustness of the results. In this presentation we discuss this issue and present ways to enhance existing robust MCDA techniques in a data-driven context.

4 - Linking Voice of Industry (Recruiters) with B-Schools' Service Operations using Q Sort Technique through Quality Function Deployment
Jitendra Sharma, Tinu Agrawal

Customer needs are the most important input for designing of any product or service in today's scenario. In this context, B-Schools have to be one-step ahead of the industries' expectations and meeting these expectations requires the expectations be understood. In this paper, authors have attempted to link Voice of Industry-Recruiters to business education process using Q-Sort technique in QFD for complete industry satisfaction. The paper discusses the collection of industries' voice and their development into structured, evaluated and quantified requirements through Q-sort technique.

■ HA-17

Thursday, 8:30-10:00 - Room 005

Second-Order Conic Optimization

Stream: Interior Point Methods and Conic Optimization
Invited session
Chair: *Jacek Gondzio*

1 - Mixed-Integer Second-Order Conic Optimization (MISOCO): Disjunctive Conic Cuts and Portfolio Models
Tamás Terlaky

The use of integer variables naturally occurs in Second Order Conic Optimization problems, just as in linear and nonlinear optimization. Thus, the need for dedicated MISOCO algorithms and software is evident. This talk gives some insight into the design of Disjunctive Conic Cuts (DCCs) for mixed-integer CLO problems, and into the complexity of identifying disjunctive conic cuts. The novel DCCs may be used to develop Branch-and-Cut algorithms for MISOCO problems. Preliminary computational experiments by solving classes of MISOCO Portfolio Selection problems show the power of the DCC approach.

2 - Interior-Point Methods within Algorithms for Mixed-Integer Second-Order Cone Programming
Hande Benson

Second-order cone programming problems (SOCPs) have been well-studied in literature, and computationally efficient implementations of solution algorithms exist. In this talk, we study an extension: mixed-integer second-order cone programming problems (MISOCPs). Our focus is on designing an algorithm for solving the underlying SOCPs as smooth, convex NLPs, while using primal-dual regularization to introduce warmstarting and infeasibility detection capabilities. We present numerical results obtained using the Matlab-based optimization package, MILANO.

3 - On the Convergence Properties of the Central Path for Second-Order Cone Optimization
Zhouhong Wang, Tamás Terlaky

In this talk, we will discuss the limiting behaviors of the central path when the barrier parameter goes to zero for Second-Order Cone Optimization (SOCO) based upon the optimal partition proposed by Bonnans and Ramirez (2005). First we will show that the optimal partition for SOCO can be identified along the central path when the barrier parameter is small enough. Then some numerical examples are presented to illustrate the convergence order of the central path of SOCO.

4 - The Second-Order Cone Programming Solver in the Fico-Xpress Optimization Suite
Csaba Mészáros

In the talk we describe the design of the barrier solver in the Fico-Xpress Optimization Suite. The new feature of the optimization engine implements a primal-dual interior point algorithm to solve large-scale second-order cone programming problems. We outline the details of the implemented algorithm and discuss topics related to the sparsity and numerical features. We also outline the modeling tools that assist the users to use the new solver feature.

■ HA-18

Thursday, 8:30-10:00 - Room 112

Nonconvex Multiobjective Optimization II

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Panos Pardalos*
Chair: *Julius Zilinskas*

1 - Solving a Tri-Objective Location Problem via Evolutionary Algorithms
Pilar M. Ortigosa, Jose Fernandez, Aranzazu Gila Arrondo, Juana López Redondo

In this work, the problem of locating a single semi-desirable facility in the plane is considered. Three objectives are taken into consideration for the first time in literature. Two recent general-purpose multi-objective evolutionary algorithms, MOEA/D and FEMOEA, are suggested to obtain a discrete approximation of its Pareto-front. A computational study shows that both algorithms are suitable to cope with the problem, although FEMOEA seems to obtain slightly better results, especially for larger instances.

2 - Solution of Bi-Objective Discrete Competitve Facility Location Problems
Algirdas Lančinskas, Pascual Fernandez, Blas Pelegrin, Julius Zilinskas

We deal with solutions of the bi-objective discrete Competitive Facility Location Problem (CFLP) which is aimed at selection of locations for a set of new facilities subject to (i) the maximization of their market share, and (ii) the influence to the facilities already in the market. We present a heuristic algorithm, based on ranking of given candidate locations, suitable for efficient approximation of the Pareto front of the problem. We discuss the performance of the algorithm, evaluated by solving different instances of the problem with different models of customers' behavior.

3 - Visualization of Pareto Sets in Multi-Objective Optimization Problems
Audrius Varoneckas, Antanas Zilinskas

Visualization of Pareto sets is of especial importance for the integration of multi-objective optimization methods into interactive optimization and optimal design systems. Recently several papers have been published on visualization of Pareto sets in objective space. We focus on visualization of Pareto sets in the space of decisions. A method is developed to visualize a set of efficient points, e.g. which are found by an investigated algorithm, as points in the two-dimensional space. The proposed method is based on ideas of multidimensional scaling.

4 - A New Visualization Technique for Enhancing Interactive Methods of Multiobjective Optimization
Ernestas Filatovas, Olga Kurasova, Dmitry Podkopaev

Interactive methods repetitively derive Pareto optimal solutions based on Decision Maker's (DM's) feedback. The accumulation of obtained solutions increases DM's cognitive load. We propose to enhance interactive methods with a graphical tool which visualizes solution outcomes using dimensionality reduction. Our technique presents an intuitive map of the solution set and provides new interaction mechanisms improving the capabilities of the DM to analyse the solution set and navigate through it. We demonstrate our technique integrated it into an interactive method of multiobjective optimization.

■ HA-19

Thursday, 8:30-10:00 - Room 128

Advances on Demand and Supply Planning in Consumer Goods and Retailing

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Heinrich Kuhn*
Chair: *Winfried Steiner*
Chair: *Michael Katehakis*

1 - Pricing and Rebate Strategy in Retail Platforms with Revenue Sharing
Hongyan Li, Shiming Deng

Given the intensive competition in retailing industries, all kinds of promotion are almost constantly running in various retailing platforms such as department stores and online retailers etc. However, given the complex operational context of large retailing platforms, many questions regarding promotion management remain unsolved. In this study, we address a pricing and rebate optimization problem in a retail platform which consists of multiple suppliers. The analytic results show the incentives of the system players. The optimal rebate strategies of the retail system is addressed in details.

2 - Cyclic Joint Replenishment with Total Volume Discounts
Guoqing Wang

We study the multiple item joint replenishment problem in which all items are ordered in cyclic manners and discounts dependent on the total order volume are involved. We develop a heuristic to deal with the problem and provide computational results.

3 - A Tractable Inventory Model with Random Lead Times
Michael Katehakis, Laurens Smit, Flora Speksma, Dwi Ertiningsih

We present a model for computing the stationary distribution of the on-hand inventory in a continuous review system with Poisson demand and Phase Type distributed lead time. We consider several additional scenarios such as lost sales and unreliable suppliers. It is shown that these models are successively lumpable. This leads to explicit analytical expressions for expected cost computations and minimization.

4 - Collaborative Supply Chains: A Case Study
Nicolas Danloup, Hamid Allaoui, Gilles Goncalves

Collaborative supply chains have become an important element for recent years for many companies to improve their supply chain efficiency. Moreover, to be competitive in industrial world, the implementation of collaborative supply chain should give positive effect that can be related to sustainable development. We first present several models of collaboration. Then we present a case study about the collaboration between several British retailers and some initial results.

■ HA-20

Thursday, 8:30-10:00 - Room 129

Demand Response and Smart Grid Infrastructure

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Vineet Goyal*

1 - Pricing Mechanisms for Control
Desmond Cai, Adam Wierman

We propose a mechanism for a principal to purchase the right to control the amount of consumption by a group of agents. Such a mechanism could be applicable when the principal is more efficient at managing the consumption of the agents than the agents themselves. We provide socially optimal and incentive compatible pricing schemes for the principal. Our scheme has applications in demand-side management, where a utility company could manage the power consumption of its end-use customers in conjunction with wholesale prices, to reduce overall energy costs of its end-use customers.

2 - Smart Homes with Price-Responsive Thermostats
Daniel Adelman, Canan Uckun

We develop a framework for a smart home's thermostat to respond optimally to dynamic electricity price signals, and for assessing the resulting market price equilibrium in a large service region. We develop two mathematical models for smart price-responsive thermostats: a "price-only" model which is not aware of home occupancy, and an "occupant-aware" model. We present extensive numerical results on ComEd's residential customers' prospective responses to dynamic prices through air conditioners during a hot summer month, both in isolation and in equilibrium.

3 - Stochastic Optimization and Risk Management for an Efficient Planning of Buildings' Energy Systems
Emilio L. Cano, Javier M. Moguerza, Antonio Alonso-Ayuso

Energy systems planning is becoming a big challenge for decision makers at the building level. In addition to inherent systems complexity, several types of uncertainties arise. Through the appropriate energy systems modeling, Decision Support Systems (DSS) based on stochastic optimization models aid to reach optimal strategic decisions. In this work, a Risk Management strategy is presented combining conflictive objectives, such as minimization of cost or emissions, with the minimization of risk, applying the Conditional Value at Risk (CVaR) approach beyond the classical portfolio scope.

4 - Optimal Price Rebates for Demand Response under Power Flow Constraints
Vineet Goyal, Garud Iyengar, Quique Schwarz, Shuangyu Wang

Demand side participation is essential for a real-time energy balance in today's electricity markets. We consider a price rebate approach for demand response where the electric utility company offers price rebates to consumers to reduce load. We study the problem of computing price rebates under AC power flow constraints that allows us to model savings from the transmission losses. This is a non-convex optimization problem and we present a SDP based iterative heuristic. Our computational study shows that the AC power flow based heuristic is significantly better than other approaches.

■ HA-21

Thursday, 8:30-10:00 - Room 006

Cutting and Packing 1

Stream: Cutting and Packing
Invited session
Chair: *Antonio Martinez Sykora*

1 - Two-Dimensional Bin Packing Problems with Irregularly-Shaped Pieces: Constructive Algorithms
Ramon Alvarez-Valdes, Julia Bennell, Antonio Martinez Sykora, Jose Tamarit

We deal with a 2-Dimensional Bin Packing Problem (2DBPP) in which bins are rectangular but the pieces to be cut from them have irregular shapes. The problem arises in many practical situations, in the steel, glass, or textile industries. We propose constructive algorithms consisting of two phases. In a first phase, a subset of the pieces still to be cut is assigned to a new bin. Then, in a second phase, the pieces of this subset are placed into the bin, one at a time, without overlapping. The computational experiments show that these constructive procedures obtain high quality results

2 - A Constructive Heuristic for the Three-Dimensional Bin Packing Problem with Transportation Constraints
Célia Paquay, Michaël Schyns, Sabine Limbourg

The aim of this work is to propose a Relax-And-Fix heuristic to build a good initial solution to the 3D BPP. First, a mathematical formulation has been developed taking into account several types of constraints such as the stability and fragility of the boxes to pack, their possibility to rotate, the weight distribution inside the bins and their special shapes. Since this model contains a lot of integer variables, we have decided to apply the Relax-and-Fix method. We have selected several sets of variables to be the branching variables and carried out some tests.

3 - An Algorithm for a Container Loading Problem with Static Mechanical Equilibrium Conditions
António Ramos, José Fernando Oliveira, José Fernando Gonçalves, Manuel Lopes

The container loading problem is a real-world driven, combinatorial optimization problem that addresses the optimization of the spatial arrangement of cargo inside containers for maximizing the containers space utilization. We propose an algorithm that combines a parallel multi-population biased random-key genetic algorithm and a constructive heuristic algorithm responsible for decoding the chromosome, generate a solution and evaluate its fitness considering a static stability approach based on the static mechanical equilibrium conditions applied to rigid bodies.

4 - A MIP-Based Dual Bounding Technique for the Irregular Nesting Problem
Ryan J. O'Neil, Karla Hoffman

Optimal placement of irregular shapes with no overlap in a minimized bounding box is a common manufacturing problem. Exact techniques solve this problem using Integer Programs built from geometric data of the shape pairs. These models use constraints based on the No-Fit Polygon to eliminate overlap, but convergence time can be excessive, due to loose primal-dual bounds. We present a new technique to compute dual bounds by allowing small amounts of overlap. This uses fewer binary variables than NFP-based models and can be used iteratively to find optimal layouts.

■ HA-22

Thursday, 8:30-10:00 - Room 007

Competitive and Cooperative Games

Stream: Game Theory and Operations Management
Contributed session
Chair: *Greys Sosic*

1 - The Role of Operations in New Product Development Alliances
Niyazi Taneri, Arnoud De Meyer

In this paper we show that operational constraints coupled with resource allocation decisions have an impact on which of two possible games two potential partners will prefer to play when engaging in product development efforts. We test and find support for the predictions of the models with data from the pharmaceutical industry.

2 - Openshop Sequencing Games
Pedro Calleja

An openshop scheduling problem consists of n jobs (players), each of them formed by m operations that have to be processed by m different machines. By assuming that there is an initial schedule on all machines we associate to any openshop scheduling problem a TU game. An openshop sequencing game assigns to every coalition the maximal cost savings the coalition can obtain by means of admissible rearrangements. We study the class of unit time openshop sequencing games, and we show that this class of games is balanced by providing a particular core allocation.

3 - Solution Concepts in Influence Games
Fabián Riquelme, Xavier Molinero, Maria Serna

We consider influence games, a cooperative simple game based on the linear-threshold model of influence spread. In these games, a team of agents or players forms a winning coalition if it is able to convince enough agents to participate in a task. We study the complexity of computing several solution concepts in such class of simple games, among other ones, Banzhaf and Shapley-Shubik power indices, core, least-core, kernel, nucleolus. This work was partially supported by 2009SGR1137, MTM2012—34426, BecasChile (CONICYT), and TIN2007—66523.

■ HA-23

Thursday, 8:30-10:00 - Room 008

Applying Analytics to Big Data for Driving Big Outcomes

Stream: Analytics Application and Practice
Invited session
Chair: *Arnab Chakraborty*

1 - Multi-Channel Customer: Predicting the Next Best Action with our Customers
Athina Kanioura

This topic delves into the realm of applying advanced analytics and Big data for driving real time personalized customer interactions across multiple touch points that improves customer intimacy, loyalty and profitability.

2 - Rise of Intelligent Machines: Applying Analytics on Machine to Machine Data (M2M) for Making Better Decision
Arnab Chakraborty, Jai Advani

This topic will touch upon the application of analytics on machine generated Big Data to drive innovative solutions and impactful outcomes.

3 - Solving Large-Scale Marketing Campaign Problems
Sebastien Lannez, Susanne Heipcke, Shalini Raghavan

This paper presents how FICO Xpress Optimization Suite has been used to develop an optimization engine capable of solving large-scale marketing campaign problems using a distributed, cloud-based solution that explores millions of decision alternatives. The presented system is FICO Analytic Offer Manager, AOM, a management system that lets marketing campaign managers design, optimize and follow up on the impact of his campaigns.

4 - An integrated QFD framework linking quality management with marketing efforts
Konstantina Kamvysi, Katerina Gotzamani, Andreas Andronikidis, Andreas Georgiou

The purpose of this paper is to provide a methodological framework that integrates quality management and marketing efforts towards customer satisfaction. Specifically, this paper discusses the development of a three-phased QFD process for planning strategic marketing activities by aligning customer requirements with the banks' positioning strategy and marketing mix tactics. Moreover, the utilization of QFD in conjunction with LP-GW-Fuzzy-AHP fosters the capturing and prioritization of customers' subjective judgments.

■ HA-24

Thursday, 8:30-10:00 - Room 212

Dynamics and Learning in Games

Stream: Dynamic and Repeated Games
Invited session
Chair: *Panayotis Mertikopoulos*

1 - Two-Timescales Game-Theoretical Learning with Continuous Action Spaces
David Leslie

In this talk, I will present a framework for learning in games with continuous actions sets, and introduce the necessary stochastic approximation theory with which such processes can be analysed. I will then demonstrate how this theory can be extended to a two-timescales system in which the values of actions can be estimated, and strategies adapted, without any player actually observing the actions or rewards of any other. This results in a system where 'individual learners' can converge successfully to Nash equilibrium, in zero-sum games and potential games.

2 - Inertial Game Dynamics and Applications to Constrained Optimization
Rida Laraki

We derive a class of inertial game dynamics by building on the well-known "heavy ball with friction" optimization method. The dynamics are generated by endowing the game's strategy space with a Hessian—Riemannian structure and then deriving the equations of motion for a particle moving under the influence of the problem's objective. By specifying an explicit Nash embedding of the simplex, we study the well-posedness of the dynamics and establish an inertial variant of the folk theorem of evolutionary game theory, showing that strict Nash equilibria attract all nearby strategy profiles.

3 - Large Deviations and Stochastic Stability in Games
Mathias Staudigl

Stochastic stability theory in games is concerned with understanding the long-run behavior of learning dynamics in games under small perturbations. Various notions of stochastic stability have been introduced in the literature. In this talk I present a new and general analysis for stochastic stability in the small noise and the large population limit. Our approach combines ideas from large deviations and optimal control theory to give a unified and robust definition of stochastic stability in games with large player sets and general noisy best-response dynamics.

4 - A Continuous-Time Approach to Online Optimization
Panayotis Mertikopoulos

We consider a family of learning strategies for online optimization in continuous time and we show that they lead to no regret in this context. This approach allows us to derive the no-regret properties of a large class of discrete-time algorithms including as special cases the exponential weight algorithm, online mirror descent and (vanishingly) smooth fictitious play. In so doing, we obtain a unified view of many classical regret bounds, and we show that they can be decomposed into a continuous-time regret bound and a term which measures the difference between discrete and continuous time.

■ HA-25

Thursday, 8:30-10:00 - Room 009

Structuring Big Data

Stream: Data Mining
Invited session
Chair: *Peter Gritzmann*

1 - Sampling-Based Johnson-Lindenstrauss Embeddings
Felix Krahmer, Dustin Mixon

A typical quality measure of randomized Johnson-Lindenstrauss (JL) embeddings is that for arbitrary point clouds, the mutual distances are approximately preserved with high probability. In this talk, we consider the scenario that only a part of the point cloud to be projected is arbitrary and unknown and most points are known before hand. For this setup, it is particularly useful to consider JL embeddings that arise by randomly sampling from a not too large set of possible rows. Our result has applications in fast approximate matrix multiplication.

2 - String Kernels for Financial Time Series Prediction
Blaz Zlicar, Simon Cousins

In this paper we present a novel application of string kernels: that is the problem of financial time series prediction. Financial time series are renowned for being extremely noisy. To overcome this we map the recent price trajectories and trading volumes of an instrument to a behaviour alphabet and use this alphabet to create strings representative of the underlying market conditions. We show that the string representation of market conditions, coupled with the kernels ability to generalise across non-contiguous substrings, can remove some of this noise and deliver performance improvements.

3 - On Data Segmentation and its Applications
Peter Gritzmann, Andreas Brieden

We present a new algorithm for segmenting data and show some of its recent benchmark and real world applications. Our method produces strongly feasible power diagrams, certain specific cell complexes, whose defining polyhedra contain the clusters, respectively. Also we show that it can be performed efficiently. We close the talk by indicating applications to various questions of predictive analytics including risk prediction. (Joint work with Andreas Brieden, and, in part, with Steffen Borgwardt)

4 - Predictive Analytics by Means of Constrained Clustering
Andreas Brieden, Peter Gritzmann, Michael Öllinger

In many different applications the precise prediction of a target value based on a large amount of historical data is of crucial importance. One natural approach is to determine homogenous subsets of data and, given some cardinality constraints, to do the prediction by using the law of large numbers for each of the subsets. Of course, the method can be finetuned by applying more sophisticated stochastical methods instead of the latter. This talk reports on several applications where this approach outperforms well-known benchmarks. (Joint work with Peter Gritzmann & Michael Öllinger)

■ HA-26

Thursday, 8:30-10:00 - Room 010

Nondifferentiable Optimization: Theory, Algorithms and Applications I

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Manlio Gaudioso*

1 - Multiple Subgradient Descent Bundle Method for Nonsmooth Multiobjective Optimization
Outi Wilppu, Napsu Karmitsa, Marko M. Mäkelä

Many of the existing methods for multiobjective optimization use scalarization instead of treating the objectives as they are. I will present a new descent method, called Multiple subgradient descent bundle method (MSGDB), where scalarization is not utilized. The MSGDB method generalizes the well-known steepest descent method for unconstrained nonsmooth multiobjective optimization problems combining the ideas of the multiple-gradient descent algorithm and the proximal bundle idea. In this presentation, the idea of the MSGDB method will be described and some numerical results are considered.

2 - Iterative Schemes to Solve Nonconvex Variational Problems
Messaoud Bounkhel

In this work, we suggest and study the convergence of some new iterative schemes for solving nonconvex equilibrium problems in Hilbert and Banach spaces. Many existing results have been obtained as particular cases, especially some recent results for solving equilibrium problems involving convex sets.

3 - Generalized Cutting Plane for Convex Nonsmooth Optimization
Manlio Gaudioso

We generalize the cutting plane model for convex optimization by allowing vertical shifting of the affine pieces. We provide some heuristic rules to tune shifting parameters, and prove convergence of the method in a bundle framework.

4 - A Levenberg-Marquardt Method with Approximate Projections
Alfredo Iusem, Roger Behling, Andreas Fischer, Yinyu Ye

We present a version of the projected Levenberg-Marquardt method for solving a system of nonlinear equations with additional convex constraints where the orthogonal projections onto the feasible convex set are replaced by approximate and easily computable ones. We establish an R-linear convergence rate for the method under certain reasonable error bound conditions.

■ HA-27

Thursday, 8:30-10:00 - Room 213

Emerging Applications of Decision Support Systems

Stream: Decision Analysis, Decision Support Systems
Contributed session
Chair: *Marion Penn*

1 - Optimum Periodic Inspection Interval and Replacement Policies for a One-Shot System with Minimal Repair
Tomohiro Kitagawa, Tetsushi Yuge, Shigeru Yanagi

We analyzed maintenance and inspection polices for a one-shot system, considering the inspection interval and the limitation on the number of minimal repairs. We assume a system that consists of m units in series. The system is inspected periodically to check units and minimal repairs are carried out instantly when a unit failure is detected at the inspection. When totally n-th failure is detected, all units in the system are replaced and become "as good as new". We optimize the number of repairs until replacement and the inspection interval that minimize the cost rate.

2 - Fast Timetable Generation for Railway Capacity Planning in Norway
Leonardo Lamorgese, Carlo Mannino

In a recent project we developed a timetable generation system to assist Norway's railway capacity planning department to evaluate the effect of potential infrastructural decisions. Given a demand of trains for every line, a railway network is feasible if a conflict-free timetable exists for all trains. To this end, a fast and possibly exact method is required. The algorithm extends techniques which we have successfully applied to real-time train dispatching and follows the so called "micro-macro" approach which has recently drawn much attention in the literature.

3 - Evaluating Path-Dependencies in Networks: A Realoption Approach
André Mangelsdorf, Thomas Spengler

So far path-dependency in interfirm-networks has not been covered in literature in depth and we lack in the evaluation with realoptions in this field of interest at all. Thereby, path-dependency can alter the optimal decision sequence by narrowing available action alternatives. Especially in networks with resource specialization this phenomena may arise and thereby may influence the decision to enter a network. For the determination of change in value of a network-entrance by emerging path-dependency, a binomial-realoption model will be used for evaluation and thus giving decision support.

4 - Applying Decision Analysis to Public Policy Decisions: Case Study on Banning Neonicotiniods
Marion Penn, Lyn Thomas, Ian Rowley

Exploring the applicability of Decision Analysis to public policy decisions, via a case study on the recent banning of Neonicotiniods by the EU to avoid harm to bees. This project combines time lines, decision trees and layered influence diagrams to explore the issues considered and the decision criteria employed. Providing insight into the problem itself and the public positions presented by a variety of interested groups.

■ HA-29

Thursday, 8:30-10:00 - Room 011

OR in Mining

Stream: OR in Petrochemicals and Mining
Invited session
Chair: *Eduardo Moreno*

1 - A Network-Flow based Algorithm for Scheduling Production in Multi-Processor Open-Pit Mines Accounting for Metal Uncertainty
Amina Lamghari, Roussos Dimitrakopoulos

We consider a variant of the open-pit mine production scheduling problem, accounting for metal uncertainty and multiple destinations for the mined material. The problem is formulated as a two-stage stochastic problem with recourse, and a heuristic based on network flow techniques is developed to solve this formulation. Numerical results are provided to indicate the efficiency of the proposed solution method to generate good solutions in relatively short computational times and its superiority over recent algorithms from the literature.

2 - Using Direct Optimisation Methodologies for Deterministic and Stochastic Open Pit Production Scheduling
Eduardo Moreno, Daniel Espinoza, Marcos Goycoolea, Orlando Rivera

Given a block-model of an open cut mine, a production schedule defines which blocks should be extracted, when to extract them, and what to do with them once extracted. Recent developments have made the IP formulation of this problem computationally viable in real-sized instances. We compare the performance of the IP and the conventional nested pit (NP) approaches on 5 publicly available block models. We also present how this IP approach can be adapted to consider grade and prices uncertainties, allowing to solve two-stage stochastic problem up to near-optimality on real-sized problems.

3 - Stochastic Programming applied to Mine Planning under Geological Uncertainty with Differents Levels of Information
Gonzalo Nelis, Nelson Morales, Julian Ortiz

Production scheduling in mining involves decisions like extraction periods and destination of mine material to maximize value. However, information about the deposit is limited when these decisions are made, hence they risk being suboptimal because they are based on estimations of grades and others. It follows that considering variability in the scheduling process may lead to better decisions for the industry. In this work, we use geostatistical tools to produce geological scenarios and stochastic programming in order to evaluate their impact on schedule for different levels of information.

■ HA-30

Thursday, 8:30-10:00 - Room 012

Recent Models on Cooperative Games and Integer Programming

Stream: Allocation Problems in Game Theory
Invited session
Chair: *Osman Palancı*
Chair: *Mehmet Onur Olgun*

1 - Model for Evaluating Strategies for Overload Relief in Oversubscribed Clouds
Merve Unuvar, Salman Baset

To maximize revenue and fully utilize available capacity in a data center, the cloud providers oversubscribe physical resources such as CPU, memory, disk and network, which, if not managed carefully, can lead to overload. In this work, we are proposing a Mixed-Integer Programming (MIP) model to relieve the overload by migrating or terminating user applications on an overloaded host, while meeting the Quality of Service is guaranteed. We solve the proposed MIP model by using a relaxation induced local search algorithm and compare our results with a default ILOG MIP solver.

2 - On the Grey Shapley Value
Serap Ergun, Osman Palancı, Sirma Zeynep Alparslan Gok

The Shapley value is one of the most widespread concepts in cooperative game theory. This paper focuses on the Shapley value for cooperative games where the set of players is finite and the coalition values are interval grey numbers. The grey Shapley value is characterized with the aid of the properties of additivity, efficiency, symmetry and a dummy player, which are straightforward generalizations of the corresponding properties in the classical cooperative games.

3 - Cooperative Grey Games with Allowing for Stock Outs
Mehmet Onur Olgun, Gultekin Ozdemir

Inventory management studies to minimize the total costs per unit time and to determine the quantity of the stocked material to be ordered. A system on which the information is partly known and partly unknown is called the grey information. In this work, we extend the results of Meca et al. (2004) depending on the grey information revealed by the individual firms. We introduce cooperative grey games with allowing for stock outs, and focus on sharing ordering cost rule (SOC-rule) to distribute the joint cost.

4 - Cooperative Games and Bubbles
Osman Palancı, Sirma Zeynep Alparslan Gok, Gerhard-Wilhelm Weber

The involvement of uncertainty in cooperative game theory is motivated by the real world where noise in observation and experimental design, incomplete information and further vagueness in preference structures and decision-making play an important role. In this study, a new class of cooperative games namely the cooperative bubbly games, where the worth of each coalition is a bubble instead of a real number is presented. Further, a new solution concept the bubbly core is defined. Finally, the properties and the conditions for the non-emptiness of the bubbly core is given.

■ HA-31

Thursday, 8:30-10:00 - Room 013

Network Design

Stream: Telecommunications and Networks
Invited session
Chair: *Markus Leitner*

1 - The Capacitated Minimum Spanning Tree Problem with Non-Homogeneous Capacities
Efrain Ruiz, Maria Albareda Sambola, Elena Fernandez

In this work we present an extension of the capacitated minimum spanning tree problem (CMST) in which the capacities of the subtrees are not homogeneous. Such capacities depend on the vertices, and therefore are defined by the vertices that are selected to be directly connected to the root vertex. A formulation and a solution algorithm are proposed, and results over test instances are presented.

2 - The Node-Quadratic Prize-Collecting Steiner Tree Problem
Markus Sinnl, Markus Leitner, Ivana Ljubic

We introduce the node-quadratic prize-collecting Steiner tree problem: We are given a graph with node revenues, edge costs and interaction costs between pairs of nodes. The goal is to find a subtree, s.t., the difference between revenues and cost is maximized. The problem has applications in bioinformatics. We model the problem as quadratic program and transform it into an integer program (IP). We investigate the polytope associated with this IP to derive valid inequalities and show that some of them are facet-inducing. A computational study to complement our theoretical work is also done.

3 - A Polyhedral Study of the Diameter Constrained Minimum Spanning Tree Problem
Markus Leitner, Luís Gouveia, Ivana Ljubic

We consider the diameter constrained minimum spanning tree problem (DMSTP) on a graph. Given an edge-weighted undirected graph, the objective is to find a minimum-weight spanning tree such that the number of edges on the path between any two nodes does not exceed a given diameter D. In this work, we study integer programming models for the DMSTP in the natural space of variables, i.e., in the space of undirected edge design variables. We introduce several new classes of facet-defining inequalities that are based on so-called jump inequalities.

4 - Mathematical Programming Models for Traffic Engineering in Ethernet Networks Implementing the Multiple Spanning Tree Protocol
Martim Joyce-Moniz, Bernard Fortz, Luís Gouveia

The Multiple Spanning Tree Protocol (MTSP), used in Ethernet networks, maintains a set of spanning trees that are used for routing the demands in the network. Each spanning tree is allocated to a pre-defined set of demands. We present mixed-integer programming models for the Traffic Engineering problem of optimally designing a network implementing MTSP, such that link utilization is minimized. This is the first approach that focuses on using exact methods to solve this problem. We also propose a binary-search algorithm that efficiently produces near-optimal solutions for the problem.

■ HA-32

Thursday, 8:30-10:00 - Room 014

Supply Chain Concepts

Stream: Production Management & Supply Chain Management
Contributed session
Chair: *Jaime Palma*

1 - Sustainable Supply Chain Management: Developing a Framework through Conceptual Modelling
Norma Harrison, Tayyab Amjed

The research and implementation of environment-friendly and socially-responsible supply chain practices are minimal. This study, embedded in academic literature and industry publications, treats sustainable supply chain management as a meta-construct and develops conceptual models for sustainable planning, procurement, manufacturing, transportation and warehousing. These are grounded in stakeholder theory, the resource-based view, triple bottom line, and supply chain operations reference models.

2 - Application of Inequality between Arithmetic and Geometric Mean to Optimization of Economic Functions
Zrinka Lukac, Vedran Kojic

Differential calculus is a powerful technique commonly used to solve optimization problems in economics. However, its implementation is not always simple. In this paper the application of inequality between arithmetic and geometric mean (AGM inequality) is considered as an alternative way to optimize certain economic functions. The paper emphasizes the advantage of AGM inequality over the differential calculus technique in the calculation of stationary points and the optimal values of the observed functions.

3 - Changing Production Chain by using 3D-Printing
Maria Mavri

Production chain is the procedure of transforming raw materials into goods. Many and different steps are necessary in order to convert available resources to products such as planning, manufacturing, selling. Recently, the above procedure seems to be changed. 3D-printing restructures the steps of the production chain. Customized products, small or big markets could be served without enabling companies to warehouse or produce goods with large cost. The scope of this paper is to describe changes, which will be produced in production chain by using 3D-printing technology.

■ HA-33

Thursday, 8:30-10:00 - Room 015

Defence and Security Applications V

Stream: Defence and Security Applications
Invited session
Chair: *Ana Isabel Barros*

1 - Risk Analyses for some Vulnerability Models of Industrial Control Systems
Alla Kammerdiner

Industrial control systems are facing new security challenges. Infrastructure, industrial and facility processes are increasingly interconnected. Failures in one process may result in disruption of others. If power generation is controlled by energy consumption, the compromised data on consumption may affect generation and transmission. This work investigates how our ability to protect critical infrastructure depends on the topology of the network system and the vulnerability of the control components. New models are proposed and their risk analyses are performed via stochastic optimization.

2 - Combining Hard and Soft Evaluation of Security Risk Factors
Leandro Teixeira, Antonio Rodrigues

The configuration of surveillance resources in the waterside area of a port can be supported by risk maps. These maps result from the combination of several factors, which have to be estimated from geographic and oceanographic data as well as from expert judgments. We provide and illustrate a methodology, based on utility theory, for the elaboration of both types of estimates and for their combination.

3 - Probabilistic Influence Diagrams for Modelling Influence Operations
Ken McNaught

We consider a problem relevant to military influence operations. A high-level mission can be decomposed into lower-level objectives and tasks. A typical way of representing this is as an effects tree. While this is a useful description of the problem, a decision analytic influence diagram offers a more flexible representation. It can provide support for resource allocation decisions by allowing the analyst to model the relationship between resource commitment, together with its associated cost, and the likelihood of achieving high-level objectives, together with their associated benefits.

4 - Simulating Anti-Submarine Warfare with MANA
Willem Knippenberg, Wouter Noordkamp, Herman Monsuur, René Janssen, Raymundo Hordijk

The agent-based simulation programme MANA is a military oriented tool for exploring scenarios. This research focuses on the suitability of MANA as a simulation-tool for exploring ship-design concepts in a premature state of the development. For this end, an Anti-Submarine Warfare scenario has been modelled in MANA. The procedure of the model and the output of the simulation are both compared with a highly detailed physics-based programme. It appears that MANA is suited for quick analyses, but becomes limited when scenarios become more and more complex.

■ HA-34

Thursday, 8:30-10:00 - Room 016

Financial Modeling 1

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Dave Strugnell*

1 - On the Ruin Probabilities of a Multidimensional Risk Model
Tatjana Slijepcevic-Manger

Multidimensional models with common arrival process describe situations where each claim event produces more than one type of claim. One example is motor insurance where an accident could cause claims for different types of bodily injuries and property damages. We consider a multidimensional insurance risk model perturbed by Brownian motion. An explicit asymptotic estimate is obtained for the finite-time ruin probability in the heavy-tailed claims case.

2 - Real Option Valuation of Sequential R&D Investment
Michi Nishihara

This paper develops an investment timing model of R&D involving research duration, a growth opportunity, rival preemption, technological and market uncertainty, and debt financing. We find that with the slightest threat of preemption longer duration can delay investment. Higher uncertainty of duration speeds up investment and enhances the project value especially with the fear of preemption. Higher uncertainty of technological success increases the growth option value and accelerates investment. These findings are consistent with the empirical evidence.

3 - Decision-Making for Pre-Retirement Investment Strategy
Dave Strugnell

Decision-making over long-term investment strategy for retirement savings requires models of investor risk preferences and returns on available assets, both of which are subject to error. We argue that optimal strategies should be robust to reasonable variation in key model parameters, and present a range of stochastic models of asset class returns for the South African market. We further consider features of the risk preference model essential for consistency with empirical evidence and intuition, informing tentative conclusions regarding asset allocation strategies for retirement purposes.

4 - The Limit Order Book in a High Frequency Regime
Peter Lakner, Joshua Reed, Sasha Stoikov

We model the one-sided limit order book for sell orders as a measure-valued process. Limit orders are placed on the book according to a distribution which varies depending on the current least expensive price, and market orders remove from the book the current least expensive price. We consider the order book in a high frequency regime in which the rate of incoming limit and market orders is large and traders place their limit sell orders close to the current best price. We provide weak limit for the scaled order book process, and study the transient and long-run behavior of the limit.

■ HA-35

Thursday, 8:30-10:00 - Room 131

Analysis and Management on Risk and Security

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair: *Dimitrios Vlachos*

1 - Containerization and Performance Evaluation in Port Transport: Case of the Extra Zone Port ZEP of the BMT Company-Bejaia
Fazia Aoudia-Rahmoune, Djamil Aïssani

In the era of globalization and liberalization of international trade, developing countries have little choice to follow the trend and build capacity to cope with change and the increase in international trade. This is only possible by perfecting platforms leading receptions and sends. That is why it is essential to attach great importance to port treatment. In this work, we analyze container's movements of the ZEP after modeling, thereafter to make a simulator that allows us to evaluate its performance of the ZEP in current conditions and to provide for variations of parameters in the future.

2 - A Simulator for Distributed Algorithms
Malika Yaici

The complexity of distributed systems led to the need to evaluate them using simulation. To model a distributed system we need to determine the number of nodes, their behavior and the complex relationships between them. Because of the similarity between the concepts of agent in a multi-agent system and component in a distributed system, a distributed system has been modeled using agents. The paper is on the conception and realization of a simulator of distributed algorithms based on agents using the multi-agent platform JADE.

3 - Design of Cost Efficient, Sustainable and Secure Food Supply Chains
Dimitrios Vlachos, Christos Keramydas, Naoum Tsolakis, Eleftherios Iakovou

In this research we firstly present a quantitative analytical cost-optimization model for sourcing in perishable agri-food supply chains taking into account service level and dietary preferences. We then discuss a more generic framework for agri-food supply chain policy-making, which embraces sustainability, food nutrition, and security aspects. A System Dynamics methodology is employed that captures the effect of environmental and social regulatory interventions on cost, quality, and security along the supply chain.

4 - Mathematical Programming as a Tool for Virtual Soccer Coaches: A Case Study of a Fantasy Sports Game
Guillermo Durán, Flavia Bonomo, Javier Marenco, Javier Marenco

This presentation addresses the potential of mathematics to support sports decision making using as a test case a fantasy soccer game organized by an Argentinian newspaper. Two mathematical programming models are presented that choose a virtual team lineup for each round of the Argentinian soccer league. The a priori design creates a competitive team for the game, while the a posteriori model determines what would have been its optimal lineup once all the results are known. The a priori model was entered in the game, achieving results that positioned it among the highest scoring participants.

■ HA-36

Thursday, 8:30-10:00 - Room 132

Sustainability and Environmental Management

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Israel Quintanilla*
Chair: *Marina Segura*

1 - Public Preferences for Multifunctional Agriculture System, using Analytic Hierarchy Process. Differences in Calculating Priorities
Inmaculada Marqués, Baldomero Segura

Multicriteria analysis (MCA) and the Analytical Hierarchy Process (AHP) can help assess the social priorities to integrate them into the decisions policies with the aim to maximize the use of the agricultural system. However different methods have been developed to derive priorities. These methods are derived from different concepts of the estimation quality criteria and under different assumptions about the perturbation factor structure. In this paper we present the results of comparison of these prioritization techniques among the most commonly used and recommended methods in literature.

2 - Poultry and Olive Associated Production: A Multicriteria Analysis of Sustainability
Luisa Paolotti, Cesare Castellini, Antonio Boggia, Lucia Rocchi, Adolfo Rosati

This paper aims to compare three different poultry production systems in term of sustainability assessment (economic, social, environmental indicators) through a multicriteria method. The systems compared are a conventional broiler farm and 2 free-range systems (10m2 pasture/bird), one where the chickens forage in a pasture, and the other which combines the pasture in an olive orchard. The study shows how, especially from an environmental perspective, the poultry system associated with the olive oil production reduces the land use and some agronomic processes necessary in olive oil production.

3 - Management and Valuation of Ecosystem Services of Mediterranean Natural Parks
Marina Segura, Concepcion Maroto, Concepción Ginestar

Studies of a natural parks network revealed the stakeholders' difficulty to prioritize the ecosystem services directly. In addition, there is a lack of Decision Support Systems to manage environmental services, which are the most important in Mediterranean protected areas. As these services are free, their management should be supported by the society. We propose a multiple criteria methodology to manage and evaluate the ecosystem services by using group decision making. We define criteria, indicators and methods for allocating resources to the most important services for the stakeholders.

4 - A Regional Assessment of Sectorial, Environmental and Social Risks from Livestock Farms by using Multi-Criteria Techniques
Israel Quintanilla, Áurea Gallego Salguero, Consuelo Calafat Marzal, Concepcion Maroto

The European livestock sector is under strong social and legal pressure. The laws and regulations focus on defining minimum distances between farms and urban centres and/or other farms. The main environmental issue is the risk of groundwater contamination and the complaints due to odours represent a social risk. The objective of this study is to assess the situation of Valencian livestock including the regulations, as well as environmental and social risks. AHP and PROMETHEE methods have been used to involve stakeholders and to classify farms in order to support agricultural policy decisions.

■ HA-37

Thursday, 8:30-10:00 - Room 017

Multiobjective Optimization in Asia, and Related Subjects

Stream: Multiobjective Optimization
Invited session
Chair: *Tetsuzo Tanino*
Chair: *Tamaki Tanaka*

1 - Using a Maximizing Set Method to Rank Alternatives under Fuzzy MCDM
Ta-Chung Chu

Most ranking methods cannot present connection by formula between ranking procedure and the final fuzzy evaluation values of alternatives under fuzzy multiple criteria decision making (MCDM) model. This work suggests a maximizing set method to resolve this limitation. Membership functions of final fuzzy evaluation values in the suggested fuzzy MCDM model can be developed. A maximizing set method from Chen (1985) is used to defuzzify these values to rank alternatives, where ranking procedure can be clearly displayed by formulas. A numerical example shows feasibility of the suggested method.

2 - Some Existence Criterions for Solutions to a Class of Generalized Equilibria under Multi-Objective Multifunctions
Poom Kumam, Parin Chaipunya

The concept of an equilibrium plays a vital role in the theory of optimization. In this present article, we consider the generalized equilibria and propose some sufficient conditions under which the particular multi-objective multifunctions enjoy the existence of such equilibrium. By products of our results are also presented subsequently.

3 - Observation on Quasiconvexity for Set-Valued Maps via Scalarization
Tamaki Tanaka, Syuuji Yamada

In general, there are several types of quasiconvexity for set-valued maps and some gaps between original set-valued maps and their scalarized ones by marginal functions. We report mathematical characterization of certain types of quasiconvexity for set-valued maps via scalarization and consider such application to multiobjective problems.

4 - Multiple-Criteria and Group-Decision Making in the Fleet Selection Problem for a Public Transportation System
Jacek Zak

The paper presents an application of combined MCDM-GDM methodologies to rank different tram—cars. The evaluation is based on a consistent family of criteria that includes different aspects and interests of different stakeholders (passengers, operator, local authorities). The way of defining and modeling decision maker's (DM's) and stakeholders' preferences, and reaching the group compromise along two separate frameworks: "ex-ante" and "ex-post" is presented. Computational results generated by different ranking methods (AHP-ANP, Electre, Promethee) are demonstrated.

■ HA-38

Thursday, 8:30-10:00 - Room 214

Soft OR / Systems Practice

Stream: Soft OR / Systems and Multimethodology
Invited session
Chair: *Ashley Carreras*

1 - Systemic Thinking in Management Practice: Using Soft Systems Methodology in Family Businesses in Catalonia
Alberto Paucar-Caceres, Joan Roma, David Sierra, Diane Hart

This paper claims that 'soft' OR can provide important tools when making sense of the complexity faced by organisations, particularly family businesses. There is a reluctance to accept these approaches and we explore some of the reasons. Soft Systems Methodology is used to conduct an organised, systemic reflexion to integrate different visions, perceptions and interests amongst the stakeholders through a series of workshops for top and middle managers from a group of small family businesses in Catalonia. The paper should be of interest to systems practitioners, consultants and managers.

2 - Managing the Client-Consultant Relationship
Ashley Carreras, L. Alberto Franco, Thanos Papadopoulos, Elena Tavella

The communication between client and consultant is always a critical factor in any project, this is particularly the case when a project requires the use of Problem Structuring Methods. Both the client and the consultant undergo a process of transformation in their respective understandings of the problem at hand and the nature of the techniques that will help them reach a successful conclusion. Drawing upon Tsoukias' concept of a Productive Dialogue we analyze the structure and content of conversations from real projects to see how this communication can be understood and enhanced.

3 - Evaluating the Value of PSM use in Urban Planning Projects
Ine Steenmans

There has been significant recent interest in evaluating the performance of PSMs. The aim of this practice-based project is to develop evidence supporting arguments for greater use of PSMs in the field of urban planning, which is currently undergoing a 'turn' towards more collaborative practices. Critical, however, to this intended outcome, is a framework capable of evaluating longitudinal changes in the value added by PSMs to both the content and the process of planning. This paper presents such an evaluation framework and reflects on the processes of its validation and implementation.

4 - A Simulation Study of a Combination System of Enterprise Resource Planning (ERP) and Informality
Yucan Wang, Andrew Greasley, Pavel Albores

Current ERP research is limited to system implementation, not focusing on the flexibility of ERP to respond to changes in everyday business. Therefore, this study explores a combination system of an ERP and informality, to provide organisations of efficiency and flexibility simultaneously, by using a mixed method. The qualitative part aims to define a new system corresponding to the constraints of using a single ERP. The quantitative part contains a discrete-event simulation study that is intended to examine the impact of operational performance when a company implements the hybrid system.

■ HA-39

Thursday, 8:30-10:00 - Room 018

Recent Developments in the SCIP Optimization Suite

Stream: Discrete and Global Optimization
Invited session
Chair: *Gerald Gamrath*

1 - SoPlex 2.0
Matthias Miltenberger, Ambros Gleixner

In this talk we present the latest developments of SoPlex, the linear programming solver of the SCIP Optimization Suite. SoPlex has been used since almost 20 years to reliably solve LPs in the academic world as well as practical problems of industry partners. For our current release we created an entirely new interface and introduced several new features. Most important being the ability to solve LPs exactly. Due to the clever combination of floating point and rational arithmetic the exact solving process is barely slowed down compared to a standard precision run.

2 - Presolving in SCIP
Dieter Weninger, Gerald Gamrath, Thorsten Koch, Alexander Martin, Matthias Miltenberger

Presolving attempts to eliminate redundant information from the problem formulation and simultaneously tries to strengthen the formulation. It can be very effective and is often essential for solving instances. Especially for mixed-integer programming problems, fast and effective presolving algorithms are very important. We show some standard and newly developed presolving algorithms of the non-commercial solver SCIP.

3 - Generic Branch-Price-and-Cut
Jonas Timon Witt, Martin Bergner, Gerald Gamrath, Marco Lübbecke, Christian Puchert

Reformulating a given mixed-integer program by the use of Dantzig-Wolfe decomposition leads to a potentially stronger linear programming relaxation. The reformulated problem can be solved by applying a branch-price-and-cut algorithm. Our generic branch-price-and-cut solver GCG, which is based on SCIP, automatically detects the structure of the constraint matrix belonging to a given mixed-integer program, performs the decomposition, and solves the reformulated problem via branch-price-and-cut. We present some important features and report on the latest experiments with GCG.

4 - Recent Branching Improvements in SCIP
Gerald Gamrath

One of the essential components of a branch-and-bound based mixed-integer linear programming (MIP) solver is the branching rule. We report on recent branching improvements developed within the academic MIP solver SCIP, including strong branching with domain propagation and cloud branching.

■ HA-40

Thursday, 8:30-10:00 - Room 019

Innovations in Meta-Analytics III

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair: *Kenneth Sörensen*
Chair: *Roberto Battiti*
Chair: *Marc Sevaux*

1 - An Enhanced Particle Swarm Optimisation Method Designed for Real-Time Applications by using Neural Network
Cedric Leboucher, Stéphane Le Menec, Patrick Siarry, Hyo-Sang Shin, Rachid Chelouah, Antonios Tsourdos

This paper proposes to reduce the computational time of an algorithm based on the combination of the Evolutionary Game Theory (EGT) and the Particle Swarm Optimisation (PSO), named C-EGPSO, by using Neural Networks (NN) in order to lighten the computation of the identified heavy part of the C-EGPSO. The EGT part consists in determining an Evolutionary Stable Strategy iteratively by solving a system of Ordinary Differential Equations and this part might be computationally intensive. Therefore, it is proposed to use NN to decrease the computational time and obtain a real-time algorithm.

2 - A Dandelion Code Extension
Carlos Luna-Mota, Elena Fernandez

The Dandelion Code has proven to be a useful tool to represent spanning trees in population based algorithms. However, the good properties of the Dandelion Code can be exploited in a broader set of algorithms, such as local search or Latin hypercube sampling. The Partially Ordered Neighborhood Structure associated with an extension of the Dandelion Code is introduced and its good properties are illustrated with examples.

3 - Improving the Performance of Metaheuristics with Solution Polishing
Christian Blum

The term "hybrid metaheuristics" refers to research which is concerned with the development of efficient combinations between metaheuristics and other techniques for optimization. In this work we propose the combination of a metaheuristic known as ant colony optimization with the "solution polishing" option of CPLEX. Solution polishing is the implementation of a branch & cut approach with the aim to improve a given solution rather than proving optimality. We show in the context of various string selection problems that "solution polishing" can help to make a metaheuristic more efficient.

4 - Meta-Analytics for Extreme Personalization in E-Commerce
Roberto Battiti

Learning and Intelligent OptimizatioN (LION) means combining learning processes with modeling, problem-solving, and optimization. E-commerce is an area where dynamic models of user behavior are critical in order to provide a better personalization of the interaction between a customer and an e-commerce business. Collaborative recommendation is now a standard tool for a growing number of e-commerce sites. The talk reviews some problems in this area and proposes novel methods to marry analytics with adaptve ways to convey information to a decision-maker in e-commerce.

■ HA-41

Thursday, 8:30-10:00 - Room 216

Stochastic/Robust Routing and Inventory Routing

Stream: Stochastic Models for Service Operations
Invited session
Chair:
Chair: *Jacqueline Bloemhof*

1 - Dynamic Orienteering in Textbook Sales
Jeffrey Ohlmann, Shu Zhang, Barrett Thomas

We consider a stochastic orienteering problem on a network of queues motivated by the textbook industry. A salesperson visits professors during office hours to promote textbooks. At each epoch, the salesperson must decide whether to stay in the queue at the professor's office or to leave for another professor's office. The salesperson's objective is to meet with professors in order to maximize expected sales resulting from the visits. We focus on developing a rollout approach to obtain dynamic routing policies to maximize the total expected sales.

2 - Benders Decomposition for Production Routing Under Demand Uncertainty
Jean-François Cordeau, Yossiri Adulyasak, Raf Jans

We consider the stochastic production routing problem with demand uncertainty in two-stage and multi-stage settings. The decisions in the first stage include production setups and customer visit schedules, while the production and delivery quantities are determined in the subsequent stages. We have developed a solution algorithm based on Benders decomposition for the two-stage problem and we explain how this approach can be extended to the multi-stage case. We also show how solving the two-stage problem in a rolling horizon framework can provide good solutions to the multi-stage problem.

3 - Optimal and Heuristic Robust Policies for the Inventory Routing Problem with Outsourced Transportation
Demetrio Laganà, Luca Bertazzi, Adamo Bosco

We study the Stochastic Inventory Routing Problem with Outsourced Transportation from the robust optimization point of view. First, we design an exact dynamic programming algorithm for the proposed problem, and we compare the optimal policy minimizing the total expected cost with the minimax optimal policy arising with the robust version of the problem. The comparison is performed on the worst case. Second, we propose an approximated dynamic programming algorithm for the robust Stochastic Inventory Routing Problem with Outsourced Transportation.

4 - The Inventory Routing Problem for Perishable Products: A Green Approach
Jacqueline Bloemhof, Mehmet Soysal, Jack van der Vorst

The transition to sustainable food supply chain management has brought new key logistical aims beside cost minimization. The foremost ones of the new aims are the abilities to control product quality in the supply chain, and to reduce environmental impacts of operations. We develop a stochastic model for the inventory routing problem that manages relevant main key performance indicators of total waste, total quality lost, total working hours for drivers, total cost and total energy use (emissions) simultaneously. The stochastic model captures the risk associated with uncertain demand.

■ HA-42

Thursday, 8:30-10:00 - Room 215

Business Intelligence, Knowledge Management & Decision Systems

Stream: Decision Support Systems
Invited session
Chair: *Fatima Dargam*
Chair:

1 - Assessing a Firm's Patent Litigation Propensity and the Effectiveness of its Defense Strategy: Decision Support Models
Ilan Vertinsky, Steven Minns, Steven Minns

Despite a dramatic recent increase in patent litigation and its growing importance as a competitive tool, there is a paucity of research in this area. Using insights from network theory and economics, we develop and test econometric models to assess the patent litigation propensity of firms and the effectiveness of their defensive strategies. We utilize a unique data set (1995-2006) compiled from multiple sources: patent data from NBER, financial data from Compustat, litigation data from LexMachina's IPLC and alliance data from Thomson's SDC Platinum.

2 - The Theory of Search Applied to Business Strategy
Haemin Aziz, Allan Payne

This paper presents a viewpoint of a business strategy based on the Operations Research technique known as the Theory of Search. The first part gives a brief description of the previous work in business strategy whilst the second section enumerates Theory of Search and its techniques. The third portion develops a general business strategy of a user finding units of a business strategy and draws conclusions about the characteristics of the user and the strategy. The fourth portions analyses the business strategy documentation process and shows how the search process is applied.

3 - A System based on a Competency Framework to Support the Choice of Teaching Activities
Isabelle Linden

In recent years, the business administration department of our university committed in a quality process, that integrates the development of a competencies framework. The project started with the identification of 9 key capabilities developed by the students. They do not only guide every actor of our education process but also support the communication between students, teaching staff and socio-professional partners. This work describes the system developed to support students' choice of optional activities by providing a visual summary of the level of each capabilities resulting of a choice.

4 - Effective Knowledge Sharing for Intelligent Supply Chain Decision Support
Shaofeng Liu, E. Irina Neaga, Oluwafemi Oyemomi

Along with the complexity of supply chain networks in current automotive industry, challenges have arisen for decision makers to tackle knowledge sharing problems, especially when facing the "big data" situation. This paper explores the key factors that the "big data" paradigm brings to the knowledge sharing community in the automotive industry. A theoretical framework is proposed based on the review of recent literature with the identification of KPIs that affect the effectiveness of knowledge sharing using "big data".

■ HA-43

Thursday, 8:30-10:00 - Room 217

Various Advances on Optimisation in Health Care

Stream: Optimisation in Health Care
Invited session
Chair:
Chair: *Omid Nohadani*

1 - Online Scheduling of Outpatient Procedure Centers
Brian Denton, Bjorn Berg

Outpatient procedure centers (OPCs), are a fast growing trend for providing specialty health care procedures (surgical and non-surgical). This talk will describe a generalization of the stochastic online bin packing problem which can be applied to scheduling of OPCs. We first present a multistage stochastic programming formulation of the problem. Next, we describe exact methods based on decomposition of the scenario subproblems a fast approximation for which worst case performance bounds can be derived. Finally, we present numerical results, based on a real OPC, and discuss future research.

2 - Evaluation of Inventory Technologies for Operating Rooms
Vera Tilson, Gregory Dobson, Anthony Froix, Abraham Seidmann

After labor, supply chain costs are the second-largest expense for hospitals, constituting up to 40% of the total operating budget. According to a recent PWC study perioperative services account for approximately 61% of these costs. We examine the issue of supply and inventory planning in operating rooms, and evaluate the benefits of standardization and of using technologies such as bar codes and RFIDs.

3 - On Biological and Geometrical Uncertainties in Radiation Therapy
Omid Nohadani

In radiation therapy, treatment variables can be optimized to attain desired and complex dose distributions. However, uncertainties can degrade otherwise optimal treatments, so much so that they may turn out clinically unacceptable. We investigate geometric sources of uncertainty and discuss the corresponding robust convex or non-convex methods. Furthermore, an extension to multi-modal treatments is motivated in conjunction with concurrent chemotherapy. We show that spatiotemporal and biological changes can be incorporated for individualized treatment.

■ HA-44

Thursday, 8:30-10:00 - Room 218

Managing Risk in Supply Chains I

Stream: Managing Risk in Supply Chains
Invited session
Chair: *Kumar Sanjay*

1 - Unveiling the Supplier Risks with a Neural Network Based Supplier Selection Model
Gulcan Petricli, Gül Gökay Emel

Suppliers pose a high level of risk especially for production oriented businesses as outsourced materials comprise up to 80% of their total cost. In order to reveal the risk, suppliers of a Tier-1 manufacturing company will be evaluated by a two-step neural network model. While the first step eliminates strategically unfitting suppliers, the second step looks for technical fitness. Outcomes of the evaluation will be compared with real life supplier decisions in order to determine the risk.

2 - Managing Supply Chain Disruptions: A Comparison of the Automotive and Food Industry
Tobias Gelau, Ole Hansen, Maja Herrmannsdoerfer

The ability to manage unexpected disruptions is a key factor of retaining the performance and reliability of supply chains. This work investigates the disruption management of two different supply chain types, the automotive and the food supply chain. Interviews with practitioners from both industries have been analysed to identify specific disruption management strategies. The authors observe that depending on the different characteristics of the two supply chains, varying strategies are required to manage disruptions efficiently. The work provides a decision support in handling disruptions.

3 - Qualifying Stock Impact of Supply Chain Disruptions under Various Market Cycles and Industry Domicile
Kumar Sanjay, Jiangxia Liu, Ashutosh Deshmukh

This research explores the effect of supply chain disruptions on companies and competitors. Stock market reactions are used to assess the impact of disruptions. We specifically analyze the impact based on market cycles and industry domicile of affected companies and competitors. We find that the effect of disruptions is dependent on the upward or downward trend in the stock market. Also, American domicile companies experience greater negative impact from disruptions. Our study has implications for supply chain managers who make decisions regarding investments in disruptions mitigation.

4 - Carbon Emissions Reduction and Transfer in Supply Chains under a Cap-and-Trade System with Emissions-Sensitive Demand
Gendao Li, Yu Xiong

In this paper, through a stylized model, we investigate the carbon emission and transfer in a supply chain comprised by a manufacturer and a retailer under the cap-and-trade system. Optimal price and carbon emission reduction are derived under both centralized and decentralized supply chain. The impact of carbon price and consumer environment sensitivity is analyzed. We found that under decentralized supply chain, the transfer decision depends on the carbon price and consumers' emission sensitivity. The results of this paper can shed light on companies' carbon emission reduction decision.

■ HA-45

Thursday, 8:30-10:00 - Room 219

Business Analytics Optimization and Big Data

Stream: Business Analytics Optimization and Big Data
Invited session
Chair: *Matan Abraham*

1 - Large-Scale PCA in Mapreduce Under the Manhattan Norm
Diego Klabjan

The Manhattan or L1 norm is known to be more robust to outliers than the standard L2 norm. We developed an iterative algorithm for solving large-scale PCA algorithms that in each iteration solve a weighted L2 PCA problem. This L2 problem is solved by mapreduce and the weight updates are also computing by mapreduce.

2 - Big Data Tools and Techniques in the UK Retail Sector
Elly Philpott, Ramakrishnan Ramanathan, Yanqing Duan, Guangming Cao

This study is based on interviews with 12 leading Big Data users/consultants in the UK retail sector. These companies included those operating pure off-line, both online and offline, pure online retailers and also Big Data consultants. We used Technology-Organisation-Environment framework to structure the interviews. A number of Big Data tools and techniques have been mentioned by our interviewees. They included, among others, tools such as Excel including special macros and add-ins, SQL, SAP, SAS and SIMALTO. We provide a more detailed analysis of these tools and techniques in this paper.

3 - Relaxed Normality Assumption in Stochastic DEA for Efficient Handling of Big Data
Panagiotis Zervopoulos, Ioannis Mitropoulos

The scope of this theoretical work is to present an alternative stochastic Data Envelopment Analysis (DEA) program to enable the measurement of efficiency with minimum computational burden when big data is present. The new stochastic DEA program assumes that uniform distribution prevails. When this program is applied to big data, the elapsed time for measuring efficiency scores is no more than 2% of the time that conventional stochastic DEA programs require. In addition, there is no significant difference between the efficiency scores measured by the new and conventional DEA programs.

4 - The Use of Data Envelopment Analysis (DEA) for Profiling Specialist Healthcare Providers in South Africa
Matan Abraham, Shivani Ramjee, Kathryn Dreyer

This research illustrates how DEA can be used to aid the decision-making process of specialists allowing them to make the most efficient use of resources when treating patients; and highlights how DEA improves on provider-profiling techniques currently used by managed care organisations. Claims data from a prominent South African health insurance administrator are used to analyse 545 general/paediatric surgeons. The use of claims data as opposed to individually collected micro-data is considered. A stepwise DEA using sensitivity analysis is performed to help ensure interpretability of inputs.

Thursday, 10:30-12:00

■ HB-01

Thursday, 10:30-12:00 - Room 118

Robustness in Railway Operations (RobustRailS)

Stream: Railway and Metro Transportation
Invited session
Chair: *Richard Lusby*

1 - Adapting Stopping Patterns of Railway Lines to Improve Robustness from the Users' Perspective
Jens Parbo, Otto Anker Nielsen

This study considers the problem of enhancing railway timetable robustness without adding slack time, hence increasing the travel time. The approach integrates a transit assignment model to assess how passengers adapt their behaviour whenever operations are changed. First, the approach considers the existing stopping patterns of the railway lines. Then, based on the passenger demand we try to optimize the overall utility by changing the stopping pattern in a way that capacity utilization is reduced without affecting the frequency of the train lines nor increasing the passengers' travel time.

2 - A Branch-and-Price Framework for Rolling Stock Recovery
Jørgen Thorlund Haahr, Richard Lusby, David Pisinger, Jesper Larsen

Disruptions in railway passenger transportation are regrettably not uncommon and render planned rolling stock schedules infeasible. Finding new schedules in such time-critical situations is not trivial. We present a Branch-and-Price framework for solving this optimization problem, which is embedded in a rolling time horizon framework in order to model uncertainty. Provisional results are presented based on historical data from the suburban railway operator in Copenhagen (DSB S-tog).

3 - Integrating Depot Planning when Recovering Rolling Stock Schedules
Richard Lusby, Jørgen Thorlund Haahr, Jesper Larsen, David Pisinger

We consider integrating two important operational level planning problems arising in the railway industry. Traditionally, the routing of rolling stock units and depot planning problems are treated separately; however, the ordering of the units in the depots naturally influences the possible routes each can be assigned. Here we describe two techniques for incorporating depot planning in a larger framework for rescheduling rolling stock units under disruption. Preliminary results from DSB S-tog, a suburban railway network operator in Copenhagen, are presented.

4 - Partitioning a Passenger Rail Network and Rolling Stock Units to Reduce Disruption Propagation
Simon Bull, Richard Lusby, Jesper Larsen

Disruptions to railway operations can negatively affect passenger's perception of rail transport, and it is therefore useful to create schedules that can resist propagating delays. One approach to reducing disruption propagation is to group rolling stock units and partition the rail network, such that each independent partition is served by one unit group. We present a rolling stock optimization model for comparing different network partitions and finding unit group allocations, and present preliminary results from data for the Danish rail network operator (DSB).

■ HB-02

Thursday, 10:30-12:00 - Room 111

Variants of the Vehicle Routing Problem 1

Stream: Vehicle Routing
Invited session
Chair: *Daniele Manerba*

1 - A New Formulation and Approach to Solve the Black and White Traveling Salesman Problem
Ibrahim Muter

This study proposes a new formulation and a column generation approach for the black and white traveling salesman problem. This problem is an extension of the traveling salesman problem in which the vertex set is divided into black vertices and white vertices. The number of white vertices visited and the length of the path between two black vertices are constrained. We modeled the undirected version of the problem as a traveling salesman problem with an extra constraint set. A branch-and-price algorithm is designed to find the integral optimal solution for this problem.

2 - Specific Multi-trip Operators for Vehicle Routing Problems
Yasemin Arda, Yves Crama, Véronique François, Gilbert Laporte

In vehicle routing problems with multiple trips (VRPM), each vehicle is allowed to perform more than one trip during its working period. Classical solution techniques for this problem use existing VRP heuristics to create trips, together with bin packing methods aimed at assigning these trips to the available vehicles. In this work, specific local search operators for the VRPM are proposed. Heuristics using these operators are compared with classical solution techniques mentioned above.

3 - Results on the Polyhedron Associated with Node-Balanced Vehicle Routing Problems
Antonio Martinez Sykora, Tolga Bektas, Luís Gouveia, Juan José Salazar González

This talk will present some results on the polyhedron associated with the unit-demand vehicle routing problem where, along with the usual capacity limitations, a lower bound is imposed on the number of customers visited on each route. The results concern to the dimension of the polyhedron and some facet-defining inequalities.

4 - A Column Generation Approach for the Multi-Vehicle Travelling Purchaser Problem with Pairwise Incompatibility Constraints
Daniele Manerba, Michel Gendreau, Renata Mansini

Recently, a Multi-Vehicle Travelling Purchaser Problem variant, characterized by the presence of pairwise incompatibility constraints (PIC) between products, has been introduced. PICs yield the impossibility of loading two incompatible products on the same vehicle. We propose a branch-and-price approach, based on a set-partitioning formulation. Two different procedures are introduced to solve the pricing problem, namely a labeling algorithm solving a resource-constrained Elementary Shortest Path Problem on an expanded graph, and a tailored branch-and-cut. Preliminary tests seem very promising.

■ HB-03

Thursday, 10:30-12:00 - Room 001

Network Location

Stream: Location
Invited session
Chair: *Maria Albareda Sambola*

1 - Degree Dependent Tree Location
Alfredo Marín

Spanning trees on graphs usually aim to optimize an objective which depends on the edges weights. But there are still some problems in the field where the goal is to identify spanning trees with a given structure, usually depending on the degrees of the nodes. For some of these problems we present Integer Programming formulations, heuristic approaches and branch-and-cut algorithms providing good computational results.

2 - A Path Location Model with Equality Aspects
Maria Barbati, Giuseppe Bruno

A path location problem consists in locating a path that enables the transfer of flows from given origin-destination pairs. The topic can have several applications within transportation and logistics contexts. We propose a multi-objective model in which balancing or equality aspects, i.e., measures of the distribution of distances of users from the path, are considered. The model can be used when there is the need to balance risks or benefits among all the potential users. The application of the proposed model shows its ability to find solutions with significant level of equality.

3 - The p-Median Facility Location Problem with Uncertainty on the Costs
Sergio García Quiles, Laureano Fernando Escudero

The p-median problem is one of the most classical problems in Discrete Location and consists on choosing p locations and assigning the other locations to these p medians so that total allocation cost be minimum. Here we study how to solve this problem when the costs are uncertain: a radius based formulation is developed to model the minimization of the expected cost over a set of scenarios at the same time that a set of first order stochastic dominance constraints are required to reduce the risk on the cost due to non-wanted scenarios. A computational study is provided.

4 - The Probabilisitic p-Center Problem
Maria Albareda Sambola, Antonio Manuel Rodriguez-Chia

When locating emergency facilities, the aim is often to ensure that the best possible coverage is assured to all customers. Among the basic facility location models built upon this idea, we find the p-center problem which seeks the set of p facilities minimizing the longest distance between a customer and its closest facility. We extend this model to the case where it is uncertain which potential customers will require being served. In this situation, the probabilistic p-center problem aims at minimizing the expected maximum distance between a request and the set of facilities.

■ HB-04

Thursday, 10:30-12:00 - Room 119

Network Traffic Modeling II

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Jaume Barceló*
Chair: *Nicolas Chiabaut*

1 - A Mesoscopic Simulation based Dynamic Traffic Assignment Model
M^a Paz Linares, Carlos Carmona, Jaume Barceló, Oriol Serch

In this work we develop a dynamic traffic assignment model based on the dynamic user equilibrium by solving a variational inequalities formulation under a preventive approach. An iterative solution algorithm, which is a modification of the Method of Successive Averages, considers the time and a variable traffic demand on each path of the network within the flow propagation and assignment processes. The dynamics of the reassigned flows at each iteration is simulated by a new mesoscopic multiclass multilane model accounting for lane changes and traffic control at signalized intersections.

2 - Scale Selection in Multi-Scale Traffic Flow Modelling
Mahtab Joueiai, Hans van Lint, Serge Hoogendoorn

Traffic is a highly complex system in a sense that it is made up of multiple interconnected elements. Since the behaviour of a complex system at different scales is related, our descriptions of traffic flow phenomena should also include these relationships. Multi-scale modelling is an adaptive strategy to reproduce and explain all traffic phenomena that are observable at different scales. In this paper we will analyse the concept of scale separation that is basis of multi-scale modelling. Furthermore, complexity of the phenomena will be quantified and use to select appropriate modelling scale.

3 - An Integrated Traffic Modelling for Ramp Metering with Dynamic Speed Limit Strategies
Josep Maria Torne, Francesc Soriguera, Nikolas Geroliminis

A new integrated strategy, i.e., rampmetering together with dynamic speed limits (DSL), is proposed to reduce the capacity drop occurrence in the vicinity of an on-ramp. It is tested with a cell transmission model extension which incorporates the ability to reproduce DSL strategies together with capacity drop phenomenon.

4 - Methodology for Measuring Performance of High Occupancy Vehicle Lanes
Ali Haghani, Masoud Hamedi, Yanru Zhang

Making more efficient use of existing system through HOV lanes is a cost-effective solution to improve mobility. Effective management of such facilities calls for continuous and reliable monitoring of their performance. This research focuses on developing an evaluation framework that combines traffic data from several sources to estimate key HOV indicators. Motivated by advancements in travel time measurement technologies, a pattern recognition algorithm for separating travel time on HOV and regular lanes collected by Bluetooth sensors is developed.

■ HB-05

Thursday, 10:30-12:00 - Room 002

Stowage Planning

Stream: Port Operations
Invited session
Chair: *Dario Pacino*

1 - The Terminal Management Perspective on the Ship Stowage Planning Problem
M. Flavia Monaco, Marcello Sammarra, Gregorio Sorrentino

The Ship Stowage Planning Problem, i.e. determining the stowage position of containers in a containership, is usually faced by the shipping line to optimize vessel related objectives. Here we discuss the problem from the point of view of the terminal manager which aims to minimize the cost of the loading process. We refer to the Gioia Tauro port which adopts a DTS configuration. In this context, the operative costs are related to yard-to-quay transport of containers and possible yard-shifts. We propose a Binary Model, a heuristic algorithm, and discuss the numerical results on real instances.

2 - Port Call Duration Optimisation through Quay Crane Parameter Constrained Containership Stowage Planning
Tommi Muona, Evrim Ursavas, Iris F.A. Vis

Container terminals face an increasing pressure to shorten the port calls of containerships. As a result, investments must be made and planning has to be optimised. This research provides an approach to evaluate the effects of deploying a new type of quay cranes, capable of serving adjacent ship bays, to handle ultra-large containerships. The evaluation is based on the terminals' and the shipping line's perspectives by considering port calls per port and for the whole multi-port service. Port call durations are defined by the stowage plans limited by the number and type of quay cranes.

3 - Heuristic Algorithms for Solving the Slot Planning Problem
Francisco Parreño, Dario Pacino, Ramon Alvarez-Valdes

In the Slot Planning Problem, for each location of the container ship we are given a list of containers to be loaded, and the problem is to assign each container to a feasible position, satisfying the specific packing constraints associated to the ship locations and to the different types of containers involved. We have developed a GRASP algorithm in which the constructive randomized phase packs as many containers as possible and the improvement phase tries several moves in order to minimize the number of containers left out. The algorithm has been tested on a set of real-world instances.

4 - Stowage Plans with Hazardous Containers
Anna Sciomachen, Daniela Ambrosino

We analyze the impact of hazardous containers on sea transport and stowage plans. Starting from recent results on the well-known Master Bay Plan Problem, we plan the shipping of containers' lots via liner service. We present a MILP model in which rules derived from the International Maritime Dangerous Good Code are considered. A heuristic method aimed at optimizing the available space on each ship and minimizing the total shipping costs is also given. Stowage plans with and without hazardous containers derived from data of maritime terminals in the port of Genoa are presented and compared.

■ HB-06

Thursday, 10:30-12:00 - Room 211

Learning and Games in Networks

Stream: Social and Economic Networks
Invited session
Chair:
Chair: *Ozan Candogan*
Chair: *Kostas Bimpikis*

1 - Competing in Networks
Kostas Bimpikis

This paper examines a game-theoretic model of competition between firms, which can target their marketing budgets to individuals embedded in a social network. We provide a sharp characterization of the optimal targeted strategies and highlight their dependence on the social network structure. Furthermore, we identify network structures for which the returns to targeting are maximized, and we provide conditions under which it is optimal for the firms to asymmetrically target a subset of the individuals. Finally, we provide a lower bound on the extent of asymmetry in these asymmetric equilibria.

2 - Global Games on Networks with Noisy Information Sharing
Behrouz Touri, Jeff Shamma

Global games are games with imperfect information where each player takes a noisy observation of an underlying state of the world and subsequently chooses to take a binary action. In this paper, we consider a setup where the private signals are shared through a noisy channel. We show that under a general condition on the noisy channel the threshold policy surviving the iterated elimination of the dominated strategies is unique by arguing that iterated elimination of dominated strategies induces a contraction mapping on the space of thresholds.

3 - Modeling Media Content Production and Consumption among Users and Platforms in a Digital Social Network
Patrik Wikström

This paper presents the results from an exploratory modeling study of production and consumption of media content in online social networks. The agent-based model captures the social interaction and innovative behavior of both content producing organizations and individuals and is able to generate a number of observed real-world phenomena such as the dynamics of illegal/legal content distribution; the transformation of the creative industries from product-based to service-based economies; and the motivational drivers behind amateur creativity.

4 - Balancing Load via Small Coalitions in Selfish Ring Routing Game
Xudong Hu, Xujin Chen

This talk concerns the asymmetric atomic selfish routing game for load balancing in ring networks. It has been known that the classical Nash equilibrium may cause large loss of efficiency in terms of maximum link loads. In this paper we extend the classical Nash equilibrium to a general one which allows coordination within any coalition of up to k selfish players on the condition that every player of the coalition benefits from the coordination. Our study shows that the network performance, in terms of maximum load, benefits significantly from coordination of small-sized coalition.

■ HB-07

Thursday, 10:30-12:00 - Room 003

Dynamical Models in Sustainable Development III

Stream: Dynamical Models in Sustainable Development
Invited session
Chair: *Katrin Seddig*

1 - Optimal Harvest with Different Fishing Fleets for Obtaining a Total Allowable Catch Quota of the Oriental South Pacific Jack Mackerel Fishery
Victor M. Albornoz, Cristian Canales

A methodology proposed for obtaining an optimal harvesting policy of the oriental south pacific jack mackerel fishery is described as a planning tool in the exploitation of this resource with four different fishing fleets. More precisely, a nonlinear optimization model that maximizes the biomass yield is formulated. The model is based on an age structure population dynamic model and considers the fishing selectivity of each fleet and conditions that ensure the sustainability of the studied renewable resource. The main aspects of the methodology, the results and conclusions are presented.

2 - An Agent-based Simulation Approach for Scheduling the Charging Process of Electric Vehicles in Fleets
Katrin Seddig, Patrick Jochem, Wolf Fichtner

In the field of energy economics there are various approaches for modeling. This paper applies an agent-based simulation for analyzing charging and load shift potentials of fleets of electric vehicles. Hereby the construction of the model with the interaction and behavior of different agents is considered. This paper gives a brief systematization of agent-based simulations in the context of energy economics with a special focus on fleets of electric vehicles and corresponding issues like scheduling of charging processes, availability of electricity or grid restrictions.

■ HB-08

Thursday, 10:30-12:00 - Room 120

Sustainable Supply Chains

Stream: Energy Economics, Environmental Management and Multicriteria Decision Making
Contributed session
Chair: *Jacqueline Bloemhof*

1 - Planning and Scheduling of Multiproduct Multistage Semicontinuous Production with Perishability and Waste Considerations: Dairy Supply Chain
Çağrı SEL, Bilge Bilgen, Jacqueline Bloemhof, Jack van der Vorst

The Dairy industry is a significant component of many economies, and is a major industry in the most developed and developing economies of the world. Effective planning and scheduling of Dairy Supply Chains has attracted more interest due to increasing awareness on freshness and environmental concerns such as production loses and waste. In this study, we introduce a mixed integer linear programming model for multiproduct multistage semicontinuous planning and scheduling of yoghurt production accounting perishability and waste considerations.

2 - Collaborative Tactical Planning to Facilitate Industrial Symbiosis
Gábor Herczeg, Renzo Akkerman

Resource efficiency is a key aspect in sustainable supply chain management. To improve resource efficiency in industrial symbiosis (IS), one company's production waste substitutes virgin resources in another company's production process. To optimize economic benefits for both parties, tactical planning of operations need to include waste treatment, storage, as well as resource procurement. To facilitate IS, collaborative planning models are developed that consider waste supply and demand. The goal of the collaboration is to include IS in tactical planning and to maximize waste utilization.

3 - Two-Stage Stochastic Modeling of New Dairy Production Technologies in a Supply Chain Context
Bryndís Stefánsdóttir, Martin Grunow

The evaluation of new and more sustainable production technologies requires integrated decision making to account for the resulting changes in the supply chain. A two-stage stochastic MILP model which integrates the technical design and selection of new dairy production technologies with the relevant supply chain decisions is introduced. The aim is to improve the efficiency of the whole supply chain, accounting for food specific characteristics and demand uncertainty. The applicability of the methodology is shown for a dairy company in Germany.

4 - Resource Efficiency in Food Supply Chains
Aleksander Banasik, Argyris Kanellopoulos, G.D.H. (Frits) Claassen, Jacqueline Bloemhof, Jack van der Vorst

This research focuses on improving resource efficiency & effectiveness of food supply chain such that raw materials and resources are used to their full potential. We take the mushroom supply chain as an illustrative example and demonstrate the complexity for improving resource efficiency as it involves conflicting economic and environmental objectives and uncertainty. We propose a Multi Objective Optimization model to support managerial decisions and improve sustainability of the mushroom supply chain in the Netherlands. Trade-offs between economic and environmental indicators are calculated.

■ HB-09

Thursday, 10:30-12:00 - Room 121

Models for Electricity Production and Distribution

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Paolo Pisciella*

1 - Pumped-Storage Hydropower Optimization: Effects of Several Reservoirs and of Ancillary Services
Martin Densing

The economic environment for hydropower in Europe has changed in recent years: With the advent of more wind and solar generation, the spread between peak and off-peak prices is decreasing, such that the dispatch of pumped-storage hydropower needs to be carefully chosen to be profitable. We consider a dual-scale medium-term stochastic programming model for hydropower dispatch using the occupation times of the electricity price. We model interconnected reservoirs, and we evaluate profits of ancillary services. In terms of mean-risk optimization we consider hedging against inflow variations.

2 - A Mixed-Integer Program for the Optimised Capacity and Dispatch Planning of Residential Cogeneration Systems
Erik Merkel, Russell McKenna, Wolf Fichtner

Research is lacking in considering important constraints for the cost-minimal capacity and dispatch of residential combined heat and power (CHP) systems, like non-linear economies of scale. A mixed-integer program is presented that determines the optimal capacity and dispatch of a CHP unit and thermal storage through piecewise linear approximation. Based on data from a field trial in the UK it takes into account important technical and economic aspects previously neglected. Results indicate that total annual costs can be significantly reduced compared to a reference case of a CHP-only system.

3 - Multicycle Optimization of VVER-Type Reactors
Roman Cada

In the talk we describe the problem of optimization of fuel reloading patterns for nuclear reactors. We discuss the influence of different fresh fuel types on length and quality of loadings obtained. We present a computational method based on a combination of several approaches, mainly based on topological structure and nonlinear optimization with a combination of some local search methods guided by topological properties. The methods are incorporated in a new optimization code Enyo. We compare VVER440 and VVER1000 reactor types regarding optimization process and criterions to be met.

4 - Transmission Lines Switching in Electric Power Networks by Means of Nonlinear Stochastic Programming
Francesco Piu, Alois Pichler, Asgeir Tomasgard, Maria Teresa Vespucci

Switching off selected transmission lines of an electricity network can lead to savings in the total production costs. This fact is gaining increasing interest since new transmission lines are required to access power production places not exploited in the past (e.g., off-shore wind parks). This offers the opportunity to redesign the power network and to incorporate new switching possibilities. The problem is to identify the transmission lines with the highest savings potential. We employ stochastic programming to face the problem and we study how to achieve a tractable problem size.

■ HB-10

Thursday, 10:30-12:00 - Room 122

DEA Theory II

Stream: Theoretical Developments in DEA
Invited session
Chair: *Emmanuel Thanassoulis*

1 - A Probabilistic Efficiency Analysis using Stochastic DEA and Bayesian Techniques
Panagiotis Mitropoulos, Michael Talias, Ioannis Mitropoulos

Stochastic DEA can deal effectively with noise in the efficiency measurement but unfortunately formal statistical inference on efficiency measures is not possible. We use a Bayesian perspective to improve result robustness by increasing parameter accuracy and reducing the effect of outlying observations. This model incorporates the uncertainty in DEA by means of a probabilistic-analysis approach. Moreover, it is known that Stochastic DEA in their initial settings require panel data. This paper addresses this limitation with a combined stochastic DEA-Bayesian model in cross sectional data.

2 - A Learning Ladder Towards Efficiency: Proposing an Application of Social Network Analysis in Data Envelopment Analysis
Abaghan Ghahraman, Diego Prior

Stepwise efficiency improvement facilitates the process of inefficiency removal. Based on the knowledge-based view of efficiency, a network-based approach is proposed to find the optimal stepwise benchmarking paths toward the efficiency frontier. The approach treats the Data Envelopment Analysis system as a network of teaching and learning firms and calculates the overall shortest paths taking into account both input endowment similarity and efficiency gap covered in each step. For an empirical example, the method is applied to a dataset of Canadian bank branches.

3 - On Productive Efficiency and Total Factor Productivity Change of China's Listed Food Companies - Based on the DEA Method and 2008-2012 Panel Data
QIU Hong, Zhu Nan, Dan Yang

This paper applies Data Envelopment Analysis (DEA) to measure the productive efficiency and total factor productivity change of China's listed food companies, based on 2008-2012 panel data. Meanwhile, the study also finds that the New Hope Company is both in the largest production scale and highest production efficiency in 2011 and 2012 by using the super-efficiency evaluation.

4 - Assessing University Research Output from Different Perspectives
Emmanuel Thanassoulis, Dimitris Despotis, Dimitrios-Georgios Sotiros, Yannis Smirlis, Giannis Karagiannis

Most assessments in the literature of academic research output have been at an academic unit level. We compare individual academic staff members both within academic units and across academic units from a variety of perspectives. One perspective is that of the duration of the academic in an academic unit. A second perspective is that of the salary cost of the academic to the academic unit. We contrast the findings from the alternative perspectives both within and across academic units and derive information that would be of value both to the individual and the home department.

■ HB-11

Thursday, 10:30-12:00 - Room 113

Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Monique Guignard-Spielberg*

1 - A Model for Forest Harvesting and Road Network Design under Uncertainty in Wood Demand and Prices
Antonio Alonso-Ayuso, Laureano Fernando Escudero, Monique Guignard-Spielberg, Andrés Weintraub, Martin Quinteros

We consider a problem of forest planning along a time horizon. Basic decisions concern the areas to harvest in each period, the amount of timber to produce to satisfy the demand of the different products (sawmills low and high quality and pulp plants). Additionally, a road network must be designed for access and storage of timber. The model considers that there exists uncertainty in the demand and price of the products. This uncertainty is represented via a set of scenarios. An MIP Stochastic model is used for representing the problem. Some preliminary computational experience is reported.

2 - A Branch&Price Approach for the Vehicle Routing Problem with Intermediate Replenishment Facilities
Lucas Létocart, Paolo Gianessi, Alberto Ceselli, Roberto Wolfler-Calvo

Vehicle Routing Problem with Intermediate Replenishment Facilities is defined on a graph where the node set consists of a depot n clients and p replenishment facilities. The aim is to find the least cost set of routes that visit each client exactly once with a fixed capacity vehicle based at the depot. Vehicles can recharge at facilities so as to perform not one but a sequence of routes called a rotation. We propose a Branch&Price algorithm where the pricing is an elementary shortest path problem with resource constraints. Tests have been conducted on medium-sized benchmark instances.

3 - Satisfaction Guaranteed
Sophie Toulouse, Jean-François Culus, Frederic Roupin

A large variety of combinatorial optimization problems fall into the framework of Boolean Constraint Satisfaction Problems (CSPs). We here focus on CPSs where the constraints are of arity at most k and the goal is to satisfy as many constraints as possible (kCSPs). Since kCSPs are NP-hard in the general case, we address the question of their differential approximability: What kCSPs are approximable within some constant factor? What predicates are the hardest? For 2CSPs, what graph structures enable to beat solutions obtained by means of SDP relaxation?

4 - Improving Crossdock Efficiency Through Improved Door Assignment
Monique Guignard-Spielberg, Peter Hahn, Heng Zhang

We consider an actual crossdock where trucks to be unloaded are available at the start of the day, and assigning incoming and outgoing trucks to doors is currently done manually every day. Instead we propose to consolidate the goods for that day by destination and determine the location of these staging areas and of the corresponding doors, as well as that of inbound trucks, so as to minimize, by an NLIP heuristic, the total labor required to empty incoming trucks, move goods across the dock and load the outbound trucks, while ensuring that goods are shipped within twenty four hours.

■ HB-12

Thursday, 10:30-12:00 - Room 004

Decentralized Multi-Project Scheduling

Stream: Project Management and Scheduling
Invited session
Chair: *Andreas Fink*
Chair: *Jörg Homberger*

1 - Decentralized Multi-Project Scheduling: Review and Classification
Andreas Fink, Jörg Homberger

The problem is characterized in that individual decision makers pursue individual goals. This may involve decision makers that control individual projects and/or global resources. A coordination mechanism must resolve conflicts due to interdependencies between the projects, which may result from temporal and resource-oriented constraints. After providing a more detailed description of such kinds of problems and the resulting peculiarities of decentralized decision making, a classification of respective problem types is provided, which leads to related requirements for solution procedures.

2 - Benchmark Instances and Solutions for the Decentralized Multi-Project Scheduling Problem
Jörg Homberger, Andreas Fink

Benchmark instances and solutions for the decentralized multi-project scheduling problem are described. The considered multi-project scheduling problem takes different kinds of decision makers (project agents and resource agents), as well as private information of the decision makers (objective functions and precedence relations of activities) into account. Solutions, calculated by a new automated negotiation approach, are also presented. In order to compare alternative solution approaches a web-based evaluation system is introduced.

3 - Two-Level Heuristic Algorithm for the Hierarchical Scheduling Problem
Zdenek Hanzalek, Roman Capek, Premysl Sucha

We deal with the scheduling problem where both the projects and the available resources are hierarchically structured in more levels of abstraction like subprojects, resource centers and resource areas. For such a problem we propose a hierarchically structured scheduling model and the heuristic algorithm, which is composed of more cooperating levels, reflecting the hierarchical structure of the problem. For the evaluation of the algorithm, we use the standard benchmark instances from the PSPLib library, which are further adjusted to follow the hierarchical structure of the studied problem.

■ HB-13

Thursday, 10:30-12:00 - Room 123

Process Planning and Task Scheduling under Uncertainties

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*
Chair: *Olga Battaïa*

1 - Renewal Theory Methods to Compute Stationary Inventory Control Strategy Parameters (for Lot-sizing)
Alexander Mandel

As is known to compute stationary inventory control strategy parameters (for lot-sizing) the renewal theory methods can be used. In this presentation, under corresponding model, original minimal average multi-step costs criteria are replaced by one-step minimal costs criteria where the stationary inventory level distribution substitutes the stationary demand distribution. The point is that the stationary inventory level distribution is realized only when time is rather big but stationary control strategies are applicable only in case when the number of reverse time steps tends to infinity.

2 - The Impact of Deadline Rush on Tardiness Across Three Material Flow Policies
Kenneth Doerr, David Nembhard

We explore some of the consequences of Deadline Rush to the on-time performance of material-flow policies. Deadline Rush is a term used to describe the behavioral response to a deadline, and in particular the hyperbolic increase in work rate as a deadline approaches. We examine how Deadline Rush impacts the probability of on-time completion of a quota under three material-flow policies: paced-synchronous, paced-asynchronous, or unpaced. We show that individual differences in deadline reactivity matter when determining the relative efficiency of these three policies.

3 - Production Planning in Dairy Industry: An Industrial Case Study
Bilge Bilgen

This paper addresses the production planning problem of several products in a multi-stage production system stimulated by a particular case study in the dairy industry. The model incorporates several distinguishing characteristics of dairy production, such as multi-stage bulk production, shelf life requirements, intermediate storage, setups, resource speeds, minimum and maximum lot sizes, conservation of flow among various tanks, and demand satisfaction. The objective is to maximize the total profit to determine the quantity of intermediate and end products processed on various resources.

4 - Optimal Design of Assembly Lines with Flexible Workers
Olga Battaïa, Xavier Delorme, Alexandre Dolgui, Johannes Hagemann, Sergey Kovalev, Sergey Malyutin

This presentation will describe an application of the optimisation module of the Advanced Platform for Manufacturing Engineering and Product Lifecycle Management (amePLM). It deals with the assignment of flexible workers in mixed assembly lines. We prove that the problem is NP-hard in the strong sense, develop an integer linear programming formulation to solve it, and propose conventional and randomized heuristics.

■ HB-14

Thursday, 10:30-12:00 - Room 124

Advances in Nonlinear Optimization: Theory and Applications II

Stream: Nonlinear Programming
Invited session
Chair: *Tunjo Perić*
Chair:

1 - Vendor Selection and Supply Quotas Determination by using Multi-Objective Fractional Programming and Game Theory
Tunjo Perić, Zoran Babic, Sead Resic

In this paper a new methodology for vendor selection and supply quotas determination is proposed. This work deals with a concrete problem of flour purchase by a company that manufactures bakery products. The problem is solved by the model that combines revised weighting method for determining the objective function coefficients, and multiple objective fractional programming and coopeartive game theory techniques for vendor selection and supply quotas determination.

2 - Methods for special structured quadratic constrained quadratic programmings
Cong Sun, Yaxiang Yuan

Consider a kind of quadratic constrained quadratic programmings (QCQP) which come from wireless communications. The problems have nonconvex objective functions while the constraints have only positive definite second-order terms. By approximating the problem as a series of trust region subproblems, we achieve a feasible solution of QCQP. This point acts as the starting point of the nonconvex Sequential Quadratic Programming (SQP) method, to achieve a stationary point of the QCQP problem. Such methods allow us to solve these QCQP problems with low complexity and achieve considerable solutions.

3 - Trajectory-based Method for Nonlinear Constrained Optimization
Terry-leigh Oliphant, Montaz Ali

The trajectory-based method for solving constrained nonlinear programming problems is proposed. The augmented Lagrangian problem reformulation is used to convert the constrained problem into an equivalent unconstrained problem and a new scheme for updating the penalty parameter is discussed.

4 - Direct Search Based on Probabilistic Descent
Zaikun Zhang, Serge Gratton, Clément Royer, Luis Nunes Vicente

Direct search methods are a class of derivative-free algorithms based on evaluating the objective function along polling directions. It is typical to assume that the directions form a positive spanning set, so that at least one of them is descent. We study a more general framework where the directions are only required to be probabilistic descent, meaning that with a certain probability at least one of them is descent. This framework enjoys almost-sure global convergence and a global rate of 1 over the squareroot of k for the gradient norm with overwhelmingly high probability.

■ HB-15

Thursday, 10:30-12:00 - Room 125

Contemporary Issues in Revenue Management

Stream: Revenue Management II
Invited session
Chair: *Fredrik Odegaard*

1 - Exponential Approximations for Network Revenue Management
Christiane Barz, Dan Adelman, Canan Uckun

We consider a new approximation architecture for the network revenue management problem using exponential functions to express concavity. We address a number of technical challenges in fitting parameters and demonstrate numerical performance compared against other approximations.

2 - Dynamic Pricing with Strategic Consumers and Social Learning
Tatsiana Levina, Yuri Levin, Mikhail Nediak, Jue Wang

We present a dynamic pricing model for a monopolist offering a durable product to multiple segments of strategic consumers. Consumers use social learning to determine the true quality of the product in order to make their purchase decision. The network structure is captured by weighting the impact of the consumers' reviews of the product with their level of influence in the social network. The firm's objective is to maximize the expected profits. We study the structure of the optimal pricing policy of the monopolist in relation to consumer preference for quality and network parameters.

3 - Revenue Management with Ancillary Services
John Wilson, Fredrik Odegaard

Motivated by the growing prevalence for airlines to charge for checked baggage, we consider the pricing of ancillary products. We assume there are two types of customers: those that only demand a primary item and will not consume the ancillary service and those that demand a primary item provided they also receive the ancillary service. The objective is to determine optimal prices both primary and ancillary products and derive structural properties for when it is optimal not to charge separately for ancillary services.

4 - Bundle Pricing of Ancillary Services with Dependent Valuations
Fredrik Odegaard, Mihai Banciu

This paper introduces a novel approach to bundle pricing of products or services when consumers' valuations exhibit dependence. We model the joint density of valuations using copula theory and provide analytical derivations for the prices under different bundling strategies. We also provide sharp bounds for the profit function regardless of the dependence functions and analyze how the typical assumption of independence impacts the seller's profits. Specifically, we find that the relative gap in profitability, which we call the "price of independence", can be arbitrarily bad.

■ HB-16

Thursday, 10:30-12:00 - Room 127

Topic Modeling and Information Retrieval with Applications

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Anton Khritankov*

1 - Finding Scientific Topics and Similarity Search
Anton Khritankov

Finding relevant scientific results is a common problem for researchers. It usually requires a researcher to know exactly what to look for, which might not be the case when research starts. We propose a feasible solution to this problem based on similarity search using topic models. In this report, we present a software system we built for a major library where it is used to search a collection of over 800 thousand full-text Ph.D. theses and other documents. We demonstrate the system and topic search on several examples.

2 - Topic Profiles - Applications of Topic Models
Caslav Bozic

Topic Models are statistical language models based on LDA. Instead of assigning only one 'language' to the document, they use a distribution across 'topics' which are in turn defined as distributions over words. This corresponds with the intuitive notion of a document containing a mixture of distinct topics, which can appear in different combinations and proportions. The presented results of method's novel applications include creation of 'Topic Profiles' for scholarly authors by analyzing texts of their publications, and using the profiles for quantitative matching with funding opportunities.

3 - Thematic Classification for EURO/IFORS Conference Using Expert Model
Arsentii Kuzmin, Alexander Aduenko, Vadim Strijov

The decision support system predicts the areas, streams and sessions for the abstracts of a major conference. Abstract collections from the previous EURO/IFORS (2010, 2012, 2013) conferences and their expert thematic models are considered. The terminological dictionary of the conference and the global thematic model of these collections are constructed. A similarity function between two abstracts is proposed. The non-metric hierarchical clustering algorithm which considers a constructed global thematic model is used to construct the thematic model of a new conference without an expert model.

4 - **Constrained Independent Semantic Analysis**
Takashi Onoda

Many clustering methods have been proposed due to the difference of the rule to generate a cluster. The clustering is unsupervised learning, so in many cases, an initial discovered clusters by a clustering method do not coincide with users' desired clusters. So many clustering methods are extended to deal with users' constraints. Recently, Independence Semantic Analysis (ISA) have been proposed. ISA is different from Latent Semantic Analysis (LSA). In this paper, we propose a method of constrained ISA. We show experimental results for some benchmark datasets using the proposed method.

■ HB-17

Thursday, 10:30-12:00 - Room 005

Conic Optimization and IPMs (contributed)

Stream: Interior Point Methods and Conic Optimization
Invited session
Chair: *Lino Silva*

1 - **An Active-Set Method for Conic Constrained Quadratic Programming**
Noam Goldberg, Sven Leyffer

We consider the minimization of a quadratic objective subject to second-order cone constraints; a formulation that generalizes bound-constrained quadratic programming and which can also be used for tackling more general variants. We propose a two-phase solution method: First, a projected gradient method is used to quickly identify the active set of cones. In the second phase a sequential quadratic programming (SQP) method is applied to rapidly converge given the subsystem of active cones.

2 - **An Adaptive Conic Approximation to Nonconvex Quadratic Programming Problems**
Qingwei Jin, Zhibin Deng, Shu-Cherng Fang, Cheng Lu

In this work, an adaptive conic reformulation and approximation is proposed for solving nonconvex quadratic programming problems. The original problem is transformed into a linear conic programming problem based on cones of nonnegative quadratic matrices. Then the linear conic problem is approximated adaptively by a sequence of subproblems. Each linear conic subproblem in the sequence can be solved using the semidefinite programming techniques. Several numerical examples are used to illustrate how the algorithm works and the computational results demonstrate the efficiency of the algorithm.

3 - **Characterizing Q-Linear Transformations for Linear Complementarity Problems over Symmetric Cones**
Julio López, Ruben Lopez, Hector Ramirez

In this work, we study the symmetric cone linear complementarity problem (SCLCP). Specifically, our aim is to characterize the class of linear transformations for which the SCLCP has always a nonempty and bounded solution set in terms of larger classes. For this, we introduce a couple of new classes of linear transformations in this SCLCP context. Then, we study them for concrete particular instances (such as second-order cone and semidefinite linear complementarity problems) and for some specific examples: Lyapunov, Quadratic, Stein and Rexalation transformations.

4 - **Improving the Preconditioning of Linear System arising in Interior-Point Methods by Updating the Controlled Cholesky Factorization**
Lino Silva, Aurelio Oliveira

This work presents an update of the controlled Cholesky factorization. It employs a hybrid preconditioner wich is build by combining the controlled Cholesky factorization and splitting preconditioner. This study reveals that the update proposed to the first preconditioner save considerable time in the preconditioning of linear systems arising in interior-point methods. It is important because the computational time required by interior-point methods is often dominated by the linear system solution.

■ HB-18

Thursday, 10:30-12:00 - Room 112

Behavioral Aspects in Multiple Criteria Decision Making

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Pekka Korhonen*

1 - **Pricing New Services Using Utility Functions**
Merja Halme, Outi Somervuori

Choice-based conjoint analysis is used to set prices of new services, which were available for a trial period in an airport relaxation area. 300 passengers evaluated the services with different prices after getting familiar with them using a questionnaire. The results allow to assess optimal prices for the different services and assess the value of different product profiles for the respondents. The study was ordered by the company managing Finnish airports. Its results will be compared with a similar study employing incentive-based conjoint analysis in the same environment.

2 - **Emotional-Motivational Responses Predicting Choices: A Neurophysiological Investigation**
Outi Somervuori, Niklas Ravaja, Murat Koksalan, Pekka Korhonen, Jyrki Wallenius

In the study, the participants made win-win and trade-off choices between three product packages (base package and two new product packages). Also, there were two conditions for the base packager: (a) high emotional attachment and (b) low emotional attachment. We found out that greater approach motivation and increased arousal elicited by a previously selected choice option predicted a stronger endowment effect. In addition, high trade-off difficulty was associated with increased withdrawal motivation (or less approach motivation) and negatively valenced arousal.

3 - **Predicting Choices with a Linear Value Function in a Four-Criteria MCDM Problem**
Tommi Pajala, Pekka Korhonen, Jyrki Wallenius

I predicted choices in a four-criteria pairwise MCDM problem with a linear value function model with the epsilon formulation (Korhonen et al., 2012). I investigated whether the Cognitive Reflection Test score is related to the predictive power, but no effects were found. Most subjects were inconsistent with their importance of criteria, questioning the usefulness of eliciting judgments of importance. The model predicted 81,7 % of choices, outperforming models using equal weights, weights derived from importance judgments, or a lexicographic strategy across both nonlinear and linear subjects.

4 - **Difficulties in Making Rational and Consistent Choices**
Pekka Korhonen, Niklas Ravaja, Outi Somervuori, Jyrki Wallenius

We present the results of an experiment with the aim to study, whether the choices of subjects are rational and/or consistent. If not, then we would like to understand "why not"? The choice problems are quite simple consisting of 2-3 criteria and 3, 4, and 6 alternatives. Our pilot study revealed that the subjects had difficulties in making rational and consistent choices. We are in the process of repeating the experiment with a larger group with an aim to look for plausible explanations to our findings. The study is based on the use of two sets of criteria: utilitarian and hedonistic.

■ HB-19

Thursday, 10:30-12:00 - Room 128

Retail Inventory Management

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session
Chair: *Heinrich Kuhn*

1 - Clickstream Big Data and Dynamic Lot Sizing Models for Online Retailers
Yeming Gong, Haoxuan Xu

Our research is inspired by a leading online retailer using clickstream big data to estimate customer demand and then ship items to customers by a mode of "Delivery Before Order Making" (DBOM) operational mode. We first use clickstream data to obtain advance demand information in order quantities, lead time, and locations. We then integrate the forecasting with a single-item uncapacitated dynamic lot sizing problem in a rolling-horizon environment. Using the real clickstream data, we study the cost saving and fast delivery effects.

2 - Dynamic Lot-sizing Models with Advance Demand Information for E-tailers
Haoxuan Xu, Yeming Gong, Chengbin Chu, Jinlong Zhang

Facing time-varying demands, our paper studies the inventory replenishment planning problems for e-tailers able to obtain advance demand information (ADI). We incorporate ADI to dynamic lot-sizing models to formulate the problems in three scenarios. 1) Companies act as pureplay e-tailers with customers homogeneous in demand lead time. 2) Customers are heterogeneous in delivery priorities. 3) E-tailers operate in a bricks-and-clicks structure, where online and offline channels are either independent or interactive. We apply the methods to several e-tailers and validate the cost-saving effects.

3 - A Genetic Algorithm to Optimize a Multi-Product Continuous Review Inventory Model with Deterministic and Stochastic Demand
Ilkay Saracoglu, Seyda Topaloglu

This study aims to develop a multi-item, multi-period (Q, r) inventory policy in order to calculate the optimal order quantity and optimal reorder point under the constraints of shelf life, budget, storage capacity, and “extra number of products” promotions. Initially, the problem is formulated as a mixed integer linear programming (MILP) model. Next, a genetic algorithm (GA) embedded with a local search is proposed as a solution approach for large-scale problems. The results indicate that the proposed approach can generate good solutions within reasonable time frame.

4 - Flexible Capacity Strategy with Flexibility Degree under Demand Uncertainty
Liu Yang, Chi To Ng

This study focuses on flexible capacity strategy with flexibility degree under demand uncertainty, which has received little attention in the literature. The flexibility degree could be used to measure a firm’s ability to hedge against the demand fluctuations through adjusting its production quantity. We find the relationship between the flexibility degree and the capacity volume, which need to be considered simultaneously when a firm makes an optimal strategy. We solve the optimal strategy and identify their conditions.

■ HB-20

Thursday, 10:30-12:00 - Room 129

Optimizing Generation with Wind and Hydro

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Ali Koc*

1 - Wind Hydro Integration in Quebec Interconnection
Ali Koc

Renewable energy integration is receiving increasing attention in the energy industry. We study daily generation and transmission planning of a pure hydro-power system with large-scale wind power integration. We propose a two-stage stochastic program that addresses the wind power intermittency and aims to reduce the operating reserves, which help to stabilize the hydro network against wind power fluctuations. We use “range of operation” approach to make the two-stage program operationalizable in the multi-period setting. We present use cases from Quebec Interconnection.

2 - On How to Account for Short-Term Flexibility in a Medium-Term Optimization of Pumped Hydro Storages: A Multihorizon Stochastic Programming Approach
Hubert Abgottspon, Göran Andersson

The work is about how short-term flexibility influence medium-term self-scheduling policies for pumped hydro storages. We have compared different approaches based on dynamic programming with varying degree of detailism for intrastage subproblems: peak / offpeak prices, price duration curves, deterministic and stochastic subproblems. The policies are tested in a Monte Carlo simulation study. The results suggest that the more complex a power plant structure or market structure (e.g., ancillary services market) is, the more a detailed consideration of short-term flexibility is beneficial.

3 - Optimal Scenario Set Partitioning for Multistage Stochastic Programming with the Progressive Hedging Algorithm
Michel Gendreau, Pierre-Luc Carpentier, Fabian Bastin

We propose a new approach to reduce the total running time of the progressive hedging algorithm for solving multistage stochastic programs defined on scenario trees. Instead of using the conventional scenario decomposition scheme, we apply a multi-scenario decomposition scheme and partition the scenario set in order to minimize the number of non-anticipativity constraints on which an augmented Lagrangian relaxation must be applied. The proposed method is tested on an hydro-electricity generation scheduling problem covering a 52-week planning horizon.

■ HB-21

Thursday, 10:30-12:00 - Room 006

Cutting and Packing 2

Stream: Cutting and Packing
Invited session
Chair: *A. Miguel Gomes*

1 - Integer Programming Formulations for Approximate Solution of Circle Packing Problems
Edith Lucero Ozuna Espinosa, Igor Litvinchev

A problem of packing circles is considered. The aim is to maximize the number of circles packed. Frequently the problem is formulated as a nonconvex continuous optimization problem. New linear integer programing formulations are proposed based on approximating the container by a regular grid and considering the nodes of the grid as potential positions for assigning centers of the circles. Two families of valid inequalities are proposed. The case of nesting circles inside one another is also considered. Numerical results are presented to demonstrate the efficiency of the proposed approach.

2 - GPU-accelerated Irregular Nesting Algorithm with Raster Representation
Andre Sato, Giovanna Ono Koroishi, Thiago Martins, Marcos Tsuzuki

Cutting and packing problems are of great importance and an efficient solution can be beneficial in both economical and environmental terms. This work proposes an algorithm for the irregular strip nesting problem, in which the items are irregular and the container is a rectangular strip, with an infinite length. A raster variant of an overlap minimization algorithm is conceived. A parallel Euclidean distance transformation implementation is used to obtain the overlap value for each pair of item in a pre-processing step. The use of a GPU resulted in improved speed for the packing algorithm.

3 - A Two-Phase Nonlinear Programming Approach for Nesting Problems with Continuous Rotations
Pedro Rocha, A. Miguel Gomes, Rui Rodrigues, Franklina Toledo, Marina Andretta

The nesting problem is a Cutting and Packing problem variant with irregular pieces that aims to place pieces inside a strip with minimum length. We propose a 2 phases approach. The first phase starts by placing a set of big pieces favouring the fitting between them, up to a target value. The second one places the small pieces in the holes between the big ones while minimizing the layout length. Managing the tradeoff between the target value, the number of holes and the big/small pieces division size is the major challenge in this approach. Preliminary experiments have shown promising results.

4 - Upper Bounds for Heuristic Approaches to the Strip Packing Problem

Torsten Buchwald, Guntram Scheithauer

We present an algorithm for the two-dimensional SPP that improves the packing of the FFDH heuristic and state theoretical results of this algorithm. We also present an implementation of the FFDH heuristic for the three-dimensional case, which is used to construct a new algorithm with absolute performance ratio of at most 5. Based on this algorithm, we prove a general upper bound for the optimal height, which depends on the continuous lower bound and the maximum height lower bound, and show that the combination of both lower bounds also has an absolute worst case performance ratio of at most 5.

■ HB-22

Thursday, 10:30-12:00 - Room 007

Auctions and Algorithmic Mechanism Design

Stream: Algorithmic Game Theory
Invited session
Chair: *Gagan Goel*

1 - Revenue Monotone Auctions for Online Advertising

Gagan Goel

Online advertising is an essential part of the Internet and the main source of revenue for many web-centric firms. A key component of online advertising is the auction mechanism which selects and prices the set of winning ads. This work is inspired by one of the biggest practical drawbacks of the widely popular VCG auction mechanism. It is known that VCG lacks a desired property of revenue monotonicity (RM) - revenue of a mechanism should not go down as the number of bidders increase. In this work, we design mechanisms that satisfy RM for two practical scenarios from online advertising.

2 - Mechanism Design for Crowdsourcing

Adish Singla

The recent adoption of crowdsourcing markets in the Internet has brought increased attention to the scientific questions around the design of such markets. A common theme in these markets is that there is a requester who has a limited budget and a set of tasks to accomplish by a pool of online workers. A key to making these markets efficient is to design proper incentive structures and pricing policies for workers. We will present our mechanisms that trade-off between efficiency and workers' incentives, under the realistic market constraints, such as skill matching and limited budget.

3 - Bidding in Markets with Non-Convex Costs: A Comparison of Market Outcomes Under Different Pricing Mechanisms

Panagiotis Andrianesis, George Liberopoulos

Truthful bidding in markets with non-convex costs, under marginal cost pricing, may result in losses for the market participants. To deal with this highly undesirable property, various pricing schemes have been proposed that provide side payments and/or higher than marginal prices. We present several such schemes and explore the market outcomes under competitive bidding for a stylized capacity-constrained duopoly. We employ a game-theoretic methodology to study the behavior of the two suppliers and compare the equilibrium outcomes under different pricing mechanisms.

■ HB-23

Thursday, 10:30-12:00 - Room 008

How Corporations Use Analytics to Impact the Bottom Line

Stream: Analytics Application and Practice
Invited session
Chair: *Rina Schneur*

1 - Resource Allocation Analytics for US Hospitals

Don Kleinmuntz

US healthcare organizations are making large investments in Analytics to cope with the requirement to provide higher quality services at lower cost. This presentation will describe lessons learned on how to address this through 18 years implementing optimization-based resource allocation Analytics in hospitals.

2 - Work Center Location and Technician Assignment to Minimize Total Business Cost

Dave Allen, Roger Tobin

Work of a telecommunications company involves installing, maintaining, and expanding its infrastructure, requiring many employees and vehicles located at work centers. These serve as a home base for workers, provide a supply chain location for parts, supplies, and tools, provide parking for vehicles, and represent a significant cost of doing business. This paper addresses the problem of determining where work centers should be located and where to assign techs to provide appropriate service levels at lowest cost. Optimized results show significant savings compared to current operations.

3 - Forget the Drones: The UPS ORION Project

Ranganath Nuggehalli

UPS delivers more than 16 million packages every day in US alone. To manage the ever increasing complexity of its delivery operations, UPS embarked on an ambitious mission in 1999 to streamline and automate its delivery route planning process. ORION (On-Road Integrated Optimization and Navigation) is the result of this long quest. Considered to be the largest operations research project in the world, ORION uses an array of technologies and advanced algorithms, to provide the UPS drivers with optimized routes. This presentation will focus on the development and deployment of the ORION system.

■ HB-24

Thursday, 10:30-12:00 - Room 212

Dynamic Mechanism Design

Stream: Dynamic and Repeated Games
Invited session
Chair: *Tristan Tomala*

1 - Incoming Demand with Private Uncertainty

Daniel Garrett

We study a profit-maximizing monopolist selling a durable good to buyers who arrive over time and whose values for the good evolve stochastically. The setting is completely stationary with an infinite horizon. Contrary to the case with constant values, optimal full-commitment prices fluctuate over time. We show how the pattern of optimal prices at a steady state can be understood by considering a stationary dynamic program. Departing from the stationary setting, we illustrate how changes in the arrival rate of buyers to the market can affect optimal pricing, providing a novel rationale.

2 - The Delayed-Verication Mechanism for Dynamic Implementation

Olga Gorelkina

This paper introduces a mechanism that virtually implements the socially efficient allocation with sequentially arriving agents, and agents' prior over future types is more informative than the principal's prior. To reveal the agents' information, the mechanism features a scheme of betting on future type reports. An agent's betting reward depends on how accurately his reported prior predicts the type reports observed in the following period. In an environment with negative externalities, this mechanism satisfies ex ante participation constraints and generates no deficit ex post.

3 - Dynamic Moral Hazard with Persistent States
Suehyun Kwon

This paper studies a principal-agent problem in a partially persistent environment. The costly unobservable action of the agent produces a good outcome with some probability corresponding to the state. The states are unobservable and follow an irreducible Markov chain. The second-best contract resembles a tenure system: The agent is paid nothing during a probationary period after which the principal implements the first-best action every period. The second- best contract becomes stationary or has a finite memory after tenure. We provide a recursive formulation for complete characterization.

4 - Approximate Implementation In Markovian Environments
Tristan Tomala

This paper considers dynamic implementation problems in environments with changing private information (according to Markov processes). A social choice function is approximatively implementable if it is correctly implemented an arbitrary large number of times with arbitrary high probability in all (communication) equilibria. We show that if a social choice function is strictly efficient in the set of social choice functions that satisfy an undetectability condition, then it is approximatively implementable. We revisit the classical monopolistic screening problem and show that the monopolist

■ HB-25

Thursday, 10:30-12:00 - Room 009

Advanced OR Methods for Data Mining

Stream: Data Mining
Invited session
Chair: *Richard Weber*

1 - Mixed-Integer Linear Programming Formulations for Feature Selection and Support Vector Classification
Sebastian Maldonado, Juan Perez, Richard Weber, Martine Labbé

The performance of classification methods, such as Support Vector Machine (SVM), depends on the proper choice of the feature set used to construct the classifier. In this work we propose two different Mixed-Integer Linear Programming formulations based on extensions of SVM. These approaches perform feature selection during classifier construction using optimization models. Experiments on real-world datasets demonstrate the effectiveness of our approaches, obtaining classification models that outperform existing techniques using consistently fewer features.

2 - Semi-Supervised Constrained Clustering with Cluster-Dependent Constraints
Cristian Bravo, Richard Weber

In this work we present a heuristic procedure to perform clustering subject to constraints for K classes, when the constraints refer to the cluster themselves, that is, an element must satisfy a set of constraints given the cluster in which the element is in. These constraints can link clusters, or can just restrict the space of feasible points that cluster can permit. The problem, combinatorial in nature, appears when incorporating external knowledge about the structure of the clusters, and is of use in Business Analytics applications, as will be shown in the presentation.

3 - Advanced Adversarial Classification using Game Theory and State-of-the-Art Data Mining Approaches
Richard Weber, Nicolas Figueroa, Gaston LHuillier

We propose to model the interaction between classifiers and adversaries in adversarial classification as a two-player game. We show how to model the interaction between players and present an adversary-aware online support vector machine (AAO-SVM) which provides competitive classification results in a real-world environment and reveals important insights into the complex relation among players. In the particular application we analyze emails in order to identify phishing messages, making necessary text mining techniques for feature construction.

■ HB-26

Thursday, 10:30-12:00 - Room 010

Nondifferentiable Optimization: Theory, Algorithms and Applications II

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Welington de Oliveira*

1 - Assessing Numerical Performance of some Nonsmooth Optimization Methods in Solving Thermal Unit-Commitment Problems
Marcelo Cordova, Erlon Finardi, Welington de Oliveira

Optimization problems arising from the energy sector often need to be decomposed for numerical tractability. In the presence of coupling constraints, Lagrangian Relaxation is an important tool for decomposing the problem into smaller, and easy-to-solve subproblems. The resulting dual problem, which is convex, but nonsmooth, provides useful information such as a pseudo solution and bounds for the optimal value. In this work we focus on bundle methods for nonsmooth convex optimization. We assess the performance of several algorithms in real-life unit commitment problems in the energy sector.

2 - Solving Convex Optimization Problems with Column Generation and Interior Point Methods
Pedro Munari, Pablo Gonzalez-Brevis, Jacek Gondzio

The column generation technique and the primal-dual interior point algorithm can be suitably combined for solving challenging optimization problems. Interior point methods provide stability to column generation, typically reducing the number of iterations and improving running times. In this talk, we describe the theoretical and computational issues regarding such combination. In addition, we present the results of using this strategy to solve convex optimization problems which arise in important real-life situations, such as data analysis, decision-making under uncertainty and networks.

3 - A Parallel Bundle Framework for Asynchronous Subspace Optimization of Nonsmooth Convex Functions
Frank Fischer, Christoph Helmberg

We present an algorithmic framework for optimizing convex functions by nonsynchronised parallel processes. Each process runs a bundle method on a problem restricted to a suitable subset of coordinates until sufficient progress is attained. To ensure convergence, dependencies between coordinates are automatically detected by analysing aggregate subgradient information. We apply the framework to problems with different structure: a single convex function, the sum of partially separable convex functions, and a function obtained by Lagrangian relaxation of packing type constraints.

4 - Non-smooth Optimization Methods for Chance Constrained Programming
Welington de Oliveira, Wim van Ackooij

Chance constrained programming is one of the main approaches for dealing with uncertainty in optimization problems. This approach is particularly suitable whenever high uncertainty is involved and reliability is a crucial issue. Contrary to conventional optimization problems, chance constraints are, in general, not given explicitly. They can be non-differentiable and difficult to be evaluated. In this work we present bundle methods suitable for solving convex problems of this class. We give some numerical results on realistic joint chance constrained energy problems.

■ HB-27

Thursday, 10:30-12:00 - Room 213

Decision Analysis and Performance Measurement

Stream: Decision Analysis, Decision Support Systems
Contributed session
Chair: *Josep Freixas*

1 - Creating New Agreements by Adjusting Evaluation Dimensions
Tsutomu Mishina, Alejandra Gomez Padilla, Kei Ogiwara

Teams where each member has diverse ideas may have great potential to perform high levels of accomplishments. However, in order to achieve goals effectively, the team must share an overall understanding of the common objectives and procedures. This paper shows a method to reach a consensus through negotiations when different opinions arise in the process of decision making. We propose a logical procedure to create a new agreement, first by increasing evaluation items, then gradually decreasing the assessment elements back to the original structure of the decision making.

2 - Measuring Decision Making Ability
Ceren Akman Biyik, IrfanUllah Shah, Sabri Erdem

Decision making is important in our daily and professional life. It has an effect especially on productivity or profitability. In this respect the aim of the study is to prepare a scale to measure decision making ability of individuals. The steps that we follow in our research process are as follows; we got five expert opinions, we have 15 phd candidates as a focus group, and idea generation with PhD candidates via workshops, scale preparation and dimension reduction via factor analysis after data gathering by pilot study and principal component analysis over target group as final study.

3 - Two-Stage Superposition Choice Procedures and their Properties
Sergey Shvydun

30 two-stage superposition choice procedures are studied. The two-stage superposition choice procedure is a procedure which sequentially applies two choice procedures in compliance with superposition principle. The main goal is to define which of them satisfy given normative conditions. Normative conditions show how a final choice is changed due to the changes of preferences, a set of feasible alternatives, or a set of criteria. A theorem is proved showing which normative conditions are satisfied for two-stage choice procedures under study.

4 - A Comparative Study of Success and Decisiveness
Josep Freixas, Montserrat Pons

The power of individuals participating in a vote depends on their position in the voting system and their intention to vote. The position of voters is modeled by the strength they have in the voting system, while voting intention is modeled by a probability vector. The decisiveness and success of the voters are the two main aspects to be measured in such situations. This work presents a study on the similarities and differences of these two main concepts, e.g., situations in which they are ordinally equivalent are determined.

■ HB-29

Thursday, 10:30-12:00 - Room 011

Planning and Scheduling in Petrochemicals

Stream: OR in Petrochemicals and Mining
Invited session
Chair: *Silvio Hamacher*

1 - Production Planning and Scheduling in Cogeneration Systems in Refineries
Ertürk Açar, Metin Turkay

Electricity and steam pose significant challenges in the daily operation of oil refineries due to the fact that they cannot be inventoried for later use. Therefore, production planning to fulfill the steam and electricity demand, considering fluctuations in the price of electricity within a day, is one of the primary objectives. In this work, we present an industrial scale decision support system for the rational analysis of operational decisions. We present our MILP modeling approach and summarize the findings on an industrial case study.

2 - Decomposition Method for Mutiperiod Blending Scheduling
Irene Lotero, Francisco Trespalacios, Ignacio Grossmann

A decomposition approach to the multiperiod blending problem arising in the petroleum industry is presented. The proposed algorithm decomposes the MINLP model in two levels: a master problem that is an MILP relaxation of the original MINLP that provides rigorous upper bounds, and a subproblem, where a subset of discrete variables are fixed, yielding a reduction in the number of binary variables and bilinear terms. These problems are solved successively until the gap between the upper and lower bounds is closed. We illustrate this method and its computational results with several examples.

3 - An Efficient Decomposition Strategy for the Petroleum Operational Planning Under Uncertainty
Tiago Andrade, Fabrício Oliveira, Gabriela Ribas, Silvio Hamacher

Oil refining is one of the most complex activities in the chemical industry, mostly because of the nonlinear nature of the refining processes and their several possible configurations. Moreover, uncertainties concerning the input data surround the definition of optimal operational plans and must, thus, be considered in the decision process. This work proposes a two-stage stochastic model for the refinery operational planning problem under uncertainty, combined with a decomposition method to efficiently solve this model. Results obtained confirm the superior performance of the proposed method.

4 - Refinery Operational Planning Under Uncertainty
Silvio Hamacher, Gabriela Ribas, Fabrício Oliveira

This article presents a two-stage nonlinear stochastic model to the refinery planning problem. The scenario tree generation is essential for good performance of the stochastic model, but there are few accounts of how to measure the influence of scenario trees on the quality of the stochastic solution. This study proposes the selection of scenario trees via quality measures that intends to assess the ability of scenario trees to approximate the solution of the stochastic model. The results provide advances in the refinery planning process and contributions for the scenario tree generation.

■ HB-30

Thursday, 10:30-12:00 - Room 012

Teaching OR/MS 1

Stream: Teaching OR/MS
Invited session
Chair: *Vladimir Deineko*

1 - OR/MS Tools for Teaching/Learning Integrated Bottom-Up Energy Modelling
Denis Lavigne

This presentation offers you an overview of a new energy modelling course that I created and taught at the École Polytechnique de Montréal during the fall semester of 2013. I will share the experience I gained from teaching it to graduate students and propose a basic course outline that could be useful for whom wishes to choose a similar approach for teaching bottom-up energy modelling using simple yet powerful software such as LEAP and OSeMOSYS. The students had the opportunity to work hands on a project that enlightened greatly their understanding of what energy modelling is.

2 - Educating Military Operations Research Practitioners
Ron Fricker, Robert Dell

The 2013 Smith Prize was awarded to the Naval Postgraduate School (NPS) Operations Research (OR) department for "effective and innovative preparation of students to be good practitioners of operations research, management science or analytics." In the spirit of the prize, this talk shares details about our degree program. NPS began offering a degree in OR in 1951, making it the first OR degree in the United States. The program is closely linked to its sponsor, the US Department of Defense, in a unique relationship that ensures NPS OR is focused on important military problems.

3 - MS Excel-based Software Tools for Decision Problems with Multiple Criteria
Josef Jablonsky

Multiple criteria decision making (MCDM) and data envelopment analysis models, even they solve different problem classes, belong to the most often used modeling techniques at all. Their effective teaching depends on availability of appropriate software tools. The paper presents two freeware software systems - DEA Excel Solver and Sanna. DEA Excel Solver covers basic DEA models, and uses the internal MS Excel optimization solver. Sanna is a simple MS Excel based application for multi-criteria evaluation of alternatives using several important MCDM methods.

4 - Using OR to Teach OR whether we Practice what we Preach
Vladimir Deineko

In this presentation we talk about our experience of developing and using IT tools to enhance the teaching and learning process. We will talk about an allocation of students to equitable teaching groups, the OR techniques behind the allocation tool, and the experience of teaching the students in the groups. In another example we describe a decision support system for generating test problems for linear programming assignments and for semi-automatic marking the students' models and solutions.

■ HB-31

Thursday, 10:30-12:00 - Room 013

Survivability and Vulnerability

Stream: Telecommunications and Networks
Invited session
Chair: *Eduardo Álvarez-Miranda*

1 - Models for Communication Network Design with Survivability Requirements
Remberto Emanuel Delgadillo, Irene Loiseau

A telecommunication network is said survivable if it is able to provide service after one of its components fails. A p-cycle provides one protection path for a failed span it crosses and also protects spans that have both end nodes on the cycle but are not on the cycle. P-cycle based networks gather the characteristics of both mesh and ring topologies. The Spare Capacity Allocation problem requires to protect the traffic of a network with p-cycles at minimum cost. We propose a new ILP model that does not require a priori candidate cycle enumeration. Results improved those of previous models.

2 - The Minimum Flow Cost Hamiltonian Cycle Problem.
Camilo Ortiz, Ivan Contreras, Gilbert Laporte

We introduce the Minimum Flow Cost Hamiltonian Cycle Problem (FCHC). Given a graph and positive flow between pairs of vertices, FCHC consists of finding a Hamiltonian cycle that minimizes the total flow cost between pairs of vertices through the shortest path on the cycle. Applications arise naturally in general network design problems in which a ring topology is sought. We present five MIP formulations for the FCHC which are theoretically and computationally compared. We also propose families of valid inequalities and perform some computational experiments to assess their performance.

3 - Vulnerability Assessment of Spatial Networks: Models and Solutions
Eduardo Álvarez-Miranda, Alfredo Candia-Véjar, Emilio Carrizosa, Francisco Javier Pérez Galarce

In this paper we present a collection of combinatorial optimization problems that allow to assess the vulnerability of spatial networks in the presence of disruptions. The proposed measures of vulnerability along with the model of failure are suitable in many applications where the consideration of failures in the transportation system is crucial. By means of computational results, we show how the proposed methodology allows us to find useful information regarding the capacity of a network to resist disruptions and under which circumstances the network collapses.

4 - Combined Network Design and Routing Optimization using Distributed Benders Decomposition
Dimitri Papadimitriou, Bernard Fortz, Enrico Gorgone

The combined network design and distributed routing problem can be formulated as a large-scale multi-period mixed integer optimization problem. Its resolution on realistic instances is intractable and unscalable with state-of-the-art solvers which ignore the distributed nature of routing. We decompose the global optimization problem following the distributed Benders decomposition method. Using this method, the optimization problem subdivides into a distributed master problem solved at each node and subproblems of tractable size involving only local decisions when computing routing paths.

■ HB-32

Thursday, 10:30-12:00 - Room 014

Supply Chain Management - Assembly Lines and Maintainance

Stream: Production Management & Supply Chain Management
Contributed session
Chair: *Ileana Perez*

1 - Calculation of the Troughput Time in Simple Assembly Lines with Learning Effect
Tamás Koltai

During the startup period, learning effect may significantly influence the operation time of workstations in assembly lines. When learning effect is present, the operation time of the workstations depends on the number of times the operations are repeated. The operations, however, are repeated fewer times at the downstream workstations, than at the upstream workstations. This phenomenon makes the estimation of the throughput time difficult. An algorithm is presented to calculate the throughput time of a given production quantity in simple assembly lines at the presence of learning.

2 - A General Framework for Comparing Condition-based Maintenance with Age-based Maintenance
Bram de Jonge, Ruud Teunter, Tiedo Tinga

Condition-based maintenance (CBM) is often preferred over age-based maintenance because of its just-in-time nature. However, the performance of CBM strongly depends on the characteristics of the deterioration process, the cost structure, the setup time required to perform preventive maintenance, the accuracy of the measured condition information, and the uncertainty in the deterioration level at which failure occurs. We present a general framework for assessing the benefits of CBM.

3 - A New Look at the Bowl Phenomenon
Alysson M. Costa, Pedro B. Castellucci

The bowl phenomenon states that assembly lines having central stations with slightly less load than external ones are more productive than perfectly balanced lines. The topic has been the subject of some controversy in the literature. We present new simulations that tend to confirm the existence of the phenomenon. These simulations are different from previous ones since they: a) consider the indivisibility of tasks in the load assignment, b) use a large set of new instances recently proposed in the literature and c) are extended to the case of heterogeneous workers.

4 - General Procedure Oriented to Improve a Maintainance Plan Based on PMO and RCM
Ileana Perez, Jose Alberto Rojas Lopez, Lina Marcela Moncayo Gonzalez, Yasmin Tocoche

This paper presents a general procedure oriented to improve a maintenance plan based on the Methodology of Preventive Maintenance Optimizing (PMO). It integrates decision making tools of the Reliability Centered Maintenance (RCM) methodology, Industrial Engineering Tools such as motion and time studies techniques, key performance indicators analysis and continuous improvement models. It also exhibits design and implementation in a Colombian meat food company.

■ HB-33

Thursday, 10:30-12:00 - Room 015

Hyperheuristics: Interfaces, Implementations and Applications

Stream: Hyperheuristics
Invited session
Chair: *Shahriar Asta*
Chair: *Daniel Karapetyan*

1 - The Broadening Future of Hyper-heuristic Interfaces
Andrew J. Parkes, Ender Özcan

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. We discuss ideas for enriching the interface to allow better search control. 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.

2 - Hyperheuristic Applied to Maritime Service Network
Kassem Danach, Wissam Khalil, Shahin Gelareh

Many exact methods proposed to solve variants of service network design problem (SNDP). However, it is known that the successes with such methods are almost limited even with small size instance with more real features of real practice. In this article, we are resort to hyperheuristics to develop methods based on a low level heuristics for solving instance in liner shipping SNDP. Our problem description takes into account more aspects of reality (time windows, customers' priorities, delays, fuel, assets, etc.). Our work is supported by computational experiments from the real-world cases.

3 - Cretaing Heuristics viA Many Parameters: CHAMP
Shahriar Asta, Ender Özcan, Andrew J. Parkes

Hyper-heuristics are search methodologies which, in contrast to meta-heuristics, take the search a level higher to either low level heuristic selection or heuristic generation. We represent a generation heuristic using a "many parameter" representation stemmed from policy indexing (hence the name Creating Heuristics viA Many Parameters - CHAMP). Index policies assign scores to available options leading to a ranked based decision system. We have performed experiments on the well-known online bin-packing problem (NP-hard) resulting in powerful policies outperforming well known heuristics.

4 - James: A Modern Java Framework for Optimization using Local Search Metaheuristics
Herman De Beukelaer, Guy Davenport, Geert De Meyer, Veerle Fack

A major advantage of metaheuristics is that they are generally applicable to optimization problems from various fields. James is a modern object-oriented Java framework that exploits this generality by separating metaheuristic implementation from problem specification. A wide range of generic local search algorithms are provided, which can easily be applied to any user-defined problem, by plugging in a custom objective and neighbourhood for the corresponding solution type. Predefined components are included in the framework for common optimization problems, including subset selection.

■ HB-34

Thursday, 10:30-12:00 - Room 016

Financial Modeling 2

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Luiz F. Autran M. Gomes*

1 - ARIMA: A Model for the Time Series Forecast applied to Sao Paulo Stock Exchange Index
Leonardo Alves de Carvalho, Edson Pamplona, Paulo Rotela Junior, Fernando Salomon

The study aims to evaluate the performance of the ARIMA model to predict the time series of Sao Paulo Stock Exchange index. The research method used was mathematical modeling and followed the Box-Jenkins methodology. To compare the results with other models of smoothing we used as a parameter for assessing the MAPE (Mean Absolute Percentage Error). The results prove that the 'one step ahead' model used had lower MAPE indicating their better fitness, and it shows that the ARIMA model can be used for time series of indices related to the stock exchange.

2 - The Influence of Crude Oil Prices in Emerging and Developed Capital Markets
André Salles

The purpose of this work is to study the relationship between crude oil prices and selected stock markets. This work studies the cointegration and the conditional correlation of crude oil and stock market returns. It also estimates SUR models to explain each stock market index returns using first the global stock market index as a regressor and later the global stock market and crude oil returns as repressors of five emerging markets and five developed markets. The data used in this study is daily closing quotations in US$ of stock market index of selected emerging, developed and global stock

3 - Application of Real Options Fuzzy Pay-Off Method: An Ex-post Multi-criteria Analysis
Luiz F. Autran M. Gomes, Luiz Geraldo Biagioni Martins, Carlos Bastian-Pinto

The purpose of this paper is to demonstrate the importance and also to recommend the application of multi-criteria decision aid methods especially in decisions under uncertainty and changing environments. By using an actual case presents an ex-post evaluation, applying the Real Options Fuzzy Pay-Off method, to select the best alternative location of an expansion industrial project and comparing with the decision taken at that time by the company. It highlights the relevance of scenario analysis and the introduction of qualitative variables in addition to economic and financial parameters.

4 - Degree of Relationship Between Indicators of Capital Market, the Financial Indicators and the Return of Shares in Brazilian Companies — A Multi-criteria Analysis
Nelson Hein, Adriana Kroenke, Itzhak David Simão Kaveski

This study aimed to establish the degree of relationship between the indicators of the capital market, financial-economic indicators and the return of share, in the brazilian companies. To make the analysis was used the Vikor multi-criteria method. Were selected 27 companies belonging to IBrX-50 (Brazil), basing the analysis for the periods 2008 to 2012. It was concluded that, for some companies the analyzed years, tend to have similarities in efficiency positions in the capital market, in the traditional economic and financial indicators and the return of shares.

■ HB-35

Thursday, 10:30-12:00 - Room 131

Stochastic Modeling

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Frank Herrmann*

1 - **An Agent-based Simulation of the Diffusion of Intelligent Technical Systems in Future Markets**
Christian Stummer, Lars Lüpke, Sabrina Backs

In the German Leading-Edge Cluster (Spitzencluster) "it's OWL" 174 companies and research institutions cooperate in 45 projects in furthering the development of (successful) intelligent technical systems. Our contribution lies in setting up a tool that can support decision makers in finding the "best" combination for the attributes of their systems with respect to the envisioned market segments. To this end, we resort to scenarios for the respective markets ("ITS 2020") and run simulations for various alternatives. In our talk, we discuss remaining challenges and provide some initial results.

2 - **A Bayesian Negotiation Model for Reliability and Price**
María Jesús Rufo Bazaga, Jacinto Martín, Carlos Javier Pérez Sánchez

This paper presents a Bayesian sequential negotiation model between a manufacturer and a consumer on two issues (price and lifetime of a product). A mediator's presence is not required. The decision problem is solved under the manufacturer viewpoint. A class of parametric lifetime distributions that belong to the exponential family is considered. Thus, a unified framework addressing the main points in the work is shown. In particular, a simulation-based approach is proposed. Finally, an application is presented to show that this technique can be easily applied in practice.

3 - **Simulated Determination and Usage of a Clearing Function for Leadtime Estimation**
Frank Herrmann

In production systems, nonlinear relationships occur between lead times of orders and the system workload. Relative recently a clearing function (CF) is introduced to describe these nonlinear relationships. A new simulation based determination of CF is presented. Its quality is analysed. In addition it is applied to two major problems in operative production planning and control. A CF based order release outperforms an inventory based order release.

■ HB-36

Thursday, 10:30-12:00 - Room 132

Sustainable Forest Management

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Gaby Deckmyn*

1 - **Multi-criteria Analysis Techniques to Prioritize Criteria and Indicators for Sustainable Management of Mediterranean Forests**
Pablo Valls-Donderis, María C. Vallés, Francisco Galiana

A set of criteria and indicators for sustainable forest management under Mediterranean conditions applicable at the forest management unit scale have been identified. Aspects have been defined for each criterion, they refer to the specific topics that it covers. In order to verify and prioritize the criteria, aspects and indicators, two processes have been carried out: a participation process to rank criteria and aspects according to participants' preferences for a specific forest; and a questionnaire with experts to rank the indicators through pairwise comparisons.

2 - **Simulating Temporal Dynamics of Provisioning Ecosystem Services from Agricultural and Agro-Forest Land Uses**
Marcos Jiménez-Martínez, Christine Fürst

A key issue in land use planning is how to maintain the functioning of ecosystem processes to ensure the provision of natural resources. Through this research, land use models accounting for management techniques will be embedded to spatially assess their impact on the temporal fluctuations of biomass related products (food, fodder, energy, raw industrial materials) provision on a district/watershed scale in Upper East Ghana. This project contributes to the development of the software platform GISCAME, supporting the assessment of regional land use change scenarios.

3 - **How to make Mechanistic Forest Simulations Fast and Easy for End-users: A Belgian Study using Regional Bayesian Parameterization**
Gaby Deckmyn

Mechanistic forest models can simulate responses to changes in climate and management, but their use is hampered by the high number of input parameters and the resulting large uncertainties. We used Bayesian parameterization to acquire robust parameter values that were used to simulate growth and yield of for different species, soil types and climate regions of Flanders, under different managements and climate scenario's using the ANAFORE forest model. The results (> 600.000 simulations) were used to create a database that allows fast analyses on climate, soil and management effects.

4 - **Carbon Footprint and the Management of Metrological Laboratories**
Teresa Pino, José L. Pino, Mª Teresa Cáceres

Metrology is important for scientific research,industry and our everyday lives.This activity belongs to the service sector, and not out among the most studied activity due to contamination. However, calibrations require laboratories that keep the controlled and constant environmental conditions throughout the year and this implies high energy consumption. In this work we show how by associating carbon emission parameters with various decision variables, traditional models can be modified to support decision-making for minimize operational cost and carbon footprint in metrological laboratories.

■ HB-37

Thursday, 10:30-12:00 - Room 017

Multi-Actor Multi-Criteria Analysis

Stream: Multiobjective Optimization
Invited session
Chair: *Cathy Macharis*

1 - **Involving Stakeholders in Transport Decision Making using Planning Workshops and MCDA**
Michael Bruhn Barfod, Marie Pryn

Developments regarding decision making in the transport sector has revealed an increasing need for involving stakeholders in the decision support process in order to capture all aspects of the often complex decision problems. This paper proposes the use of planning workshops and multi-criteria decision analysis to gather stakeholders and decision makers with the purpose of improving the final decision making by including a collaborative planning approach. An outline is made for how the planning workshop can be used for real decision support at different organizational levels in the process.

2 - **Should we Weight the Stakeholders in Multi-actor Multi-criteria Analysis (MAMCA)? Problem Description and Solutions**
Klaas De Brucker, Cathy Macharis

Recently MCA has been geared towards addressing stakeholder interests. For instance, in MAMCA criteria are clustered so that they contribute to particular stakeholder objectives. Here, the problem arises of aggregating the different points of view. We discuss several approaches to aggregate stakeholder points of view. Most of these use weights to obtain the multi-actor solution. A distinction is made between intra- and inter-stakeholder weights. Also the possibility of not using inter-stakeholder weights is discussed. The different approaches are illustrated using a real-life case study.

3 - **Application of MCDA Methods and Stochastic Dominance Rules in the Entry Mode Selection Process in International Expansion**
Dorota Górecka, Małgorzata Szałucka

When the company decides to go on foreign markets, it must take a number of strategic decisions, e.g., select a proper entry mode. Various entry modes differ greatly in resource commitment, degree of risk, level of control or profit potential. Hence, it is essential to conduct an analysis of their advantages and disadvantages from the point of view of various internal and external factors and taking into account the opinion of different participants of the decision-making process. The aim of the paper is to carry out the simulation of the entry mode selection, using MCDA methods and SD rules.

4 - Evaluation of City Distribution Projects: A Stakeholder-based Approach
Lauriane Milan, Cathy Macharis, Sara Verlinde

Organizing freight transport in a sustainable way is one of the challenges faced by urban areas. Most of the measures that have been tested suffer from a lack of systematic evaluation and long term adoptions often fail, because not all stakeholders were taken into account (Macharis & Melo, 2010). The new City Distribution—Multi Actor Multi Criteria Analysis (CD-MAMCA) assessment framework incorporates the city distribution actors and their objectives as the primary focus complemented with a Multi-Criteria Decision Analysis performed with the GDSS-PROMETHEE GAIA.

■ HB-38

Thursday, 10:30-12:00 - Room 214

Soft OR / Systems and Multimethodology 1

Stream: Soft OR / Systems and Multimethodology
Invited session
Chair: *Leroy White*

1 - Refining a Generic Constitutive Definition of PSMs through the use of Quantitative Data
Mike Yearworth, Leroy White

Is it possible that PSMs are actually in widespread use? We do not know for sure because use of PSMs could be under reported. What seems more likely is that use of PSMs is not recognised or described as such, and is also under reported. In previous work we have addressed the problem of how to identify non-codified PSM use. Here we discuss how our method might be implemented at scale in order to answer the question. We also discuss the benefit of obtaining a large data set of PSM use in terms of refining our generic constitutive definition of PSMs through the use of quantitative data.

2 - Building a Better Model: A Novel Approach for Mapping Organizational and Functional Structure
Damian Flynn

Complex organisations often rely on informal social group networks which can contradict the organisation's more formal hierarchy chart. The ability to perform is shaped by both formal and informal arrangements. This paper proposes a novel methodology for developing a model to represent the true functional and organisational structure within an organisation using a combination of social network analysis and group model building techniques. The methodology described represents a useful way to capture the current organisational state and its value is discussed through a case study.

3 - Promoting More Efficient Energy Behaviours: From a Soft OR Structuring Approach to Contextualised Understanding
Marta Lopes, Carlos Henggeler Antunes, Maria São João Breda, Paulo Peixoto, Nelson Martins

Energy behaviours are recognised as increasingly important in the context of energy efficiency in the residential sector. More effective behaviour change interventions are required as a support for effective policies promoting energy efficiency. A multimethodology approach is used for structuring the influence of energy behaviours on energy consumption and contextualised understanding generated through a real-world intervention is exploited. Electricity monitoring data and questionnaires are analysed to identify the most relevant variables and validate the conceptual model developed.

■ HB-39

Thursday, 10:30-12:00 - Room 018

Advances on TSP and Related Subjects

Stream: Discrete and Global Optimization
Invited session
Chair: *Gerald Gamrath*
Chair: *Vladimir Ejov*

1 - SLH Algorithm for Solving Hamiltonian Cycles Problem
Vladimir Ejov

We describe a deterministic, polynomial complexity algorithm for solving the Hamiltonian Cycle Problem (HCP) in undirected graphs, called Snakes and Ladders Heuristic (SLH). We observed that the algorithm is successful even in cases where Hamiltonian cycles in the graph are extremely rare. The use of a stopping criterion ensures the heuristic terminates in polynomial time if no improvement is made. Comparison of SLH performance to the state of the art TSP algorithms Concorde and LKH (adapted to solving HCP) is provided. Practical on-line demonstration of SLH will accompany the presentation

2 - Investigating the Robustness of the TSP Routes through the Recognition of Special Structured Matrices
Azmin Azliza Aziz

In this study, the robustness of the TSP routes is investigated by recognizing the special combinatorial structures of Kalmanson and Burkard matrices. A recognition algorithm was developed and executed on a number of randomly generated instances. The procedures produce four lower bounds which provide guarantees on the quality of the solutions. Computational experiments showed that the proposed LP-based procedure performs consistently well and provides the best lower bounds to the TSP solutions. This is supported by small average deviation between the TSP tour lengths and the lower bounds.

3 - Conjecture about the Extremal Graphs for the Geometric-Arithmetic Index with Given Minimum Degree
Ljiljana Pavlovic, Tomica Divnic, Milica Milivojevic

The geometric-arithmetic index GA of a graph is defined as sum of weights of all edges of graph. The weight of one edge is quotient of the geometric and arithmetic mean of degrees of its end vertices. Let G(k,n) be the set of connected simple n-vertex graphs with minimum vertex degree k. We give a conjecture about structure of extremal graphs of this index for n-vertex graphs with given minimum degree. We find for k greater or equal to q(n-1), where q is approximately 0.0874, extremal graphs in G(k,n) for which geometric-arithmetic index attains its minimum value or we give lower bound.

4 - A Kind of Rollout Algorithm for N-Vehicle Exploration Problem
Xiaoya Li

This paper studies a kind of exploration problem with N vehicles, which is transformed to a sequential decision problem within a dynamic programming framework with complexity of factorial of N. By introducing two types of heuristic algorithms, the author proposes a kind of rollout algorithm that can greatly improve the performance of the base heuristic. Numerical examples show that the rollout algorithm using the second base heuristic always obtains the optimum, so the author discusses the relationship between rollout algorithm and optimal algorithm of N-vehicle exploration problem at last.

■ HB-40

Thursday, 10:30-12:00 - Room 019

Innovations in Meta-Analytics IV

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair: *Helena Ramalhinho Lourenco*

1 - Meta-Analytics for Market Basket Analysis
Antonio Ladrón de Guevara, Helena Ramalhinho Lourenco, Pedro Martins

The Market Basket Analysis consists in mathematical modeling and algorithm techniques to analyze the customer purchasing behavior and helps design of marketing strategies to increase sales. The main objective of this work is to study the application of Clique Models in the Market Basket Analysis. We propose the use of Metaheuristics to perform this Analytics study and evaluate the implications of the results in Marketing Strategies of a retailer company. We focus on the marketing analytics perspective, not on the mathematical and algorithm. The results presented are based on a real database.

2 - A Regret Model Applied to the Maximum Coverage Location Problem with Queue Discipline
Francisco Silva, Pedro Nunes, Helena Ramalhinho Lourenco

The article considers a special type of the Maximum Coverage Location problem where a queue discipline is considered at each server/location. This problem considers the location of services that do not only depend on the time between the demand points to the server, but includes also the service waiting time in a queue. Examples of such services are medical systems, police operations, and other public services. We propose a metaheuristics based on GRASP that incorporates the p-minmax Regret method to evaluate the heuristic solutions with respect to to its robustness within different scenarios.

3 - Advances in Solving Max 3-SAT Problems
Peter Greistorfer, Cornelia Rainer, Haibo Wang, Gary Kochenberger

We investigate a penalty function approach for the Max 3-SAT problem. This work extends a metaheuristic multi-start algorithm, which is based on adaptive memory projection. We present different randomized choice rules and advanced weighing schedules for the base greedy heuristic and introduce the first Max 3-SAT results made with LocalSolver, a new generation hybrid optimizer. Additionally, we use an LP-formulation and CPLEX to evaluate performance and results' quality of our different heuristic solution procedures, based on a DIMACS test set of problem instances.

■ HB-41

Thursday, 10:30-12:00 - Room 216

Stochastic Models for the Design of Supply Chain Networks

Stream: Stochastic Models for Service Operations
Invited session
Chair: *Walid Klibi*

1 - Service-Oriented Carriers Selection in Transportation Auctions under Uncertainty
Monia Rekik, Walid Klibi

We consider the problem of strategic carriers selection encountered by shippers that decide to outsource their transportation activities to external carriers on a long-term basis. The trading mechanism corresponds to a combinatorial reverse auction where the shipper is the auctioneer and competing carriers are the bidders. We propose a stochastic model for determining winning bids under the assumption that both shipment volumes and carriers quality of service are not known with certainty.

2 - Integrating Resilience in Stochastic Production-Distribution Network Design Models
Walid Klibi, Atidel B. Hadj-Alouane

This research studies alternative resilience seeking formulations to the production-distribution network design problem. The mathematical model builds on stochastic programing to consider uncertainty into a set of scenarios considering potential demand surges and disrupted production-distribution capacities. To foster resiliency, the concepts of chaining and multiple sourcing are inspected. This gives rise to a two-stage stochastic location-allocation model with multiple products and capacitated production features, and where the decisions include technology and facilities mission selection.

3 - A Stochastic Programming Approach to Design a Robust Supply Flow by Considering the Response Time Characteristics
Alireza Ebrahim Nejad, Onur Kuzgunkaya

The contingent sourcing is a cost-efficient strategy to deal with disruptions. The response time is crucial since only a fraction of required capacity might be available within this period. The objective of this paper is to determine optimal safety stock level and response speed of back-up supplier to build a robust supply chain. In order to incorporate the randomness associated with response time and disruptions, we present a robust optimization model. Through a sensitivity analysis we identify the optimal supply chain configuration with respect to the level of decision maker risk aversion.

4 - Studying of Networks' Dynamics by means of Probabilistic Modeling
Mark Korenblit, Ilya Levin, Vadim Talis

The work deals with a study of networks that grow according to a number of regularities. Specifically, each new vertex is connected to at most one existing vertex; any connection is realized with the same probability; the probability of connecting a new vertex to any existing vertex depends on the position of its degree in the sorted list of vertex degrees. We propose a number of models for such networks called one-max constant-probability models. The provided computer simulation allows studying the dynamics of the networks' topologies by recognizing some previously unknown phenomena.

■ HB-42

Thursday, 10:30-12:00 - Room 215

Integrated and Simulation-Based DSS Approaches

Stream: Decision Support Systems
Invited session
Chair: *Isabelle Linden*
Chair: *Shaofeng Liu*

1 - An e-Kanban based Decision-Support System for Semiconductor Ingot Manufacturing
Taho Yang

The present study proposed an e-kanban based decision-support system (DSS) for semiconductor ingot manufacturing which is comprised of three sub-systems - Lean system, e-Kanban and intelligent decision support system. This problem is motivated by an industrial-academic research project which becomes the foundation for the development. A semiconductor ingot manufacturing case is used for the empirical illustrations. The results are promising, there are foreseeable challenges which will also be addressed as future research opportunities.

2 - Multi-Resolution Analysis (MRA): Integrated Solutions for Today's Analytical Challenges
John Tindle

Multi-resolution analysis (MRA) is a general term developed in various centers of excellence regarding modeling, simulation, and analysis. The basic premise is that complex domains of capability should be analyzed from different perspectives with tailored models and tools appropriate for each perspective, but with the various segments of the analysis integrated to provide traceability of cause and effect for combined total impact. MRA produces greater depth of understanding in less time than traditional monolithic modeling approaches by employing 5 operations research techniques.

3 - Improved Decision Making by Incorporating Expert Opinions into Statistical Models
Dries Benoit, Kristof Coussement, Michael Antioco

Interest in the use of company (big) data and statistical methods to guide decisions has been increasing in recent years. However, the impact of refining decisions based on statistical analyses by integrating management opinions into the decision-making process has been under-investigated. This study develops an expert system that formally integrates subjective human expert opinions with objective organizational data. We empirically test our Bayesian expert system on a customer-satisfaction dataset and contrast it with the frequentist and human-experts alternatives.

■ HB-43

Thursday, 10:30-12:00 - Room 217

Scheduling and Optimisation Models

Stream: Optimisation in Health Care
Invited session
Chair:
Chair: *Engin Bayturk*

1 - An Optimization Model for Health Facility Location Planning Considering Congestion

Camila Metello, Fabrício Oliveira

Although health facility allocation has been a highly discussed theme in current literature, it is rarely combined with staff sizing, which, in terms of budget and process times, is a critical variable. We present an optimization model to plan health facilities logistics that focuses on process time minimization and considers congestion without compromising its linear structure. The model was applied to plan the mass vaccination against Influenza in Rio de Janeiro. Results helped generating a list of possible new facilities and a more efficient vaccine distribution plan.

2 - Comparison of Different Collimator Technologies Used in IMRT from an Optimization Point of View

Merve Gören, Z. Caner Taşkın

Collimator systems used in Intensity Modulated Radiation Therapy (IMRT) can form different geometric shapes of apertures depending on their physical capabilities. We compare the efficiency of using regular, rotating and dual multileaf collimator (MLC) systems under different combinations of consecutiveness, interdigitation and rectangular constraints and a virtual freeform collimator. We formulate the problem of minimizing beam-on time as a large-scale linear programming problem. To deal with its dimensionality, we apply column generation approach.

3 - Appointment Scheduling for the Breast Clinical of Oporto Oncological Hospital

Alcinda Barreiras

This problem studies a scheduling system for patients with breast cancer. The clinical breast unit of Oporto Oncological Hospital is responsible for the schedule of the diagnosis appointment, treatment decisions appointment and follow-up appointment, as well as imaging, laboratory and pathological exams required for each patient. The variables for the model are the waiting times and the pre-established intervals between the different phases of the pathway that a cancer patient has to go through.

■ HB-44

Thursday, 10:30-12:00 - Room 218

Managing Risk in Supply Chains II

Stream: Managing Risk in Supply Chains
Invited session
Chair: *Kumar Sanjay*

1 - The Impact of Supply Chain Disruptions on Stockholder Wealth in Japan

Jiangxia Liu, Kumar Sanjay, Ashutosh Deshmukh

Past research has shown that disruptions in supply chains result in negative stock market returns. These results are, however, affected by various factors including firm domicile. Moreover, studies relating supply chain disruptions and stock market impact have been limited to the US companies. In this research, we study the stock impact of disruptions on Japanese companies. We find that despite apparent resilience of Japanese companies, supply chain disruptions cause negative reactions in Japanese companies. The negative reactions are similar in magnitude to that in the US companies.

■ HB-45

Thursday, 10:30-12:00 - Room 219

Routing Problems

Stream: Hybrid Heuristics
Invited session
Chair: *Niaz Wassan*
Chair: *Naveed Wassan*

1 - A Hybrid Meta-Heuristic for the Mixed Fleet Vehicle Routing Problem: A Case of Gas Delivery in the UK

Lina Simeonova

The purpose of this paper is to introduce a real-life version of the Mixed Fleet Vehicle Routing Problem (MFVRP) based on real data, collected from the market leader in the UK's gas delivery sector. An initial solution is obtained using a guided randomized version of the Sweep algorithm, amended to fit the nature of the problem. Local search techniques (including a meta-heuristic) are efficiently used to improve the quality of the solution. New rich MFVRP datasets are proposed ranging from 20-200 customers and some interesting results are reported.

2 - The Vehicle Routing Problem with Divisible Deliveries and Pickups

Gábor Nagy, Niaz Wassan, M. Grazia Speranza, Claudia Archetti

The VRP with divisible deliveries and pickups is a new reverse logistics model. Each customer may have a pickup and delivery demand that may be served, if beneficial, in two separate visits. The model is placed in the context of other problems and formulated as a mixed ILP. We study the savings that can be achieved by allowing pickup and delivery quantities to be served separately with respect to the case where they have to be served simultaneously. Both exact and heuristic results are analysed for a better understanding of the problem structure and an estimation of the savings achievable.

3 - The Fleet Size and Mix Vehicle Routing Problem with Backhauls: Formulation and Set Partitioning-based Heuristics

Niaz Wassan

In this paper we present a new variant of the classical Vehicle Routing Problem — the Fleet Size and Mix Vehicle Routing Problem with Backhauls (FSMVRPB). An ILP formulation of the FSMVRPB is presented. Optimal solutions for small size instances are produced and upper and lower bounds are generated for larger ones. In this paper we also propose a Set Partitioning Problem (SPP) based heuristic. Three frameworks are developed and tested on a set of new FSMVRPB data instances which we generated. Computational results are presented which can be used for future benchmarking.

4 - A Hybrid Two-level Variable Neighbourhood Search for Vehicle Routing Problem with Backhauls and Multiple Trips

Naveed Wassan

The VRP with backhauls is one of the well-studied VRP versions in reverse logistics. This problem involves two types of customers, namely deliveries and pickups with known demands served by a fleet of vehicles operated from a depot. Our VRPB model extension allows for multiple trips of vehicles in order to achieve cost savings. A hybrid two-level VNS is implemented; in the second level of the VNS skeleton a VND is used as a local search to manipulate the search efficiently. Computational results are reported.

Thursday, 12:15-13:45

■ HC-50

Thursday, 12:15-13:45 - Plenaries room

Plenary Session R. Blackburn

Stream: Plenary Sessions
Keynote session
Chair: *Gerhard-Wilhelm Weber*

1 - Operations Research in BASF's Supply Chain Operations
Robert Blackburn

Over the years, Operations Research has been used extensively to support the chemical industry in configuring and planning their end-to-end supply networks. The applications deal with a wide range of problems, ranging from long-term strategic problems related to product portfolio and warehouse allocation, to mid-term tactical problems such as inventory and transportation optimization and to very short-term operational problems, such as order quantities and production scheduling problems. Modeling approaches for customized make-to-order product industries differ from those of plain make-to-stock industries. Additionally, as process industry is designed through "many-to-many" processes, its network dimensionality asks for different solution approaches than problems of a convergent network (automobile industry) or divergent network (food industry). In this talk we examine the planning and design tasks with regard to industrial examples from BASF, draw some conclusions about the degree to which different classes of problems have been solved, and discuss challenges for the future.

Thursday, 14:00-15:30

■ HD-01

Thursday, 14:00-15:30 - Room 118

Planning and Operations of Rapid Transit Systems

Stream: Railway and Metro Transportation
Invited session
Chair: *Juan A. Mesa*
Chair: *Alicia De-los-Santos*

1 - A Rolling Stock Modelling Approach for Medium Size RTS Networks
David Canca, Alejandro Zarzo, Eva Barrena

Rolling stock is one of the most difficult phases in the railway planning process and also plays a key role in a cost-efficient operation. The rolling stock circulation plan includes a set of interrelated subproblems as train composition determination, vehicle and carriage rest location, vehicle circulation problem and maintenance policies. In this paper, we propose a general modelling approach to determine the minimum number of vehicles needed to perform the actual schedule, a cyclic weekly train circulation and the most convenient maintenance policy for medium size RTS networks.

2 - Building Train Schedules from Frequency Maps
Alejandro Zarzo, David Canca, Eva Barrena

In the past few years a set of acceleration strategies for managing congestion problems in RTS have attracted increasing interest (e.g., the so called short-turning and deadheading approaches). Usually, the output of these models is an optimal frequency plan including new cycles and deadheaded trips. After this stage, the frequency plan should be finally converted into a concrete and compatible train schedule. In this paper we present a general ILP model in order to obtain such schedules for a given frequency map with the objective of preserving regularity as much as possible.

3 - Optimal Shortest Paths in a Public Transportation Network from Different Points of View
Francisco A. Ortega Riejos, David Canca, Juan A. Mesa, Miguel Angel Pozo

The k-shortest path (KSP)-problem is a classical problem with many applications in flow networks and optimization. The problem was initially studied in 1959 by Hoffman and Pavley but the fastest KSP algorithm was developed by Eppstein in 1988. In this work we provide a review of the shortest path problem algorithms (commonly used as a starting point for developing the KSPs algorithms) and revise the main techniques for determining the KSPs. Thirdly, we analyze the suitability of these algorithms to the context of railway transportation from both user and operator perspectives.

4 - Congestion in Railway Transit Lines: Frequency and Capacity Setting in Presence of an Alternative Mode
Alicia De-los-Santos, Gilbert Laporte, Juan A. Mesa, Federico Perea

We focus on the line planning problem taking into account aspects related to rolling stock and personnel planning. We assume that the fleet size is limited, that is, the problem we are considering is a capacitated problem and the line network can be congested. The main novelty in this paper is the consideration of vehicle capacities and service frequencies as variables, as well as the inclusion in the model of a congestion function measuring the level of in-vehicle crowding. Computational experiments will be presented.

■ HD-02

Thursday, 14:00-15:30 - Room 111

Variants of the Vehicle Routing Problem 2

Stream: Vehicle Routing
Invited session
Chair: *Puca Huachi Penna*

1 - **The Open Vehicle Routing Problem with Different Vehicle Types**
Refail Kasimbeyli, Melis Alpaslan

In this work, open vehicle routing problems are studied and different mathematical models considering different cases are presented. First we consider the problem in which all vehicles that will be used are exactly given. The second problem considers the case where we have different number of vehicles for different types and we need to minimize not only the total route costs but also to minimize the number of used vehicle types. Therefore, a two-objective mathematical model is developed for this problem and different scalarization methods are applied to calculate efficient solutions.

2 - **Adaptive Local Search and Variable Neighborhood Search Algorithms for the Heterogeneous Fleet Vehicle Routing Problem with Simultaneous Pickup and Delivery**
Mustafa Avci, Seyda Topaloglu

The Vehicle Routing Problem with Simultaneous Pickup and Delivery (VRPSPD) has been considered with homogeneous fleet of vehicles so far. In this study, the VRPSPD is extended by assuming the fleet of vehicles to be heterogeneous. In order to solve the problem, two solution approaches are developed. The first approach is based on an adaptive local search method while the second one is based on Variable Neighborhood Search. The performances of the algorithms are compared on a set of randomly generated problem instances.

3 - **Solving of the Open Routing Problems by SOMA**
Juraj Pekár, Zuzana Čičková, Ivan Brezina

The routing problems can be extended to open versions where in contrast to the classic formulation is not required to return the vehicle to the starting point. That problems are particularly applicable in the case of rental of vehicles, when financial costs are associated only with the distribution actually made and it is not relevant whether the vehicle returns to the depot or not. The use of metaheuristics remains a popular way to solve corresponding problems. We present the solving of open travelling salesman problems and open vehicle routing problem by self organizing migrating algorithm.

4 - **A Hybrid Algorithm for a Large Class of Heterogeneous Fleet Vehicle Routing Problem**
Puca Huachi Penna, Anand Subramanian, Luiz Satoru Ochi

This paper deals with the a large class of Heterogeneous Fleet Vehicle Routing Problems (HFVRP). To tackle this class of problems we present a multi-start hybrid heuristic based on the Iterated Local Search (ILS) metaheuristic that uses a Set Partitioning (SP) formulation to add memory to the ILS framework. In order to verify the efficiency of the algorithms, the developed heuristic was used to solve several variants of the HFVRP, including features like multi-depots, time windows and backhauls. Extensive computational experiments demonstrate the notable contribution of this approach.

■ HD-03

Thursday, 14:00-15:30 - Room 001

Applications of Location Analysis

Stream: Location
Invited session
Chair: *Justo Puerto*

1 - **An Empirical Comparison of Customer Retail Patronization Models**
Burcin Bozkaya, Seda Ugurlu, Vivek Singh, Alex Pentland

Several models in the literature aim at modeling customer retail patronization. One model, originally proposed by Huff, has been widely used with various extensions. Recently discrete choice models, originally pioneered by McFadden, have spawned an interest for modeling utility with random error components. We empirically validate the two models using grocery purchase transaction data from a major consumer bank. Results show that both models work well with homogenous customer groups and limited number of choice alternatives. We also point out cases where one model works better over the other.

2 - **A Two-Stage Stochastic Transportation Problem with Fixed Handling Costs and A Priori Selection of the Distribution Channels**
Yolanda Hinojosa, Justo Puerto, Francisco Saldanha-da-Gama

A transportation problem with stochastic demands, fixed handling costs at the origins and fixed costs associated with the links is addressed. It is assumed that uncertainty is captured via a finite set of scenarios. The problem is formulated as a two-stage stochastic program. The goal is to minimize the total cost associated with the selected links plus the expected transportation and fixed handling costs. A prototype problem is presented which is progressively extended to accommodate capacities at the origins and multiple commodities. The results of a set of computational tests are reported.

3 - **Optimal Location of Battery Stations and its Charger for Electric Vehicles Based on Japanese Road Networks**
Yudai Honma, Shigeki Toriumi

Electric vehicles (EV) have attracted an increasing amount of attention. However, the continuous cruising distance of an EV is limited to around 160 km, which is insufficient for everyday use. Battery capacity is the limiting factor in long-distance EV travel. In planning the EV infrastructure, an appropriate number of EV stations and chargers must be installed. In this study, on the basis of the supporting infrastructure for widespread EV use, we propose a mathematical model for optimal location of EV stations and its charger in Japanese road networks.

■ HD-04

Thursday, 14:00-15:30 - Room 119

Optimal Control of Motorways

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair:
Chair: *Claudio Roncoli*

1 - **Optimisation of Multi-Lane Motorways in Presence of Vehicle Automation and Communication Systems**
Claudio Roncoli, Markos Papageorgiou, Ioannis Papamichail

The introduction of Vehicle Automation and Communication Systems (VACS) is expected to bring along strong changes that call for new control strategies with the purpose of alleviating motorway traffic congestion. In this work, VACS are acting both as sensors (providing information on traffic conditions) and as actuators, permitting the integration of Variable Speed Limits and Lane Changing Control with Ramp Metering. The problem is formulated as an optimal control problem based on a first-order model for multi-lane motorways. A case study is presented on a motorway using real data.

2 - **Optimizing Real-Time Traffic Information for Freeways**
Klaus Bogenberger, Gerhard Huber

When Real-Time Traffic Information (RTTI) is provided via a color-coded map of a freeway network, usually only a few speed-classes are used to illustrate the current traffic states, even though exact speed values are available. A scheme for quantifying the resulting loss of information on motorways is introduced. Different algorithms to optimize the quality of RTTI leading to highly nonlinear problems are developed. These NLPs are solved using genetic algorithms or, if possible, they are transformed into shortest path problems. Both approaches are tested with real data of a German freeway.

3 - **Integrated Control of a Urban Freeway Off-ramp and Neighboring Intersections**
Xianfeng Yang, Yang Lu, Gang-Len Chang

Via an interchange off-ramp, congestion at the downstream intersections of main arterial often cause the queue spillback and then substantially reduce the freeway capacity. Therefore, this study proposes a two-stage control strategy that accounts for both potential off-ramp spillback and local congestion. Based on the real-time data, the first-stage of signal priority control focuses on providing signal progression to the off-ramp traffic. Under oversaturated condition, the second-stage of gating control is activated at upstream of arterial to constrain the entry flows to the interchange area.

4 - An Optimal Fleet Allocation of Emergency Response Teams on Freeway Using a Two-Stage Stochastic Programming
Hyoshin Park, Ali Haghani

Stochastic programming is used to identify optimal allocations of emergency response teams on the freeway. Previous studies used the probability of incidents, considering all incidents equal and ignoring scenarios in which two incidents occurred within proximal regions and intervals. In this study, first stage decisions are made before a realization of uncertainty of primary incidents. The recourse in the second stage includes excessive response to secondary incidents, using multi-state mixture model to present distribution of excessive response time due to the negative impact of an incident.

■ HD-05

Thursday, 14:00-15:30 - Room 002

Hinterland Transportation

Stream: Port Operations
Invited session
Chair: *Claudia Caballini*

1 - Petri Net Modelling and Optimization of Container Terminal using Automated Guided Vehicles
Danko Kezić, Anita Gudelj

We study a modelling and traffic control optimization problem of the automated guided vehicle (AGV) system in a container terminal. The authors present a formal mathematical technique to calculate deadlock prevention control places (supervisor) which must be added to the net. We are using Hybrid Petri net and P-time MRF1 class of Petri nets. By changing the parameters of resources, such as the loading time or segment capacity, an attempt was made to determine the conditions under which the transportation system performs optimally.

2 - Fleet Deployment in RoRo Liner Shipping under Inventory Constraints at Ports
Saurabh Chandra, Kjetil Fagerholt, Marielle Christiansen

We propose an integrated model for fleet deployment in RORO liner shipping that considers inventory constraints at the served ports in different routes served by the company. We consider time varying demand/production at various ports for cargoes managed by the company.

3 - Truck Carriers Cooperation in Container Transportation: A Heuristic Approach
Claudia Caballini, Simona Sacone, Mahnam Saeednia

Our work proposes a heuristic approach for planning truck trips of multiple carriers cooperating with the purpose to reduce empty trips while maximize their cost saving. The approach foresees a pre-processing step in which transportation demand is decomposed to isolate nonoptimized trips, and a second phase where a linear optimization model allows combining trips of different carriers. Trips values due to customers importance as well as time windows related both to orders due dates and transportation nodes are considered. Simple instances have been tested to prove the heuristic efficacy.

4 - Yard Arrangement at the Container Terminal with Irregular Configuration
Etsuko Nishimura

Relatively new marine container terminals often have a rectangular configuration by making use of reclaimed land to serve large vessels with deep draft. However, due to geographical reasons some terminals have an irregular configuration. At the terminal with irregular configuration with RTG operated, the storage capacity depends on the location and number of aisles used for yard trailers movement. In this study, we consider the aisle location problem at the container terminal with polygon configuration. We also consider the container storage problem under the aisle location obtained.

■ HD-06

Thursday, 14:00-15:30 - Room 211

Information Economics and Networks

Stream: Social and Economic Networks
Invited session
Chair: *Alper Nakkas*

1 - Ad Exchanges and the Problem of Disclosing Information
Sofia Ceppi

In the advertisement exchange scenario, publishers ask an exchange for ads to display to users. To provide each of these ads, the exchange runs an auction among advertisers who express an interest in displaying their ads. In this scenario, the actors benefit from targeting the users. However, to achieve an accurate targeting, the exchange should disclose information about users. This has the side effect of reducing the competition in the market, and, thus, the revenue of the exchange. We aim to design a mechanism that uses the information while reducing the revenue loss of the exchange.

2 - Railroads and Economic Growth: A Trade Policy Approach
Fernando Pérez Cervantes

What was the impact of railroads on the output of the United States during the 19th century? I construct a railroad data set to estimate travel times between every pair of counties for every year between 1840 and 1900. I use these results, together with a Ricardian model of trade and output data from the 19th century to estimate county gains from trade using a fixed-point algorithm that I designed. Then, I estimate counter-factuals. My estimates suggest that if railroads had been suddenly made unavailable in there would have caused a large reduction in output, contrasting with Fogel (1962).

3 - The Impact of Valuation Heterogeneity and Network Structure on Equilibrium Prices in Supply Chains
Alper Nakkas, Yi Xu

Supply chains can be very complex and highly asymmetric structures. The impact of these structures on the surplus sharing between manufacturers and their suppliers is not straightforward. To this end, we consider a strategic bargaining model in which suppliers negotiate procurement prices. We provide a supply chain network decomposition algorithm that takes manufacturer valuations into consideration and show that the equilibrium behavior of the manufacturers and suppliers can be deducted from their behavior in the smaller supply chain network structures that are determined by the algorithm.

■ HD-07

Thursday, 14:00-15:30 - Room 003

Fuzzy Programming and Fuzzy Regression Analysis

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair: *Juan Carlos Figueroa-García*
Chair: *German Hernandez*

1 - Interval Type-2 fuzzy Linear Programming: An Application to Logistic Networks
Juan Carlos Figueroa-García, German Jairo Hernandez

This paper shows an application of Interval Type-2 fuzzy linear programming to a logistics problem involving fuzzy uncertainty coming from multiple experts who provide an individual estimate of the demands of the customers. Using linear programming models and previous results (Figueroa 2010, 2012, 2014) we find a solution to the problem based on the fuzzy linear programming model proposed by Zimmermann (1979). Some concepts of Interval Type-2 fuzzy linear programming are introduced, a mathematical model is presented, and some interpretation aspects regarding the study case are discussed.

2 - Solving Linear Programming Problems Involving Interval Type-2 fuzzy Technical Coefficients
German Hernandez, Juan Carlos Figueroa-García

This paper shows a method for solving linear programming problems whose technical coefficients are Interval Type-2 fuzzy numbers. Type-2 fuzzy numbers deal with linguistic uncertainty coming from the perception of multiple experts about a variable, so its applicability to decision making problems, in this case linear programming, is high. Using the decomposition theorems for fuzzy sets and the Zadeh's extension principle, we present a general method for solving this kind of problems. In addition, an application on a PERT problem is presented, and some interpretation aspects are explained.

3 - An Application of Fuzzy Logistic Regression
Gultekin Atalik, Sevil Senturk

Fuzzy set theory was proposed by Zadeh in 1965. Many studies have been done to combine several statistical methods and fuzzy set theories, called fuzzy statistics, such as design of experiment, time series analysis, probability theory and regression analysis. Fuzzy regression model was first introduced by Tanaka et al.. This proposed model is called possibilistic model. Tanaka's possibilistic model was revised by Chan et al. in 2007. The aim of this study is to solve fuzzy logistic regression model proposed by Pourahmad and et al. with Tanaka's revised model. The results are discussed.

4 - Ranking of Strategies in a Strategy Map based on Logarithmic Fuzzy Preference Programming
Hossein Safari, Fatemeh Mirzaei Rabor

There is a well-known technique in MCDM entitled AHP. Pairwise matrix was used in AHP which always has a risk related to inconsistency. So Least Square Method was developed to minimize inconsistency. Then Logarithmic LSM introduced that gain better solutions with crisp data. With fuzzy data, at first Fuzzy Preference Programming was presented. In continue, logarithmic FPP was developed that solve through meta-heuristics algorithms. This paper introduces a method for converting LFPP to a NLP. Finally new method was tested for strategies ranking with programming in LINGO.

■ HD-08

Thursday, 14:00-15:30 - Room 120

Teaching OR/MS 2 (JMP)

Stream: Teaching OR/MS
Sponsored session
Chair: *Volker Kraft*

1 - How to Teach Crime Analytics? An Introductory Board Game Motivating Policing Strategies
Richard Weber, Victor Bucarey

Crime is an important threat in most cities. The recent increase in data availability allows developing quantitative models for crime analysis. What we have observed, however, is the need to recognize the potential of advanced mathematical tools to improve the effectiveness of policing strategies. Secondly, we noticed a lack of knowledge and experience among engineering students when it comes to model complex human behavior. We present a board game that introduces the key concepts of policing strategies and serves as an introduction to crime analytics and agent-based simulation.

2 - Teaching OR/MS using JMP (I)
Volker Kraft

The successful teaching of analytics in the classroom stands and falls with the instructor, but also depends heavily on the utility of the chosen toolset and the relevance of the examples used during lessons and workshops. JMP is software from SAS Institute aimed at Statistical Discovery, and this presentation shows how its unique philosophy and interactivity can help to foster and facilitate best practice when used in teaching. A variety of live examples will be demonstrated to illustrate the pedagogic advantage of JMP, especially in the fields of predictive modelling and data visualization.

3 - Teaching OR/MS using JMP (II)
Volker Kraft

The successful teaching of analytics in the classroom stands and falls with the instructor, but also depends heavily on the utility of the chosen toolset and the relevance of the examples used during lessons and workshops. JMP is a software from SAS Institute aimed at Statistical Discovery, and our presentation shows how its unique philosophy and interactivity can help to foster and facilitate best practice when used in teaching. A variety of live examples will be demonstrated to illustrate the pedagogic advantage of JMP, especially in the fields of predictive modelling and data visualization.

■ HD-09

Thursday, 14:00-15:30 - Room 121

Exact and Heuristics Decision Support Approaches for Energy Distribution, Planning and Management

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Chiara Bordin*

1 - Optimizing the Use of Domestic Loads in an Energy Management System
Carlos Henggeler Antunes, Ana Soares, Alvaro Gomes

A methodology to be implemented in an energy management system to schedule domestic loads is presented. A genetic algorithm is used to solve this problem considering a limit for the contracted power, an energy safety margin to take into account changes of non-controllable load and avoid the risk of interruption of energy supply, and end-users' preferences. These are tackled by assigning variable costs to the time slots in which the end-user allows the operation of controlled loads. The aim is minimizing the overall cost associated with energy purchase and preference violation.

2 - Contract Portfolio Optimization for Energy Trader
Cristian Bovo, Mario Innorta

A mathematical model for the optimization of the contract portfolio of a trader for the supply of natural gas will be described. The objective function is the minimization of the supply cost taking into account the following constraints: balance constraints, Take or Pay (ToP) constraints; make up and carry forward constraints to hedge the risk associated with the ToP contracts; gas transmission constraints designed to represent transportation contracts holds by the trader; storage constraints. Moreover, the model will take into account the possibility to buy or sell gas on the spot market.

3 - Optimal Operation of Medium-Voltage AC Networks with Distributed Generation and Storage Devices
Maria Teresa Vespucci, Diana Moneta, Paolo Pisciella

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. In order to restore feasibility when some parameters vary, new set points need to be determined to minimize distributor's dispatching costs, while satisfying service security requirements and ensuring service quality. We propose a two-phase solution procedure: an MILP model determines the active power production and the use of storage devices; reactive variables are then computed by solving a nonlinear programming model.

4 - A Decision Support Tool for the Optimal Distribution of Thermal Energy
Chiara Bordin

This work presents a mathematical model developed for supporting district heating system optimal planning in real world applications. The objective is the connection of an optimal set of new users to the existing thermal grid, minimizing costs and respecting the main hydraulic conditions of real networks. Model constraints are inserted to control flow rate values, pressures values, water direction along the pipes and nodes degree. The model was integrated with a decision support tool which uses GIS technology and database to facilitate scenario creation and analysis of very big real networks.

■ HD-10

Thursday, 14:00-15:30 - Room 122

DEA Theory III

Stream: Theoretical Developments in DEA
Invited session
Chair: *Kaoru Tone*

1 - The Overall Malmquist Index: A New Approach for Measuring Productivity Changes Over Time
Mohsen Afsharian, Heinz Ahn

This paper proposes a new way of constructing the global framework of the Malmquist index. The proposed index preserves the role of each contemporaneous technology in the determination of the newly-proposed benchmark technology, whereby an acceptable level of discrimination between non-homogeneous observations is provided. Furthermore, previously computed results are more stable and less sensitive to changes in the shape of the benchmark technology when a new time period is incorporated. The suggested index will be illustrated by means of a real-world example from banking.

2 - Global Efficiency and Global Progress and Regress Index: A Quasi-Concave Frontier Approach
Mohsen Vaez-Ghasemi, Zohreh Moghaddas, Farhad Hosseinzadeh Lotfi

In existing models of data envelopment analysis (DEA) which evaluate efficiency measure in various time periods, technology variations have not been considered. Note that using DEA approach for deriving malmquist productivity index a specific score for efficiency will not be resulted. Thus in regards of DEA axioms, a quasi-concave frontier is considered for deriving efficiency score in different periods. Also the measure of progress and regress of units is provided which is not possible in malmquist productivity index introduced in DEA analysis.

3 - A New Approach to the Bi-Dimensional Representation of the DEA Efficient Frontier with Multiple Inputs and Outputs
Carlos Bana e Costa, João Carlos Soares de Mello, Lidia Angulo-Meza

This paper presents a new approach to the graphical presentation of DEA results. Whatever the number of inputs and outputs are, an adequate normalization of their weights is enough to generate a simple bi-dimensional graph, similar to that of the CCR frontier with one input and one output. No complementary techniques are required. It is also shown that the horizontal (or vertical) distance between a DMU and the frontier is the DMU's efficiency score obtained by the standard CCR model. The proposed normalization is also valid for the BCC model.

4 - Resampling in DEA
Kaoru Tone

In this paper, we propose new resampling models in data envelopment analysis (DEA). Input/output values are subject to change for several reasons, e.g., measurement errors, hysteretic factors, arbitrariness and so on. Furthermore, these variations differ in their input/output items and their decision-making units (DMU). Hence, DEA efficiency scores need to be examined by considering these factors. Resampling based on these variations is necessary for gauging the confidence interval of DEA scores. We propose three resampling models.

■ HD-11

Thursday, 14:00-15:30 - Room 113

Applications of Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Stephan Visagie*

1 - Adjusting the Size-Mix of Products During Stock Allocation
Elmien Thom, Stephan Visagie, Jason Matthews

A specific size-mix problem of a retailer with over 1500 stores is introduced. The retailer adjusts the size-mix sent to each store during the season. Models are presented to find good adjustments to the original forecasted size-mix of each store. Heuristic approaches are presented because solving the problem to optimality is computationally too expensive to implement in real life. Results show that the proposed heuristics improve on the solutions found by the method currently in use.

2 - SKU Assignment in a Zoned Order Picking System with Unidirectional Picking Lines
Stephan Visagie, Jason Matthews

A real life order picking system in a distribution center that utilizes 16 unidirectional cyclical picking lines for break bulk picking is presented. SKUs are processed in waves on picking lines, each of which defines a local deterministic set of orders. The assignment of SKUs to available picking lines with the main objective of minimizing total walking distance, while controlling carton utilization and work balance is considered. Three families of algorithms are introduced. Results show that the proposed algorithms improve on the current system.

3 - A 2D Irregular Levelled Strip Packing Problem: A Case Study
Isabelle Nieuwoudt, Wayne Bossenger

Kohler Signs is a small company located in Cape Town, South Africa that mainly manufacture road signs for the City of Cape Town. The image design for each sign consists of letters, numbers and shapes that must be cut from a roll of vinyl. In this talk the focus is on the packing of letters and numbers onto the roll of vinyl in such a manner as to minimie the waste. Although irregular in nature, these items are regular in one dimension. Thus, 2D regular strip packing ideas in conjunction with image processing methodologies are used to develop a new packing algorithm for this specific problem.

4 - Computing Pairs of Disjoint Paths by Order of Cost
Marta Pascoal

Pairs of disjoint paths between two nodes have important applications in routing, for instance, when a backup path is needed in case one of the arcs of the best path fails or in order to avoid over-exposure of the same region to hazardous materials. The problem of finding the minimum cost pair of disjoint paths can be formulated as a minimum cost flow problem and can be solved polynomially by an adaptation of labeling algorithms. In this talk we address the problem of ranking pairs of disjoint paths by increasing order of cost. Polynomial algorithms to rank these solutions are discussed.

■ HD-12

Thursday, 14:00-15:30 - Room 004

Project Scheduling and Control

Stream: Project Management and Scheduling
Invited session
Chair: *Mario Vanhoucke*

1 - Introducing Overtime in the Resource Renting Problem
Len Vandenheede, Mario Vanhoucke, Broos Maenhout

The use of overtime has frequently been studied in literature. Furthermore, it is applied in real-life for several reasons. However, research on the project scheduling problem (PSP) in combination with overtime are scarce. We aim to introduce the use of overtime in the Resource Renting Problem. We have developed a method to study the trade-off between stricter deadlines and a higher cost due to scheduled overtime. A computational experiment will demonstrate how the use of overtime and resource scheduling can lead to a more efficient use of resources and a better human resource management.

2 - Payment Models and NPV Maximization in Project Scheduling
Pieter Leyman, Mario Vanhoucke

In project scheduling literature several payment models exist. Although the goal is always to maximize the project NPV, these payment models have different characteristics which typically require distinct approaches to maximize each model's NPV. We propose a general local search capable of handling the different NPV profiles efficiently. This local search consists of several parts which can be turned on or off, depending on the payment model. Specifically, this methodology is applied to the resource-constrained project scheduling problem with discounted cash flows.

3 - A Forecasting Approach for Project Duration and Cost based on Exponential Smoothing
Jordy Batselier, Mario Vanhoucke

In this paper, the earned value management (EVM) project control methodology is integrated with the exponential smoothing forecasting approach. This results in an extension of the known EVM and earned schedule (ES) time and cost forecasting formulas. The enhanced EVM performance factor depends on only one smoothing parameter, which facilitates calculation. Moreover, this parameter can be dynamically adjusted during project progress according to information of past performance and/or anticipated management actions. The novel method is evaluated based on extensive real-life project data.

4 - Strategic Incentive Contract Design for Projects
Louis-Philippe Kerkhove, Mario Vanhoucke

The agency problem between the owner and the contractor in a project environment is often resolved using multidimensional incentive contracts. This research evaluates the design of such contracts from a quantitative perspective, presenting several guidelines for strategic contract design. The analysis is based on high-level models of the cost/time/scope and incentive pay-offs. Using these models, computational experiments are carried out on both real and simulated data. The presentation will focus on the preliminary results of these experiments and the managerial implications thereof.

■ HD-13

Thursday, 14:00-15:30 - Room 123

Balancing and Sequencing of Assembly Lines 1

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*
Chair: *Alberto García-Villoria*
Chair: *Xavier Delorme*

1 - The Accessibility Windows Assembly Line Balancing Problem (AWALBP): A Review of Advances and Trends
Gema Calleja, Albert Corominas, Alberto García-Villoria, Rafael Pastor

We investigate the Accessibility Windows Assembly Line Balancing Problem (AWALBP), where, in sharp contrast to traditional assembly line problems, only a portion of the workpieces can be reached from each workstation. The literature distinguishes different variants of the problem, and several formulations and solution approaches have been proposed. This talk gives an overview on recent advances in the methods used to solve AWALBP, including exact, heuristic and hybrid methods. An extensive set of computational experiments, along with some guidelines for further lines of research are reported.

2 - MILP-based Tabu Search using Corridor Method for an Assembly Line Balancing Problem with Accessibility Windows
Albert Corominas, Alberto García-Villoria, Gema Calleja, Rafael Pastor

In this work, we present an MILP-TS matheuristic for an assembly line balancing problem with accessibility windows. The proposed matheuristic uses an MILP model embedded in a tabu search (TS) algorithm to iteratively solve reduced portions of the original solution space. We use the paradigm of the corridor method to impose exogenous constraints of the original mathematical formulation and, subsequently, we apply an MILP solver to optimally solve the constrained problem. Computational results show the effectiveness of the proposed matheuristic.

3 - Ergo-Balancing in Assembly Lines based on Energy Expenditure Rate
Fabio Sgarbossa, Daria Battini, Alessandro Persona

In many assembly systems, ergonomics impacts in relevant way on productivity and human safety. Traditional optimization approaches considers only time variables. In this paper an innovative balancing model is developed including the ergonomics aspect, defined by energy expenditure rate, based on main features of assembly workstations. First, a comparison between time and energy balancing is carried out, and then a new integrated analytical model is introduced to have a unique objective function. A real case allows the validation of the approach and some further researches are defined.

4 - Efficient Multi-Objective Optimization Method for the Mixed-Model-Line Balancing and Equipment Selection Problem
Jonathan Oesterle, Lionel Amodeo

The Assembly Line Balancing Problem is a classical Operations Research problem, having been tackled over several decades. While some multi-objective approaches can be found in the literature, there only exist few studies that address the task and equipment assignments together. Our paper proposes a new efficient multi-objective optimization method for the Mixed Model Line balancing and equipment selection problem based on an adaptation of the Strength Pareto Evolutionary Algorithm-2, in which the idle time of various models among an assembly line and the equipment costs are minimized.

■ HD-14

Thursday, 14:00-15:30 - Room 124

Advances in Nonlinear Optimization: Theory and Applications III (contributed)

Stream: Nonlinear Programming
Contributed session
Chair: *Gonca Inceoglu*

1 - Generalized Inexact Proximal Algorithms: Habit's Formation with Resistance to Change, following Worthwhile Changes
Glaydston Bento, Antoine Soubeyran

This work shows how, in a quasi metric space, an inexact proximal algorithm with a generalized perturbation term appears to be a nice tool for Behavioral Sciences (Psychology, Economics, Management, Game theory, ...). More precisely, the new perturbation term represents an index of relative resistance to change, defined as a "curved enough" function of the quasi distance between two successive iterates. We show when, and at which speed, a "worthwhile to change" process converges to a variational trap.

2 - Convergence of the Gauss-Newton Method for a Special Class of Systems of Equations under a Majorant Condition
Max Leandro Nobre Gonçalves

In this talk, we study the Gauss-Newton method for a special class of systems of non-linear equations. On the hypothesis that the derivative of the function under consideration satisfies a majorant condition, semi-local convergence analysis is presented. In this analysis, the conditions and proof of convergence are simplified by using a simple majorant condition to define regions where the Gauss—Newton sequence is 'well behaved'. Moreover, special cases of the general theory are presented as applications.

3 - Enhanced Line Search Methods
Adriano Lisboa, Douglas Vieira
We start proving that the classical Golden section converges to a local optimum for any function, including multimodal ones. However, this local optimum may be worse than the starting point. This is specially undesired considering that the search direction usually induces better points near the starting point. We solve this drawback by applying a backtracking search until a no worse point is met. With this simple change, it is possible to prove that the golden section method converges to a local optimum no worse than the starting point. Analogous results follow for other line search methods.

4 - Optimality Conditions via Generalized Radial Epiderivatives
Gonca Inceoglu, Refail Kasimbeyli
In this paper, the generalized radial epiderivative for set-valued maps is introduced and its relationship to the radial epiderivative is investigated. Existence conditions for the generalized radial epiderivatives are established and a unified necessary and sufficient optimality condition in nonconvex set-valued optimization is derived in terms of the generalized radial epiderivative.

■ HD-15
Thursday, 14:00-15:30 - Room 125

Revenue Management Models in Entertainment, Online Retail and Travel

Stream: Revenue Management II
Invited session
Chair: *Kihoon Kim*
Chair: *Kathrin Armborst*

1 - Pricing and Revenue Management in Sequential Distribution Channel: An Application to the Hindi Movie Industry
Sumanta Basu, Megha Sharma, Soumyakanti Chakraborty
With about 125 movie releases in a year, Hindi movie industry is one of the largest producers of movies in the world. Recently satellite or DTH rights of the movies released are sold within 2 months of their theater release. While a movie's earnings from those channels decrease with time, an early release cannibalizes box office collection and DVD sales. Hence in this work, we attempt to determine the optimal release times to different channels using statistical methods and mathematical modeling, especially in light of video piracy, and word of mouth movie reviews through social media.

2 - A Simulation Optimization Approach for Self-Adjusting Bid Prices of a Network Revenue Management Considering Booking Cancellations and Firms Competition
Kemal Subulan, Gokalp Yildiz, Derya Eren Akyol, Adil Baykasoğlu
Recently, there is a growing attention by researchers to compute bid prices of resources dynamically in a network revenue management. A simulation optimization approach is presented in order to determine the appropriate values of coefficients in the bid price function that depends on reserved capacity and expected demand. Different meta-heuristic algorithms: DE, PSO & SOA are utilized to find out these coefficients within a simulation model. Apart from the existing literature, uncertain nature of cancellations and firms' competition throughout the booking horizon are also taken into account.

3 - Implementing Balance Scorecard Using ELECTRE Method for Revenue Management
Volkan Çakır, Idil Ekiz, Ozge Sahin
Revenue management (RM) has become an indispensable strategic tool in service industries whose total revenue often depends on the abilities of firms to use capacity efficiently. The Balanced Scorecard (BSC) is a widely used performance management tool designed to improve the performance of the businesses. This paper considers a real case application of revenue increasing project selection for BSC implementation using ELECTRE. Results show that ELECTRE was well received by the decision makers and, importantly, provided sensible and straightforward rankings and can be easily used in RM problems.

4 - Optimization of Flight Business Travel Procurement
Kathrin Armborst

Flight business travel is an important function of multinational corporations and leads to high costs. The developed decision support system assists in annual contract negotiations with airlines and optimizes airline selection and flight contingent allocation with the goal of cost reduction. Results of dynamic decision-making under uncertainty with quantity discounts applying the structured decision process and MILP models will be presented.

■ HD-16
Thursday, 14:00-15:30 - Room 127

Data Analysis and Transport Planning

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Nikita Ivkin*

1 - Vehicle Maneuvers Detection Using Data from Accelerometer
Nikita Ivkin

When applying data-driven classification approach to simulation modeling of traffic flow we suppose each simulated object (traffic vehicle) to make decisions based on the current surrounding condition. In current research we consider the subproblem of creating formal description of decisions space. Using experimental data we develop an algorithm for detecting maneuvers (like lane change or overtaking) from time series of acceleration measured in three dimensions. The proposed approach provides a technique of structured data collection for the general problem of evaluation simulation models.

2 - The Use of New Technologies to Estimate Dynamic Passenger Matrices: Proof of the Concept
Lídia Montero, Esteve Codina

The use of new technologies to track passenger progress in his/her trip contributes to simplify the estimation of dynamic passenger OD matrices. The approach proposed is based on the detection of the electronic signature of on-board devices, providing real-time dynamic data that is treated as measurements in a space-state Kalman filter formulation. A bus network has been developed for testing purposes and data generated by simulation. Some experiments have been conducted in order to assess how the quality of the a priori historic matrix and sensor layout affects the goodness of fit results.

3 - Advanced Traffic Monitoring System by Probe Vehicles under Privacy Preservation
Hiroyuki Kawano

It is increasingly important to correctly measure traffic data by probe vehicles, including speed, acceleration, location, and other data. In our previous researches, we propose that it is possible to be accurately monitored vehicle traffic by integration of supersonic wave detection devices and highway patrol vehicles equipped GPS transceivers. In this paper, we discuss accuracy of traffic volume and flows depending on density of probe vehicles. Furthermore, under privacy preserving conditions, we propose an architecture of traffic management system using our proposed methods.

4 - Using Fare-Card Data to make Commuter Cycling Policies in Singapore
Ashwani kumar, Viet Anh Nguyen, Kwong Meng Teo

Peak-hour week-day traffic congestion is a common challenge in urban mobility. Promotion of commuter cycling can help in alleviating this problem in many cities. This paper uses fare-card data to assess the commuter cycling potential in Singapore. A spatio-temporal analysis of the farecard data helps in suggesting policies like cycling towns and links for the first-mile and end-to-end cycling. Further, an optimization model is developed to make efficient policy choices for a given budget.

■ HD-18

Thursday, 14:00-15:30 - Room 112

Optimization and Decision Making: Theory and Applications

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Pekka Malo*
Chair:

1 - An Enhanced Fourier-Motzkin Method for Data Envelopment Analysis
Abolfazl Keshvari

Generating redundant constraints is an issue of Fourier-Motzkin elimination method for a general linear programming problem. In this paper, we propose an enhanced Fourier-Motzkin algorithm that does not generate redundant constraints for a data envelopment analysis problem. The algorithm also generates normal vectors of the facets of production possibility set of the DEA problem. Using the proposed algorithm and the Qhull program, we enumerate facets of some DEA problems. We compare the results, and the running times of these two methods.

2 - Solving Hierarchical Decision Making and Optimization Problems
Pekka Malo, Ankur Sinha

We consider hierarchical decision making and optimization problems, where both the leader and follower are faced with multiple objectives. Often the leader attempts to optimize the problem by taking the actions of the follower into account. However, when the preferences of the follower are unknown, it leads to decision uncertainty. In our study, we discuss practical examples and propose an evolutionary optimization strategy to solve such problems.

3 - Some Properties of Vectorized Directional Derivative For Set-Valued Mappings
Mustafa Soyertem, Mahide Kucuk, Yalcin Kucuk

A generalization of directional derivative for set-valued mappings was given by using vectorization in terms of total ordering cones. In this study, some algebraic properties of this derivative are given for a special class of set-valued mappings. These properties are demonstrated on some examples. The relations between this directional derivative and some other directional derivatives for set-valued mappings are also studied.

4 - A Two-Objective Container Loading and Assortment Problem
Zeynep Özsüt, Refail Kasimbeyli

In this work we study container loading (CLP) and assortment problem where different sizes of container types is available and a set of rectangular boxes has to be assign according to constraints. We propose a two-objective mixed-integer programming model for the CLP. The objective functions are formulated in the form of minimizing the free space of the used containers that is the wasted space, and the number of used container types. We used different scalarization methods to solve the recommended two-objective mixed-integer programming model and compared obtained solutions.

■ HD-19

Thursday, 14:00-15:30 - Room 128

Inventory Planning III

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Contributed session
Chair: *Hiroaki Sandoh*

1 - Inventory-Routing Problem with Pickups and Deliveries of RTI in Closed-Loop Supply Chain
Sabine Limbourg, Galina Iassinovskaia, Fouad Riane

Reducing environmental impact, related regulations and potential for operational benefits are the main reasons why companies share their Returnable Transport Items (RTIs) among different partners of a closed-loop supply chain. This research deals with an inventory-routing problem with pickups and deliveries of RTIs. A mixed-integer linear program is developed and tested on small instances. To handle realistic large size problems, a clustering algorithm is coupled with a simulation model. This hybrid heuristic allows assessing the benefits of information and RTIs sharing among partners.

2 - Optimizing Inventory and Pricing Decisions for a Periodic-Review System with Batch Ordering
Ying Wei, Feng Li

This paper examines inventory and pricing decisions in a periodic review system with an infinite planning horizon. Order quantities are required to be a non-negative integer multiple of certain batch size Q. Pricing decision is determined at the beginning of the planning horizon and fixed forever. A fixed and proportional ordering cost occurs for each ordering. With the objective of maximizing the long-run average profit, this paper investigates the operating characteristics of an (r, Q)-p system, and further develops a computing procedure identifying the optimal (r, Q)-p decisions.

3 - Optimal Quantity of Apparel Goods for Direct Mail
Hiroaki Sandoh, Hyewon Kim, Takeshi Koide

In direct mail industries dealing with apparel goods, of greater concern is the determination of a stocking quantity of each product to be purchased from a manufacturer prior to the seasonal catalogue. If the demand distribution of each product is beforehand identified, the problem is a newsvendor problem. This study proposes a method for identifying the demand distribution of each product listed in the seasonal catalogue, assuming that the DM firm offers advance sale of his products only to his members by sending a reservation catalogue about a half year prior to the seasonal catalogue.

4 - Model to Optimize the Internal Supply Chain in an Industry of Mobile Phones Located in Brazil
Fabricio Rodrigues Costa

The mobile phone is an electronic device with high value added. Maintain inventories of raw materials, intermediates and finished products are expensive. A supply chain network is characterized by the suppliers, plants, distributors and customers distributed across a geographic region. This concept was applied to a mobile phone industry, located in Manaus, capital of Amazon, Brazil. Was developed a model to optimize the internal supply chain using the tool Supply Chain Strategist, who has applied the concept of Material Requirement Planning dedicated to stock the main printed circuit board.

■ HD-20

Thursday, 14:00-15:30 - Room 129

Managing Smart Energy Grids under Uncertainty - II

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Pavlo Krokhmal*

1 - Stochastic Optimization Methods for Real-Time Control of Electrical Grids by Using Explicit Power Setpoints
Andrey Bernstein, Lorenzo Reyes Chamorro, Jean-Yves Le Boudec, Mario Paolone

The classic approach for controlling power networks is a combination of both frequency and voltage controls. With the increased penetration of volatile distributed generation and demand response, it shows severe limitations. A different control approach was recently proposed by the authors, enabling subsystems to directly communicate with each other in order to define real-time power setpoints and advertise a simplified representation of their internal state. In this paper, we discuss stochastic optimization methods to compute the setpoints that steer the system to an optimal and safe state.

2 - Power Control for Solar Micro-Grids in Developing Countries
Carlos Abad, Garud Iyengar

Solar micro-grids are emerging as the most promising means of providing power to isolated communities in some of the poorest parts of the world. In order to avoid depleting the battery backup the micro-grid operator shuts off a customer circuit whenever the consumer's power exceeds the individually pre-assigned power limit. In addition, weather conditions can lead to lower electricity generation and the disruption of customers that are not violating their power limits. We investigate control policies that maximize the operator's revenue while minimizing the number of disruptions to customers.

3 - Risk-Averse Strategic Planning of HVDC Grids
Pavlo Krokhmal, Bo Sun, Yong Chen

We consider the problem of risk-averse strategic planning of high-voltage direct current (HVDC) grids. HVDC transmission systems offer significant advantages comparing to the traditional AC transmissions. We discuss the problem of long-term (strategic) planning of HVDC grids that incorporate sources of renewable energy, such as large-scale wind farms. Risks of power shortages are controlled using nonlinear higher-moment coherent risk (HMCR) measures. Solution methods for the resulting mixed-integer programming problems and computational case studies are presented.

■ HD-21
Thursday, 14:00-15:30 - Room 006

Cutting and Packing 3

Stream: Cutting and Packing
Invited session
Chair: *Ramon Alvarez-Valdes*

1 - An Efficient MIP Formulation of the Container Loading Problem
Giorgio Fasano

Effective algorithms have been devised to tackle the container loading problem. An alternative overall approach addresses Mixed Integer Programming (MIP), being well-suited for the introduction of additional conditions, e.g., balancing. Direct formulations are available in the literature. They are, however, poorly efficient in practice, albeit the addition of valid inequalities. A non-intuitive MIP-model, founded on an ad hoc objective function expression, is proposed. This reformulation outperforms the straight MIP-models. It can profitably be used to build up MIP-based heuristics.

2 - Studying Different Models for the Truck Loading Process
Maria Teresa Alonso Martínez, Ramon Alvarez-Valdes, Manuel Iori, Francisco Parreño, Jose Tamarit

We model the process of loading products into trucks. There is a list of products to be delivered, these products are put in pallets and the pallets are placed into trucks. A basic model, including only limits on the axle weights, has been created. Starting from this initial model, we have studied different ways of placing the pallets into the trucks. Additionally, some realistic constraints have been studied, concerning the position of the centre of gravity, the stability of the load, and the minimization of the unloading time. The models have been tested on a set of real-world instances.

3 - Efficient Local Search Algorithms for Three-Dimensional Packing Using Sequence-Triple
Shinji Imahori, Hiroki Iwasawa

We study the problem to pack n boxes into a rectangular container with three variable dimensions so as to minimize its volume. Sequence-Triple is a topological representation of placements with a triplet of permutations of boxes. In this talk, a decoding algorithm to compute a layout of boxes for a Sequence-Triple is presented. We also propose an efficient method to evaluate solutions in the neighborhood of the current solution. Local search algorithms for the 3D-packing problem using Sequence-Triple are designed, and experimental results show the effectiveness of the proposed methods.

■ HD-22
Thursday, 14:00-15:30 - Room 007

(In)efficiency and Truthfulness in Auctions

Stream: Algorithmic Game Theory
Invited session
Chair: *Giorgos Christodoulou*

1 - The Price of Anarchy of First-Price Auctions
Giorgos Christodoulou, Annamaria Kovacs, Alkmini Sgouritsa, Bo Tang

We study the Price of Anarchy of simultaneous First-Price auctions for buyers with submodular and subadditive valuations. The current best upper bounds for the Bayesian Price of Anarchy of these auctions are e/(e 1) and 2, respectively. We provide matching lower bounds for both cases even for the case of the full information and for mixed Nash equilibria. An immediate consequence of our results, is that for both cases, the Price of Anarchy of these auctions stays the same, for mixed, correlated, coarse-correlated, and Bayesian Nash equilibria.

2 - On the Inefficiency of Standard Multi-Unit Auctions
Orestis Telelis, Bart de Keijzer, Evangelos Markakis, Guido Schäfer

We study two standard multi-unit auction formats, with significant practical applications: the Discriminatory and the Uniform Price Auctions. We consider two bidding interfaces: (i) standard bidding, which is most prevalent in the scientific literature, and (ii) uniform bidding, which is more popular in practice. We evaluate the economic inefficiency of both formats for both bidding interfaces, by means of upper and lower bounds on the Price of Anarchy of pure and Bayes-Nash equilibria. Our results signify the near-efficiency of these auctions, and justify their widespread use in practice.

3 - Combinatorial Auctions without Money
Carmine Ventre

We focus on the design of incentive-compatible CAs without money in the general setting of k-minded bidders. We trade monetary transfers with the observation that the mechanism can detect certain lies of the bidders. We prove a characterization of truthful mechanisms, which makes an interesting parallel with the well-understood case of CAs with money for single-minded bidders. We then give a host of bounds on the approximation ratio obtained by either deterministic or randomized truthful mechanisms when the sets and valuations are private knowledge of the bidders.

■ HD-23
Thursday, 14:00-15:30 - Room 008

Panel Discussion: Analytics in OR Societies

Stream: Analytics Application and Practice
Panel session
Chair: *Don Kleinmuntz*

1 - Panel Description: Analytics in OR Societies
Don Kleinmuntz, Sayara Beg, Stewart Robinson, Stephen Robinson

The burgeoning growth and attention devoted to "Big Data" and Analytics poses both a challenge to and an opportunity for OR Societies and for academic OR departments. Leaders of Analytics outreach efforts from OR Societies in the UK and USA will provide a brief overview of how their respective societies are responding, and the results to date. Session attendees are encouraged to provide their own perspectives, and to identify opportunities for international cooperation. Confirmed panelists are listed above.

■ HD-24

Thursday, 14:00-15:30 - Room 212

Repeated and Stochastic Games

Stream: Dynamic and Repeated Games
Invited session
Chair: *Xavier Venel*

1 - The Asymptotic Value in Finite Stochastic Games

Miquel Oliu Barton

Bewley and Kohlberg (1976) proved that the discounted values of finite zero-sum stochastic games have a limit, as the discount factor tends to zero, using the Tarski-Seidenberg elimination theorem from real algebraic geometry. This was a fundamental step in the development of the theory of stochastic games. The current paper provides a new and direct proof for this result, relying on the explicit description of asymptotically optimal strategies. Moreover, we prove that our approach can also be used to obtain the existence of the uniform value, as in Mertens and Neyman (1981).

2 - Attainability in Repeated Games with Vector Payoffs

Xavier Venel, Dario Bauso, Ehud Lehrer, Eilon Solan

We introduce the concept of attainable sets of payoffs in two-player repeated games with vector payoffs. A set of payoff vectors is called attainable if player 1 can ensure that there is a finite horizon T such that after time T the distance between the set and the cumulative payoff is arbitrarily small, regardless of what strategy player 2 is using. We provide a necessary and sufficient condition for the attainability of a convex set, using the concept of B-sets from the theory of approachability.

3 - Dynamic Persuasion

Nicolas Vieille, Eilon Solan, Jérôme Renault

We study a class of dynamic sender receiver models. An informed agent (say, a financial advisor) observes the successive realizations of a state of nature, which follow a Markov process, and decides what information to disclose to an uninformed decision-maker. We focus on the case where the advisor can ex ante commit to a disclosure policy (persuasion), and derive his optimal policy.

■ HD-25

Thursday, 14:00-15:30 - Room 009

Heuristics for Dynamic Transit Routing

Stream: Applications of Heuristics
Invited session
Chair: *Amelia C. Regan*
Chair: *Elise Miller-Hooks*

1 - Routing for Ridesharing Services Considering Congestion

Maged Dessouky, Xiaoqing Wang, Fernando Ordonez

We consider a vehicle pickup and delivery problem with the objective of minimizing the total travel cost and customer ride time while considering the discounted toll rates on high occupancy vehicles and the availability of HOV lanes. This problem formulation is used to represent a real-time marketplace for ridesharing. Heuristics are developed to efficiently solve the problem. The Adjust Pickup Time Algorithm and the Waiting Strategy are proposed to reduce the total cost and the customer ride time.

2 - Dynamic Vehicle Routing and Pricing with Look Ahead for Flexible Transit

Joseph Chow, Hamid Sayarshad

We propose a dynamic dial a ride and pricing problem with non-myopic policies for last mile transit, one with time-dependent non-homogeneous Poisson process for customer demands. Three policies are considered: customer-vehicle allocation, waiting/prepositioning, and dynamic fare pricing. Pricing is incorporated as discussed in Figliozzi et al. (2007). Several approximation dynamic programming methods are compared in test instances: a Q-learning-based ADP, a queueing approach based on Hyytia et al. (2012), and a benchmark using least-squares Monte-Carlo simulation.

3 - The Dial-A-Ride Problem with Uncertain Travel Times

Elise Miller-Hooks

Paratransit services, including Dial-A-Ride (or DAR) services commonly offered at airports and to mobility-impaired persons, exist worldwide. If operated efficiently, they provide door-to-door transport at significantly lower cost than taxis by serving multiple riders simultaneously and combining trips whose paths are somewhat aligned. Efficient DAR services require solution of difficult combinatorial problems. Complexities associated with the efficient provision of DAR services in real-world applications, including uncertainty in travel times, are presented here.

4 - Incremental Network Design

Martin Savelsbergh

We introduce a class of incremental network design problems that allow investigation of key issues related to the choice and timing of infrastructure expansions and their impact on the costs of the activities performed on that infrastructure. We examine three variants: incremental network design with shortest paths, incremental network design with maximum flows, and incremental design with minimum spanning trees. We investigate their computational complexity, analyze the performance of natural heuristics, derive approximation algorithms, and study integer programming formulations.

■ HD-26

Thursday, 14:00-15:30 - Room 010

Nondifferentiable Optimization: Applications to Large-Scale and Combinatorial Problems

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Enrico Gorgone*

1 - Optimal Replenishment Order Placement in a Finite Time Horizon

Giovanna Miglionico, Manlio Gaudioso, Giovanni Giallombardo

We introduce the problem of scheduling and aggregating a fixed number of replenishment orders, along a given planning horizon, with the aim of minimizing the total inventory and backorder costs. A continuous formulation is provided, which is characterized by a nonconvex piecewise affine objective function. We introduce an ad hoc algorithm, based on the coordinate search approach. To evaluate the quality of the obtained solutions we provide a discrete formulation of the problem whose exact solutions can be obtained by means of an integer programming commercial solver.

2 - A Heuristic Algorithm for Solving the Minimum Sum-of-Squares Clustering Problems

Burak Ordin, Adil Bagirov

Clustering is an important task in data mining. It can be formulated as a global optimization problem which is challenging for existing global optimization techniques even in medium size data sets. Various heuristics were developed to solve the clustering problem the global k-means and modified global k-means. However, these algorithms are not always accurate in finding global or near global solutions to the clustering problem. In this paper, we introduce a new algorithm to improve the accuracy of the modified global k-means algorithm in finding global solutions.

3 - Decomposition Approaches: The Role of the Master Problem Formulation

Antonio Frangioni, Alberto Caprara, Tiziano Parriani

Decomposition methods for large-scale programs work by separating the problem into small subproblems, and then "gluing back together" the generated information. This latter step is fundamental, and is typically achieved by a master problem. By using Lagrangian relaxation of large-scale multicommodity min-cost flows as an example, we show that, even for a fixed decomposition, choosing the right master problem formulation has a substantial impact on the overall performances and therefore is a crucial step to obtain an ultimately efficient approach.

4 - A Computational Comparison of Approaches to Lagrangian Duals: The Case Study of FC-MMCF
Enrico Gorgone, Antonio Frangioni, Bernard Gendron

The focus of this work is to compare a large set of approaches for solving Lagrangian duals of combinatorial problems. In particular we compare different nonsmooth optimization methods like (incremental, deflected, projected) subgradient-type algorithms and (disaggregated, generalized) bundle-type algorithms. We use as a test set the multicommodity capacitated network design problem (FC-MMCF), a problem arising in many different applications such as logistics, telecommunication and transportation.

■ HD-27

Thursday, 14:00-15:30 - Room 213

Decision Making and Applications

Stream: Decision Analysis, Decision Support Systems
Contributed session
Chair: *Billur Ecer*

1 - Research Project Evaluation and Selection Based on the Evidential Reasoning Rule
Fang Liu, Weidong Zhu, Jian-Bo Yang, Dongpeng Wang

Current studies on Research Project Evaluation and Selection mainly use traditional project evaluation methods, which have various limitations, such as making no difference between importance and reliability and the inability to distinguish proposals due to limited linguistic values. The Evidential Reasoning rule has the features of managing importance and reliabilities of sources separately and handling highly or completely conflicting evidence, so it is introduced to aggregate peer experts' comments. A case study is conducted using the peer review data to demonstrate the applicability.

2 - Job Selection in a Network of Autonomous Unmanned Aerial Vehicles (UAVs) for Delivery of Goods
Pasquale Grippa, Doris Behrens, Christian Bettstetter, Friederike Wall

Based on the analysis of job selection policies, we provide decision-making support for planning and operating a networked UAV-based supply service. Similar to a dynamic VRP, jobs arrive over time for certain locations according to a space-time stochastic process, and are addressed in real time. Key novelties: (i) analysis of interdependence between job selection policies and system infrastructure, both in terms of system cost and stability, and (ii) providing evidence that the timing of decision-making affects performance whereas the 'direction' of the effect is policy-dependent.

3 - A Framework of Decision Support Systems for Products Innovation
Di Xu

Products innovation is prior to production and more complex and riskier than production. It is important to have a decision support system to support products innovation, just like production which is usually supported by ERP. This paper classifies the process of products innovation into five steps: creativity collection and screening, scheme generation, demonstration and evaluation. The characteristics of these steps are different and need different kind of decision methods. A meta-synthesis method is developed and a framework of decision support systems for products innovation is proposed.

4 - Transportation of Valuable Product: A Case Study
Billur Ecer, Serpil Erol

In globalizing World, transportation has gained a remarkable importance. This study is motivated by the lack of choosing short and safety routes. Transportation of fuel product, money, weapon and ammunition can be term valuable material transportation. In this study a multi-objective mixed integer model is established. As a case study, some parts of Erzincan (Turkey) are selected and network was created. Data which are received from geographical information system are coded to GAMS. Finally routes are found for different level of valuable products.

■ HD-28

Thursday, 14:00-15:30 - Room 130

MINLP for Natural Gas Network Optimization

Stream: Mixed-Integer Nonlinear Programming
Invited session
Chair: *Jesco Humpola*

1 - Topology Planning of Gas Transport Networks
Ralf Lenz, Benjamin Hiller, Jesco Humpola, Thorsten Koch, Robert Schwarz, Jonas Schweiger

Gas transportation companies frequently need to extend their networks in order to enable feasible operations. In this talk, we present a heuristic procedure that tackles this topology planning problem in a two step approach. At first we propose different methods to derive a set of possible network extensions. Common methods in practice are to build new pipes, e.g., in parallel to existing ones or new active network elements. In a second step, the problem of finding a cost-minimal subset of the extension set that enable feasible gas operations results in the formulation of an MINLP model.

2 - Bilevel Optimization in Pipeline Transport Planning
Robert Schwarz, Benjamin Hiller, Claudia Stangl

Gas network operators are faced with the task of transporting gas through a network of pipelines. Active components such as valves, compressors and regulators are used to control the flow of gas and sustain feasible operation. Operators may also request to change the supply distribution at entries through contractual means. The suppliers then react in the manner of a Stackelberg game, which is modeled as a bilevel optimization problem. This model extends an MINLP formulation of the feasibility problem for stationary gas transport. Preliminary computational results are presented.

3 - Capacity Planning for Natural Gas Transmission Networks
Jesco Humpola, Armin Fügenschuh, Thomas Lehmann

We present a procedure for capacity planning of large-scale real-world distribution networks. It decides which combination of network extensions such as additional pipelines, compressors or valves should be added to increase the network's capacity or enhance its operational flexibility. We formulate this as a nonlinear mixed-integer problem. For its solution we use a combination of linear outer approximation and NLP solution techniques. We formulate capacity inequalities (or cutting planes) which reduce the overall solution time when added to the formulation and describe a primal heuristic.

■ HD-29

Thursday, 14:00-15:30 - Room 011

Distribution and Transportation in the Petrochemical Sector

Stream: OR in Petrochemicals and Mining
Invited session
Chair: *Vikas Goel*

1 - Balancing Chemical Production Networks by Railway Transports
Thomas Kirschstein, Christian Bierwirth

Chemical production networks consist of multiple integrated chemical production sites where a multitude of chemicals is processed. The chemicals handled at a particular production site are often disbalanced. These disbalances can be reduced by inter-site transports of the relevant chemicals. In this talk a distribution planning model for balancing chemical production networks by rail transports is presented. The model allows determining distribution plans using chemical rail cars such that chemical stocks are balanced. The application of the model is illustrated by a real-world case study.

2 - Modeling, Simulation and Optimization of an Oil Polluted Water Pumping Process in Open Sea
Benjamin Ivorra, Susana Gomez, Roland Glowinski, Angel Manuel Ramos

Oil spill contamination in open sea has caused some of the major environmental disasters. One of the cleaning techniques for these hazards is the use of skimmer ships (e.g., our partner: www.novetec.es). In this work, we are interested in improving this process. To do so, we first introduce a model to simulate the effect on the evolution of a given oil spill due to natural and pumping effects. Then, for some realistic cases, we optimize the trajectory of a skimmer in order to minimize the amount of pollutant after a fixed time. To do so, we use novel hybrid global optimization methods.

3 - Production Analysis and Operations Research at Noble Energy
Wesley Dyk, Alexander Engau

Noble Energy, Inc. is a global energy producer with offshore and US domestic onshore operations. To achieve optimal returns at maximum safety, the company develops and will use state-of-the-art analytic tools using linear, nonlinear, and global optimization. In this presentation, we first take a look at current research of production facility operations and decision-making for scheduling, crude sales and inventory. We also address our ongoing plans to extend models and methods to more general problems across company operations.

4 - Simultaneous Production and Distribution of Industrial Gas Supply Chains
Pierre-Marie Valton, Jean André, Ignacio Grossmann, Pablo Marchetti, Tejinder Singh

We describe a multi-period mixed-integer linear program to minimize cost of production and distribution of liquid products in industrial gas operations for coordinating production decisions at multiple plants and distribution decisions at multiple depots. Production decisions include production modes and rates that determine power consumption. Distribution decisions involve the source, destination, quantity, route, and time of each truck delivery. Results show that significant benefits exist with higher coordination among plants/depots to fulfill a common set of shared customer demands.

■ HD-30

Thursday, 14:00-15:30 - Room 012

Dynamical Systems and Game Theory

Stream: Applications of Dynamical Models
Invited session
Chair: *Alberto Pinto*
Chair:
Chair: *Bruno M.P. M. Oliveira*

1 - Cournot Duopolies with R&D Investment
Bruno M.P. M. Oliveira, Joana Becker, Alberto Pinto

We analyse a duopolistic Cournot competition model, where both firms can invest to reduce their production costs. We study an R&D investment function inspired in the logistic equation. We do a full characterization of the associated game and study the short and long term economical effects derived from using this new R&D investment function. For high production costs, that can correspond to the production of new technologies, the long term economical effects are very sensitive to small changes in the efficiency of the R&D programs.

2 - Dynamic Management Model of Small Work Groups
Liliya Mukhamedrakhimova, Ilmira Gerasimova

We consider the problem of small work groups management, namely the problems of its functioning improvement and ensuring the work rhythm. For solving these problems, we develop cognitive dynamic models of small work group based on linear and nonlinear relationships. Through computer simulations, the rate and sustainability of the activity process of small work groups are evaluated, control algorithms are produced, and required rate of activity is obtained. Each group member is considered as a system capable for self-regulation and self-organization.

3 - Dynamic Model of a Multi-Product Manufacturing System
Juliana Keiko Sagawa, Marcelo Nagano

A dynamic model for the production control of multi-product manufacturing systems was developed using Control Theory and System Dynamics tools. The model was applied to depict the dynamics of a real job shop production system of propylene bags. The control objective is to adjust the processing frequency of the machines to attend the demands of the products while keeping the work in process at the desired levels. The simulation results showed that the system could be successfully controlled. No similar model suitable to a multi-product system has been previously reported in the literature.

■ HD-31

Thursday, 14:00-15:30 - Room 013

Scheduling and Queuing in Networks

Stream: Telecommunications and Networks
Invited session
Chair: *Giorgio Gnecco*

1 - Scheduling Wireless Networks: The Advantage of Co-operation
Celia Glass

Wireless Networks provide low cost internet access, but have severe scheduling restrictions. On the one hand data is transmitted as packets providing unit processing times, on the other hand the access nodes cannot multi-task. Transmission is organised along a tree network with periodic local schedules, as periodicity provides reliability of service and energy saving. We present heuristics for co-ordinating transmissions across the network, and an optimal global perfect periodic solution, and then compare results to demonstrate the advantage of co-ordinated periodicities at the access nodes.

2 - Incremental Network Design for Maximum Flows
Thomas Kalinowski, Dmytro Matsypura, Martin Savelsbergh

Many real world networks are constructed over significant time periods, and often the performance of intermediate stages is an important objective, in addition to the quality of the ultimate network. We propose a class of problems combining network design and scheduling decisions, where the network is constructed over time, subject to resource and budget constraints, and the objective is the cumulative performance. We focus on the case where the underlying quality measure is the max flow value, and discuss some complexity results, heuristics, and approximation algorithms.

3 - A Branch-and-Price Algorithm for Communication Systems with High Error Correction Capability
Banu Kabakulak, Z. Caner Taşkın, Ali Emre Pusane

Channel coding aims to minimize errors which occur during the transmission of digital information from one place to another. Low-density parity-check (LDPC) codes add redundant bits to the original data to improve error correction capability. In practice, heuristic iterative decoding algorithms are used to decode received message. However, these algorithms may fail to decode if received message contains errors. We formulate the optimal decoding problem as an integer programming problem and propose a branch-and-price method for its solution.

■ HD-32

Thursday, 14:00-15:30 - Room 014

Supply Chain Management - Supply and Ressource Planning

Stream: Production Management & Supply Chain Management
Contributed session
Chair: *Pedro Martins*

1 - Does Punishment Work? On the Value of Buyer's Commitment in Supplier's Dynamic Improvement
Morteza Pourakbar, Mohammad Nikoofal, Saied Samiedaluie, Mehmet Gumus

There are strong empirical evidences that the stability in buyer-supplier relationship significantly influences supplier commitment to improve its reliability. We allow the supplier to gradually improve its reliability by investing in process improvement through offering punishment and commitment contracts. Contrary to the previous studies, our analysis reveals that punishment contract is more effective to incentivize supplier to improve its reliability. We then solve for the buyer's optimal regime, and show that it mainly depends on the cost of process improvement and outside option price.

2 - Design of the Field Study about the Criteria used in Supplier Selection
Joan Ignasi Moliné, Anna M. Coves

With the aim of contrasting the recently published literature dealing with the criteria used in supplier selection with that actually used by companies, a questionnaire has been designed in order to carry out a field study. This has been sent to the purchasing professionals collective Aerce (Association of professional purchasers, contractors and suppliers in Spain). The present article describes and develops the methodology used in the design and diffusion of the questionnaire, as well as advancing some early conclusions based on the responses obtained.

3 - Supply Management of a Commodity Processor
Zhong Chen

In this paper, we study an agricultural commodity processor's optimal policy when it sources its input from spot market and contract market. The processor also sells its processed output in another commodity market. While contracted inputs provide a better homogeneous quality which benefits the processor, it also reduces transaction costs for the farmers. In an environment where both input and output commodity prices are stochastic and correlated, we study optimal operational decisions of the processor in terms of ordering, procurement and processing.

4 - Workforce Planning and Financing on a Production/Capital Discrete-Time Model
Pedro Martins, Ana Paula Quelhas

Current day's financial crisis is imposing new challenges for small and medium sized companies, namely in the production sector. The decisions on how to manage cash-flows in order to combine production and workforce together with the financial commitments of the company are becoming increasingly complex and harder to adjust. We model the three processes (production, workforce and cash-flows) in a single framework, resorting to a discrete-time formulation. We also incorporate new strategies for financing labor, using a sequence of flexible short-term loans. We discuss applications.

■ HD-33
Thursday, 14:00-15:30 - Room 015

Algorithm Configuration: Black, White and Gray Box

Stream: Hyperheuristics
Invited session
Chair: *Patrick De Causmaecker*

1 - Algorithm Configuration: Black, White and Gray Box
Patrick De Causmaecker, Nguyen Thi Thanh Dang

The task of automated (off-line) algorithm configuration includes finding a good parameter configuration for an algorithm based on some performance measure and a problem instance distribution. This could be considered as an expensive optimization problem. Currently, most algorithms treat the target (configured) algorithm as a black-box, i.e., only the final result of each run of the target algorithm on a problem instance is taken into account. If we "open the box", we could have a gray-box or even a white-box configuration problem. We study conditions, features and techniques.

2 - Automatic Design of Metaheuristics from a Grammar Description
Franco Mascia, Manuel López-Ibáñez, Marie-Éléonore Marmion, Thomas Stützle

We present a system that is able to generate hybrid metaheuristics by combining elements from metaheuristics such as variable neighborhood search, iterated local search, tabu search, simulated annealing, etc.. The proposed system is composed of two parts: a generative grammar that allows instantiating arbitrary combinations of their components, and a method to generate a parameter description from a grammar description, which allows us to apply automatic configuration methods. We have applied this approach to several combinatorial optimization problems.

3 - Adaptation of Meta-heuristic Algorithms to Dynamic Problems
Özcan Aytaç

In this study, we investigated updating of algorithm parameters depend to problem structure during solution process. The effects of this approach to solution has been discussed. Genetic, particle swarm and simulate annealing algorithms are considered in this study. We aim to get better performance of meta-heuristic algorithms in dynamic environment.

4 - Genetic Algorithm Parameter Optimisation for Multiprocessor Task Scheduling using Design of Experiments
Sunita Dhingra, Ashwani Kumar Dhingra

The present work considers the designing of optimal parameters of genetic algorithm for the multiprocessor task scheduling algorithm such that minimum total execution time is achieved. The different experiments using different parameters of genetic algorithm such as crossover, crossover rate, selection etc. have been conducted for the well known problem of Gauss elimination with 18 tasks and 4 processors with variable communication cost. From the analysis, optimal parameters of genetic algorithm have been reported for the effective solution of multiprocessor task scheduling problem.

■ HD-34
Thursday, 14:00-15:30 - Room 016

Financial Modeling 3

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Josef Arlt*

1 - Are there Gender Differences in Consumer Credit Risk?
Galina Andreeva, Anna Matuszyk

The presentation analyzes gender differences in risk profiles in consumer credit. Gender is not normally used in credit risk assessment due to legal and ethical considerations. It can be argued that gender removal leads to reduced predictive power of scoring models and lower availability of credit for women, yet there is no definitive answer as whether this is the case. Based on a unique proprietary dataset and on a standard credit scoring methodology, the analysis provides insights into potential role of gender in credit-granting environment.

2 - Estimate Aggregated Default: An Impirical Investigation on Brazilian Loans using Cointegration Vectors
Angela De Moraes, Galina Andreeva, Jonathan Crook

Brazil has experienced a robust expansion in consumer credit during the last decade which raises concerns about the increase of vulnerabilities in the household sector. The purpose of this study is to develop econometric models to predict the behaviour of the aggregate delinquency in Brazilian consumer loans. The model consists in testing cointegrating relationships and then estimating a short run error correction model. The results based on monthly data from 2000 to 2012 show that the delinquency rate is particularly sensitive to shocks on GDP and to the variation of workers' income.

3 - Modelling of Yearly Inflation Rate
Josef Arlt, Marketa Arltova

Inflation rate is a important macroeconomic indicator, which plays a crucial role in monetary policy. The yearly inflation rate is not the appropriate measure of inflation. The spectral time series analysis shows that it delays the information with respect to the monthly and annualized inflation rate about six months. This conclusion leads to the proposal of a new nontraditional method for the yearly inflation rate forecasting. This paper was written with the support of the Czech Science Foundation project No. P402/12/G097 DYME - Dynamic Models in Economics.

■ HD-35

Thursday, 14:00-15:30 - Room 131

Simulation and Optimization for Robust Supply Networks

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Erik Kropat*
Chair: *Silja Meyer-Nieberg*
Chair: *Ozlem Defterli*
Chair: *Jens Baudach*

1 - Linking Mathematical Optimization and Stochastic Simulation for Planning of Transshipment Terminals in the Parcel Delivery Industry
Jens Baudach, Uwe Clausen, Daniel Diekmann

Mathematical optimization and discrete-event simulation represent two powerful methods with different but complementary advantages. However, both are mainly applied separately for logistical problems so far. Planning parcel transshipment terminals contains a large number of decisions, such as (un)loading dock or sorting destination assignments, as well as the consideration of complex automatic sorting systems and manual handling activities with lots of stochastic elements. Therefore, we will present a new planning approach that closely links optimization and simulation in an iterative way.

2 - Simulation based Study for Robust Supply Network Design
Partha Datta, Pallab Dutta

Studies on disruption are becoming even more relevant and important as supply chains are becoming more globalised with companies sourcing materials from far-off sources. In this paper, design characteristics of supply chains have been considered and their correlation with severity of disruption in the supply chains have been analysed employing a simulation modelling method.

3 - Shipment Transport via Transfer Ports: A Stochastic Programming Approach
Yer Van Hui, Andy Lee

This paper addresses the shipment planning problem with random processing times in intermodal logistics. Shipment activities are divided into two groups according to regional settings. Activity processing times in stage one are assumed to be random while those in stage two are deterministic. In case a shipment delay is observed, an in-process adjustment is implemented to reduce costs. We establish a two-stage stochastic programming model using an integrated scenario generation approach. An illustrative example with industry data is presented.

4 - Multistage Stochastic Model of Fuel Procurement for Electric Generation with Logistic and Commercial Constraints
Carlos Testuri, Bernardo Zimberg

In order to satisfy uncertain demand, fuels are acquired as discrete size volume cargos under contract regulation, usually two months before the arrival of the product. In the meantime, changes in demand determine extra costs such as delay or cancellation of cargos due to capacity constraints. The multistage stochastic model depicts decisions on acquisition, delay and cancellation of discrete size volume cargos of fuel at minimum expected cost, subject to uncertain demand, production and stock constraints, contract regulation, material balance, and logistic and commercial constraints.

■ HD-36

Thursday, 14:00-15:30 - Room 132

Supply Chain in Agriculture

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *LluisM Pla*
Chair: *Marcela Gonzalez-Araya*

1 - A Hierarchical Markov Decision Process Modelling Feeding and Marketing Decisions of Growing Pigs
Reza Pourmoayed, Lars Relund Nielsen, Anders Ringgaard Kristensen

Feeding is the most important cost in the production of growing/finishing pigs that has a direct impact on the marketing decisions (decisions concerning when to slaughter) and the final quality of the meat. In this paper, a hierarchical Markov decision process (HMDP) is considered to model the feeding and marketing decisions simultaneously. The model finds the optimal decisions given the current state of the pen. The state of the system is updated using a Bayesian approach based on on-line data obtained from a set of sensors in pen and finally the HMDP is tested on a set of numerical examples.

2 - Multi-Stage Model for a Real Instance in a Pig Production System
Esteve Nadal, LluisM Pla

The paper presents a two-stage stochastic model to optimize the pig production system in a multi-site instance. The model maximizes the benefit calculated from the incomes of the animals and the production costs over the time horizon considered. It provides a schedule of transfers between farms, occupancy and trucks involved. The model uses integer variables, but it is far to find an optimal solution due the time spent. A further analysis has been done by relaxing the integrity of the variables and studying the model behavior when parameters affecting to the execution's time are modified.

3 - Can Organic Agriculture Feed Turkey?: A Linear Programming Approach
Bulut Aslan, A. Yonca Demir

Conventional agriculture is a large-scale, monoculture intervention to ecology requiring the use of agrochemicals having harmful effects on natural resources, health and biodiversity. Organic farming can be a solution to dissolve these problems of economy and ecology. In this paper, we propose a linear programming model to study the viability of organic farming in Turkey's case. It aims to show that when all agricultural resources are used for organic farming, the throughput can still feed the population, surplus can be produced, endemicity and biodiversity can be retained.

4 - An Optimization Model for Planning Fruits Transport from Cold Storages to Packing Plants
Marcela Gonzalez-Araya, Wladimir E. Soto-Silva, LluisM Pla

An important issue in the fruits supply chain is related to the kind of storage where the fruits are kept and the transport used to carry them to packing plants. In this work, an optimization model for supporting fruits transport planning from cold storages to packing plants, aiming to minimize opening costs of cold storages and transport costs is proposed. The model considers constraints about plants fruits demand, plants capacity and stored fruits quantities. This model is applied to a real case from a packing plant located at Region of Maule, Chile.

■ HD-37

Thursday, 14:00-15:30 - Room 017

Advances on Recovery Inventory Management Policies I

Stream: Recovery Inventory Management Policies
Invited session
Chair: *Nihat Öner*

1 - A Co-evolutionary Network Design Method for Strategic Alliance in Express Delivery Services
Kap Hwan Kim, Friska Natalia Ferdinand, Chang Seong Ko, Ki Ho Chung

This study addresses small-sized express delivery service companies suffering from their low demand service centers and suggests optimal strategic alliance models to overcome their difficulties: merging service centers, opening/closing terminals, and also sharing consolidation terminals. The proposed approach allows an independent decision making process under the strategic alliance by each company. A co-evolutionary genetic algorithm is developed, which may be implemented under a distributed decision-making scenario.

2 - Optimization of Route Planning and Cost Allocation in Truckload Shipper Collaboration
Nihat Öner, Gultekin Kuyzu

Truckload shipper collaboration is an example of horizontal collaboration in supply chain management. In truckload shipper collaboration, a group of shippers purchasing the services of carriers come together and jointly negotiate with carriers for better rates. Identifying the minimum cost collaborative solution and allocating the calculated minimum cost are typically treated as two successive but distinct phases. In this study, we develop a new integrated optimization approach with the objective of calculating the minimum cost collaborative solution which has a good cost allocation.

3 - Coordinated Dynamic Pricing and Inventory Management for Perishable Products with Time-Dependent Demand
Onur Kaya, Sajjad Rahimi Ghahroodi

We focus on the pricing and inventory decisions for perishable products in a stochastic setting in which the demand rate is affected with not only the prices of the products but also with the freshness of the products. We model this problem through a dynamic programming formulation and determine the optimal inventory and pricing decisions. We prove certain characteristics of the optimal solution and also analyze the effect of different parameters on the optimal solution. This work is supported by Tubitak grant #111M533.

4 - Evaluating the Effectiveness of Alternative Pricing Policies for the Water Utility Sector under Uncertainty
Nurcan Demirok Donmez, Nahit Serarslan

In this study, we focus on the water utility sector because of the value water has as a natural resource. By the effect of climate changes (e.g., global warming), the water reserves are reduced and for many cities, use of water reserves may become an important issue. In order to use this scarce resource more efficiently, different mark up or mark down policies for pricing can be considered. For this reason, the policies of an important municipal water distribution authority are evaluated statistically and new policies are proposed to find some new solution alternatives.

■ HD-38

Thursday, 14:00-15:30 - Room 214

Soft OR / Systems and Multimethodology 2

Stream: Soft OR / Systems and Multimethodology
Invited session
Chair: *Giles Hindle*

1 - Structuring Investment Decisions for Smart City Transitions
Katharina Burger, Mike Yearworth, Leroy White

The study addresses the challenge of designing participatory decision making processes for smart city transitions. A process combining Delphi and ANP was developed to engage stakeholders in the process of prioritizing areas for investment and structuring delivery organizations. The study shows the impacts of converging IT systems and infrastructures, local government and workplace structures. The interdisciplinary research contributes to current debates on soft OR with its multi-method multi-paradigm approach and provides empirical contributions to studies of governance in smart cities.

2 - Action Research using Soft Systems Methodology: Exploring Alternative Intervention Modes
Giles Hindle

Soft Systems Methodology (SSM) is an approach to tackling messy, ill-structured problems. Drawing on both the author's own Action Research programme and a review of the existing literature, a taxonomy of intervention modes for SSM is presented. The taxonomy includes modes such as organisational project, individual sense making, qualitative research and executive coaching. Reference is also made to a spectrum of consulting approaches from participative to expert.

3 - Emerging Findings from a Review of an Intervention Using the Lean Systems Methodology
Gavin Betts

This research seeks to evaluate the Vanguard Methodology. Used and developed by Vanguard Consulting over thirty years, it has been labelled 'lean systems methodology' in the literature. This methodology is claimed to bring about improvements in service whilst also reducing costs. The emerging findings from a case study in which this approach was employed will be discussed.

■ HD-39

Thursday, 14:00-15:30 - Room 018

Advances in Discrete and Global Optimization and on Graphs I

Stream: Discrete and Global Optimization
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Joao Lauro D. Faco'*
Chair: *José Paixão*

1 - Optimal Regular Covering of the Plane with Equal Sectors
Adil Erzin, Natalia Shabelnikova

In the regular cover, the area split into equal regular polygons, and all the polygons are covered equally. In the paper a polygon is an equilateral triangle. We propose the new regular plane coverage models with equal sectors in which the number of sectors per unit area is minimum. Such problem is closely related to the problem of finding the least dense cover, but does not coincide with it due to the restrictions on the sector's parameters. We have found the optimum number of sectors covering one tile in a special case.

2 - On the Class of (k, l) Partition Graphs
Hayat Issaadi

Partitioning the vertices of a graph is a problem that has generated much interest, particularly when the partition is into l cliques and k stable sets. This class of graph called (k, l) partition graphs was introduced by Branstadt in 1996. In our study we present all subclasses relating to this class of graphs, which have been studied in recent years. Moreover we present some results on a generalization of this class of graphs.

3 - On (a,d)-Antimagic Labelings of Generalized Petersen Graphs P(n,3)
Lingqi Zhao

A connected graph G = (V,E) is said to be (a d)-antimagic if there exist positive integers a, d and a bijection f of E to the set containing 1,2,...,|E|, such that the induced mapping gf from V to V, where gf(v) is defined as the sum of f(uv) with respect to all uv in E(G), is injective and gf(V) is the set containing a, (a+d),..., (a+(|V |1)d). In this paper, we show that the generalized Petersen graph P(n,3) is ((5n+5)/2,2)-antimagic for odd n greater or equal 7.

■ HD-40

Thursday, 14:00-15:30 - Room 019

Prescriptive Analytics: Smart Solutions to Real-World Problems I

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair: *Stefan Voss*
Chair: *Stefan Lessmann*

1 - Car Resale Price Prediction with Ensemble Selection and Asymmetric Cost Functions
Stefan Lessmann, Hsin-Vonn Seow

Resale price prediction is important to inform decision making in the used car business. We develop a prediction model that integrates the principles of ensemble selection and asymmetric cost of error functions. This allows us to create prediction models that account for the economic consequences of forecast errors, and avoid the more costly errors type in particular. Empirical experiments on real-world data suggest that the new approach produces more accurate forecasts, is better aligned with application requirements, and offers better decision support.

2 - Functional Principal Component Analysis in Revenue Management Data
Claus Gwiggner, Catherine Cleophas

One part of revenue management is to infer similarities between markets from observed customer behaviour. The underlying observations are often high-dimensional and partly ordered in time. We performed cluster and functional principal component analysis of revenue management (RM) booking data. Our results allow to manually complement automated RM systems and to improve the underlying forecasting components.

3 - An Empirical Comparison of Classification Algorithms for Mortgage Default Prediction: Evidence from a Distressed Mortgage Market
Trevor Fitzpatrick, Christophe Mues

This paper evaluates the performance of a number of modelling approaches for future mortgage arrears status over a 12-month horizon. Boosted regression trees, random forests, linear and semi-parametric logistic regression models are applied to over 300,000 Irish owner occupier mortgages. The results indicate that the selected approaches have varying degrees of predictive power and that boosted regression trees outperform logistic regression. The findings suggest that boosted regression trees can be useful additions to the current toolkit for credit risk assessment for banks and regulators.

4 - Discrete Cyber Swarm Algorithm and Analytics Strategies for the Quadratic Assignment Problem
Peng-Yeng Yin, Fred Glover, Shun-Chieh Yang

Quadratic assignment problem (QAP) includes the widely known traveling salesman problem (TSP) as a special case, but is considered much harder than the TSP. A survey disclosed that many best QAP algorithms use multiple metaheuristics and include tabu search as a fundamental part. Yin et al. (2010) have developed the cyber swarm algorithm (CSA) which shows the advantages of particle swarm optimization that incorporates tabu search principles. This talk presents a discrete CSA for the QAP by showing the benefit of incorporating the analytics strategies.

■ HD-41

Thursday, 14:00-15:30 - Room 216

Stochastic Models in Production, Manufacturing and Services

Stream: Stochastic Models for Service Operations
Invited session
Chair: *Maria Elena Bruni*

1 - Service Levels in Inventory Management
Stefan Minner

Many inventory control models optimize stock levels subject to service level constraints. One shortcoming of these measures and the way they are applied is the use of expected values. As a consequence, performance measured empirically and for a given finite time horizon will deviate from prescribed levels derived under steady-state conditions. Further, there exist inconsistencies between certain types of service measure and the materials flow assumptions. The paper provides analytical expressions for service levels and a numerical study to show the potential for improvement.

2 - A Constraint Programming Approach for Computing Robust Sequences of Tasks in Stochastic Scheduling
Jerome Rogerie, Philippe Laborie

Stochastic scheduling often involves computing robust sequences of tasks on unary resources. In this context, Stochastic Programming usually consists of a two-stage formulation where sequencing decisions are part of the first stage whereas tasks start time are fixed online in the second stage. Scenario-based approaches benefit from high-level concepts to state that on each resource the same sequence is used across all scenarios. We present the sequence variable and same-sequence constraint introduced in CP Optimizer and show how they are used to model and solve these stochastic problems.

3 - Managing Uncertainties in Hardware-Software Codesign Projects
Jones Albuquerque, Jordi Ferrer-Savall, Silvana Bocanegra, Tiago Ferreira, Daniel Lopez-Codina, Claudionor Coelho Jr

This work presents a system-level methodology for managing and partitioning HW/SW codesign projects in presence of uncertainty at conceptual level. It uses a Stochastic Integer Linear Programming (SILP) formulation to cast the partitioning problem of objects into technologies subject to team factors, risk analysis, execution and development constraints. It also proposes an approximation to solve the SILP problem. This approximation is based on design scenarios in order to make the problem computationally feasible. Results when applied in a real project are also presented.

4 - Dynamic Pricing, Production, and Channel Coordination with Stochastic Learning
Suresh Sethi, Tao Li

We consider a two-period supply chain in which a manufacturer produces a product with benefits of cost learning, and sells it via a retailer facing a price-dependent demand. The second-period production cost declines linearly in the first-period production with a random learning rate. We examine how mean and variance of the learning rate impacts pricing, production and ordering decisions of the channel members. We show that increases in the mean or variance of the learning rate worsen the double marginalization problem. We find revenue sharing contracts to coordinate the dynamic supply chain.

■ HD-42

Thursday, 14:00-15:30 - Room 215

Collaborative Decision Making (Social Networks & Web Resources)

Stream: Decision Support Systems
Invited session
Chair: *Adiel Teixeira de Almeida*
Chair: *Fatima Dargam*

1 - Online Multidisciplinary Information Management Software

Haris Doukas, Ilias Papastamatiou, George Mavrotas, John Psarras

The Online Multidisciplinary Information Management Software (OMIMS) is a decision support tool that offers a flexible, reliable and transparent way to solve decision making problems using multi-disciplinary data sources. The OMIMS transforms information into 2-tuples (Herrera et al.) and presents the solution to the user using graphical methods. The algorithm's implementation follows an object-oriented approach, giving the user the ability to store, edit, review or discard problems. OMIMS is developed using open source programming languages. Multiple users can also work on shared problems.

2 - IT Service Selection in Cloud Computing — An Evaluation of Multiciteria Decsion Model Approaches

Holger Schrödl

The optimal selection of IT Services is of vital interest for industrial practice. From an Information Systems perspective, frameworks are provided to support this challenge. Most of these frameworks consist of a set of relevant decision criteria, but there is a lack of research on the question how to apply these criteria-based frameworks to model a particular decision model. First, the authors describe several IT service selection frameworks and transform them into appropriate MCDM formulations. Second, these MCDM formulations are evaluated with respect to their usefulness for industry.

3 - Exploring the multi-channel consumer decision-making journey

Sahar Karimi, K. Nadia Papamichail, Christopher Holland

Prior research has focused on consumers' channel switching behavior; however our current knowledge of multi-channel purchase processes is limited. This research examines consumers' choice of channel in each stage of the decision making process. A conceptual model considering the perceived value of each channel at all the stages is presented. A mixed method research is designed including interviews and Internet panel data. The result informs the current literature on multi-channel purchase and provides guideline for retailers struggling to effectively allocate sources to different channels.

4 - Multi-criteria Spatial Decision Making and Determining Location Score based on Geographic Zone with GIS

Ceren Erdin Gundogdu

Criteria of choosing location are mainly spatial. Contemporary studies confirm that determining location on GIS, which integrates geographical data and semantic data, is rational and more accurate. This study offers multi-criteria decision making conditions and models unique to a particular type of business, which is a large scale enterprise, for choosing location in a country and geographic zone based on "Life Quality Research" and "Socio-Economic Development Order of Cities and Regions" data.

■ HD-43

Thursday, 14:00-15:30 - Room 217

Medical Informatics

Stream: Optimisation in Health Care
Invited session

Chair: *Adem Tüzemen*

1 - Forecasting Negativity of BRCA1 / BRCA2 Genes for High-Risk Breast Cancer Families

Şimal Aysever, Suzan Güreli, Fadime Üney-Yüksektepe, Tülin Aktin

The causes of breast cancer are classified into two groups as modifiable and non-modifiable (genetic). Genetic risk factors for healthy individuals can be identified by BRCA1/BRCA2 gene tests which are costly and time consuming. The negativity of the gene test implies absence of non-modifiable breast cancer risk. In this study, past data of individuals who have undergone these tests will be obtained from Istanbul University Oncology Institute, and data mining techniques will be used to predict the test results beforehand. Thus, it is aimed to optimize the incurred costs and required workforce.

2 - Using GIS in Biology

Ceren Yağci, Ahmet Duran, Savas Durduran, Murat Sanda

The investigation of the biological structure of the plants in the nature, their spatial distribution has great importance for the investigations. In such kind of a studies GIS provides support to these applications for solving their problems and achieving their objectives. The natural plant taxa spread on Akseki (Antalya-Turkey) were detected by GIS method. Their relationship with habitat was investigated by the help of spatial analysis. The phytogeographical distribution, systematic features and life form of plant demonstrated in maps and provided accuracy.

3 - Optimizing Automated Medical Dispensing Cabinets through Voice of Customer

Jülide Nallioğlu, Sabri Erdem

As it is known, the pharmaceutical and medical supplies used in the health sector have significant costs due to their material values. Also some negative situations such as lost, reduced and expired supplies can be seen very often and this makes the case management of stock; therefore material planning is difficult. In this study, our goal is to provide redesigning the cabinets in the modular system in a more controlled and systematic manner in terms of the data gained by observations and customers' needs.

4 - Design of a New Appointment System Using Bill of Operation Case (BOC)

Adem Tüzemen, Şevkinaz Gümüşoğlu, Güzin Özdağoğlu

Surgical operating rooms are one of the most important decision centers in hospitals. Planning of these rooms are affected by many factors, i.e., number of rooms, surgeons materials and equipment, patient bed capacity, intensive care unit. This study focuses on inventory management for operating rooms and introduces a "bill of operation case" (BOC) model for efficient use of materials in surgical operations. BOC model is also supported with a new appointment information system which can be customized by surgeons.

■ HD-44

Thursday, 14:00-15:30 - Room 218

Humanitarian Logistics, SCM Practices and Sustainable Development

Stream: Quality and Performance Measurement in Humanitarian Relief Chains
Invited session

Chair: *Sadia Samar Ali*
Chair: *Frank Meisel*

1 - Ambulance Routing for Disaster Response with Patient Groups

Frank Meisel, Luca Talarico, Kenneth Sörensen

We consider a routing problem for ambulances in a disaster scenario. The ambulances are used for serving two types of patients: slightly injured persons who can be helped directly in the field and seriously injured persons who have to be brought to hospitals. Two mathematical formulations and a Large Neighborhood Search metaheuristic are proposed for minimizing the latest service completion time among the people waiting for help. Our experiments show that the metaheuristic produces near optimal solutions for a large number of test instances within very short response time.

2 - A Production/Remanufacturing Inventory Model with Multiple Recycled Components and Outsourcing Policy

Che-Fu Hsueh

A production/remanufacturing problem with multiple recycled components and outsourcing policy is considered. The remanufacturer purchases recycled components from the collector, and sells products after production/remanufacturing. Remanufactured products are assumed to be different from new products. Both the remanufacturer and the collector maximize their own profits. The equilibrium of the problem is formulated as a variational inequality, in which products prices, production lot sizes, ordering quantities of components, and the costs to stimulate return rates are determined.

3 - Performance Analysis of Quality Collaboration in the Supply Chain
Hyun Jung Kim, Soo Wook Kim

The Korean Standards Association developed Quality Collaboration Index for Supply Chain Management (QCI-SCM) for its 'Quality Innovation-Based Building and Expansion of Business.' This paper analyses the performance difference of quality collaboration in the supply chain on the different types of supplier-buyer relationships, based on the QCI-SCM survey results. The significance of this paper lies in the analysis-based strategic direction it provides to promote supplier-buyer quality collaboration.

4 - Performance Measures of Humanitarian Supply Chain Network
Sadia Samar Ali

The humanitarian supply chain, a network of diverse players includes military, Government, NGOs, Police, Aid agencies and Logistics service providers. The performance of a humanitarian supply chain is measured in terms of lives saved. It must be agile to respond, designed to move materials to the disaster hit areas to serve for those in need in the shortest possible time and must possess the ability to return to their original configuration.The supply chain agility and supply chain resilience are two important determinants of the pre and post disaster Supply Chain performance of this study.

■ HD-45

Thursday, 14:00-15:30 - Room 219

Location Problems

Stream: Hybrid Heuristics
Invited session
Chair: *Gabor Nagy*
Chair: *David Mauricio*

1 - A Three-Stage Approach for Solving Large Unconditional and Conditional Vertex p-Centre Problems
Chandra Irawan, Said Salhi, Zvi Drezner

A three-stage approach is proposed for solving large unconditional and conditional vertex p-centre problems. The first stage consists of some aggregated problems which are then solved with an exact method to produce promising facility sites. In the second stage, these promising facilities are used as potential facility sites for solving the p-centre problem involving the original demand points by a VNS algorithm. The obtained solution is then fed into the last stage where a VNS is utilised to solve the original problem. The method is assessed on the TSP dataset with competitive results.

2 - Adaptive Perturbation-Based Heuristics: An Application for the Continuous p-centre Problem
Abdalla Elshaikh, Said Salhi, Jack Brimberg, Nenad Mladenovic, Gábor Nagy

A perturbation-based heuristic using both a gradual and a strong perturbation is proposed to solve the p-centre problem in the continuous space. Efficient enhancements are proposed and a learning scheme is embedded into the search. Empirical results, using several existing data sets (TSP-Lib) with various values of p, show that our proposed heuristics outperform both a multi-start heuristic and a discrete-based optimal approach.

3 - The Partially Probabilistic Customer Choice Rule: A New Competitive Location Model
Jose Fernandez, Juana López Redondo, Pilar M. Ortigosa, Boglárka G.-Tóth

A chain wants to set up a single new facility in a planar market. In the classical probabilistic (or Huff) model, a customer splits his/her demand among all competing facilities according to their attractions. We analyze this model versus the new partially probabilistic model, in which a customer only patronizes those facilities for which he/she feels at least a minimum level of attraction, and split his/her demand among them proportionally to their attractions (determined by the customer's view of the quality of the facility and its distance to it), through a gravitational model.

4 - A Greedy Algorithm to Solve Large Equality Facilities Location Problem
David Mauricio

We introduce a greedy algorithm with computational low cost to solve Large Facilities Layout Problem. The proposed algorithm iteratively builds a solution, adds one facility to solution in the each iteration such that its impact over facilities added is minimal, and this procedure is repeats until all facilities are located. Numerical experiments on instance with up to 1000 facilities show that the proposed algorithm is very fast and efficient.

Thursday, 16:00-17:30

■ HE-01

Thursday, 16:00-17:30 - Room 118

Scheduling and Rescheduling: Passenger Focus

Stream: Railway and Metro Transportation
Invited session
Chair: *Leo Kroon*

1 - Ideal Train Timetabling Problem
Tomás Robenek, Jiang Hang Chen, Michel Bierlaire

Given the recent changes in legislature allowing competitors in the railway industry, the current way of planning is not sufficient anymore. The original planning is based on the accessibility/mobility concept provided by one carrier, whereas the competitive market consists of several carriers that are driven by the profit. And thus, we introduce a definition of an ideal timetable and apply the scheduled delay concept (to cover the elasticity of the demand). The aim of the Ideal Train Timetabling Problem (as MILP) is to minimize the passengers' total travel time (weighted by the demand).

2 - Shuttle Planning for Link Closures in Urban Public Transport Networks
Evelien Van der Hurk, Nigel H.M. Wilson, Haris Koutsopoulos, Leo Kroon, Gabor Maroti

Urban Public Transport Networks need to regularly close links in their network for maintenance. These closures have significant effect on the service provided to passengers. In practice, the effects of closures are mitigated by replacing the link with a shuttle service. We present an optimization-based approach for the link closure problem as a Line Re-Planning problem. Our results show that using additional shuttles routes significantly reduces delay over the standard solution, based on the real life case of the Longfellow Bridge closure in the MBTA metro network of Boston, USA.

3 - Controlling Passenger Flows in Networks
Marie Schmidt, Lisa Thom

Even if a public transportation system provides enough transportation capacity in the long run, parts of it may be overcrowded, in particular in peak hours. If transportation capacity cannot be increased on the corresponding sections, an alternative way to avoid overcrowding is to give passengers (financial) incentives to switch to less crowded connections. We investigate and compare different approaches to control passenger flows in networks by modification of arc lengths and discuss to what extent they could be used to control passenger flows in public transportation systems.

4 - Minimization of Passengers' Travel Time in Railway Traffic Control
Dario Pacciarelli, Andrea D'Ariano, Francesco Corman, Federico Sabene, Marcella Samà

This work addresses railway customer satisfaction by solving a joint train scheduling and passenger delay management problem. A MILP formulation is proposed and solved in exact and heuristic ways. The heuristic approach iterates between two steps. First, the train scheduling problem is addressed with the minimization of a weighted train delay, the weights being equal to the number of passengers per train. Second, a passenger assignment problem is solved. Computational results on a Dutch practical case study show that the heuristic computes good quality solutions within a short time.

■ HE-03

Thursday, 16:00-17:30 - Room 001

Discrete Location

Stream: Location
Invited session
Chair: *Mozart Menezes*
Chair: *Oded Berman*

1 - Practical Benchmarks for Location-Routing Decisions via Approximation Algorithms
Mozart Menezes, Vedat Verter

We aim in identifying opportunities for improvement in real-world location-routing problems. Creating an approximation scheme for location and routing problems that is easy to implement, provides a reasonable good feasible solution, provides lower bounds on costs, and provides procedures for adapting different real situations so the scheme presented could be used. We present results discriminating measures such as vehicles' capacity utilization, technology, distance travelled, and CO2 emissions.

2 - On Covering Location Problems on Networks with Edge
Oded Berman, Jörg Kalcsics, Dmitry Krass

Given that demand is distributed along the edges of a network we consider the Maximal Covering Location Problem and the obnoxious version where the coverage should be minimized subject to some distance constraints between the facilities. We show that the finite dominating set for node covering problems does not carry over to the case of edge demands. We present a solution approach for the single facility problem. Moreover, we discuss the multi-facility problem where the demand is constant on each edge and present several discretization results for tree networks.

3 - Partitioning a Graph into Connected Components with Fixed Centers and Optimizing Different Criteria
Isabella Lari, Justo Puerto, Federica Ricca, Andrea Scozzari

Given a graph with n vertices, p of which are centers and n-p are units, we consider the problem of finding a centered partition of the graph, i.e., a partition into connected components each containing exactly one center. For each pair unit-center, there is a fixed assigning cost to be incurred if they belong to the same component. Basing on these costs, we consider different objective functions. The obtained optimization problems are NP-hard on general graphs, and we present efficient polynomial time algorithms for trees.

4 - Component Commonality: The p-Median Solution to a Product Design Problem
Renato Guimaraes, Mozart Menezes

Component commonality is an important problem that permeates the manufacturing industry. Serving multiple members of a product family with a single component design reduces the amount of different SKUs one has to manage with reduced inventory cost, allows achieving high service level, but introduce inefficiencies. As it is common in supply chain management, making the right trade-offs allows the decision maker to better manage the supply chain in terms of efficiency and responsiveness. We present a model for analyzing this trade-off that has an underlying structure of a p-Median problem.

■ HE-04

Thursday, 16:00-17:30 - Room 119

O-D Estimation

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Hesham Rakha*

1 - OD-Matrix Estimation Based on Plate Scanning
Alexander Krylatov, Victor Zakharov

The problem of OD-pairs reconstruction based on plate scanning technique is considered. Comparison of plate scanning (route identification) and traditional link count approaches is made. The greater informative potential of plate scanning method is demonstrated. In addition, elements of path flow reconstruction and optimal plate scanning devices allocation are introduced. Original method of analysis of traffic data gained from plate scanning devices is presented. The developed method is illustrated by its application to the traffic network of Saint-Petersburg city.

2 - A Practical Proposal for Dynamic OD Matrix Estimation in Terms of a Bilevel Approach
Manuel Bullejos Gonzalez, Jaume Barceló, Lídia Montero

Traffic management applications have to be feeded with real-time demand matrices to efficiently find solutions in the short-term horizon. OD matrices are estimated from historic or real-time data collection and prior matrices. In this work, we present a simulation-optimization bilevel-DUE approach for Dynamic OD matrix estimation, in which the lower level is a dynamic user equilibrium problem solved by a mesoscopic simulator. Time-sliced OD matrices generated off-line with the former procedure are efficient initializations for the on-line dynamic OD estimation methods based on Kalman filtering

3 - Information Provision for Passengers in Underground Railways Using Smart Card Data
Emily Digges La Touche, Nick Tyler

This project focuses on the London Underground network and the Hong Kong MTR network as case studies, looking at the data produced from the automated ticketing systems. The data shows to be a valuable source of information about the current conditions of the network for both operators and passengers. This information can lead to passengers knowing optimal routes, a realistic travel time and the number of minutes a delay may cost them; when the delay may be caused by congestion or service problems. Operationally this can allow for delay statuses to be more realistic and dynamic to crowding.

4 - Estimation of Dynamic O-D Matrices using Synthetic Time-Dependent Static O-D Estimators and Microscopic Traffic Simulation
Hesham Rakha, Hao Yang

The paper develops a dynamic Origin-Destination (O-D) estimator that combines a maximum likelihood time-dependent static O-D estimator with a dynamic traffic assignment and simulation software. The algorithm first estimates the time dependent O-D and then uses the microscopic simulator to create the dynamic O-D table while accounting for the intricacies of vehicle-to-vehicle and vehicle-to-control interaction. The algorithm is tested using a simulated network. The simulation results using the time-dependent static O-D table and the dynamic O-D table are compared to field observations.

■ HE-05

Thursday, 16:00-17:30 - Room 002

Port Operations - Miscellaneous

Stream: Port Operations
Invited session
Chair: *Deniz Ozdemir*
Chair: *Gokberk Ozsakalli*

1 - Solving the Pre-Marshalling Problem to Optimality with A* and IDA*
Kevin Tierney, Dario Pacino, Stefan Voss

We present a novel solution approach to the container pre-marshalling problem (CPMP) using the A* and IDA* algorithms combined with several novel branching and symmetry breaking rules that significantly increase the number of pre-marshalling instances that can be solved to optimality. The CPMP is a key problem for container terminals to reduce delays of inter-modal container transports. The goal of the CPMP is to find the minimal sequence of container movements to shuffle containers in a set of stacks such that the resultig stacks are arranged by the time each container must leave the stacks.

2 - Hybrid Heuristic Approaches for Tactical Berth Allocation Problem
Cagatay Iris, Allan Larsen, Dario Pacino, Stefan Ropke

Tactical berth allocation problem deals with: the berth allocation (assigns and schedules vessels to berth-positions), and the quay crane (QC) assignment (finds number of QCs that will serve). In this work, we strengthen the current mathematical models (MM) with novel lower bounds and valid inequalities. And, we propose a hybrid heuristic which combines MM with greedy and search heuristics. Results show that problem can be solved efficiently respect to optimality and computational time.

3 - Optimal Sequencing of Parking Operations at an Automotive Maritime Terminal
Marcello Sammarra, M. Flavia Monaco, Gregorio Sorrentino

The yard management of an automotive maritime terminal often requires the consolidation of parking areas, via reallocation of cars, usually of the same brand, to predefined destination lanes. These operations are performed by a set of drivers that are transferred back from the parking areas to the pick-up points by a set of shuttle vehicles. We focus on the problem of sequencing the cars to be moved by each driver, defining the shuttle routes, taking into account the labour agreements, while minimizing both the number of drivers and shuttles needed to perform the task.

4 - Stochastic Bi-Objective Berth Allocation and Quay Crane Assignment for Quayside Operations
Gokberk Ozsakalli, Hüseyin Gençer, Deniz Ozdemir

Traditional planning of quayside operations cause unnecessary waiting of vessels and inefficient utilization of resources. Moreover, most of the integrated approaches consider deterministic vessel arrivals and quay crane handling time which is actually not realistic in practice. To this end, an integrated stochastic bi-objective model has been developed to minimize the vessel service time and quay crane movement. The mixed integer model was solved by using disjunctive decomposition algorithm and applied at Izmir Container Terminal based on the historical data. It has shown promising results.

■ HE-06

Thursday, 16:00-17:30 - Room 211

Learning, Resilience, Competition and Congestion

Stream: Social and Economic Networks
Invited session
Chair: *Alex Teytelboym*

1 - Dynamic Congestion Games: The Price of Seasonality
Marco Scarsini

We propose a model of discrete time dynamic congestion games with atomic players. This approach allows to give a precise description of the dynamics induced by the individual strategies of players and to study how the steady state is reached, either when players act selfishly, or when the traffic is controlled by a planner. We model also seasonalities by assuming that departure flows fluctuate periodically with time. We focus mostly on simple networks and give closed form formulas for the long-run equilibrium and optimal latencies, as functions of the seasonality.

2 - Learning what Matters
Manuel Mueller-Frank, Itai Arieli

We consider a generalization of the strict sequential social learning model and analyze asymptotic learning for general state, signal and action spaces. Our main result provides a sufficient condition for asymptotic learning.

3 - Network Resilience Against Epidemic Spread
Kimon Drakopoulos, Asu Ozdaglar, Asu Ozdaglar, John Tsitsiklis

We study the problem faced by a network defender when an epidemic is evolving on a known network. We assume that the network defender has full information on the state of the epidemic and can allocate curing rates to nodes under a budget constraint. The goal is to minimize the expected extinction time of the epidemic. We find necessary and sufficient conditions on the graph structure under which curing policies that achieve sublinear extinction time exist.

4 - Knowledge Leadership: A Systems Approach
Uttarayan Bagchi, Amitava Dutta, Jack Hayya

Knowledge leadership seeks to make the process of knowledge exploitation cheaper, better and faster. We contend that accomplishing this tall objective requires a shift of mind along the lines articulated by Peter Senge in his writings on systems thinking. On one hand, the process perspective must be supplemented with an explicit recognition of interrelationships. On the other hand, practitioners will benefit by thinking of knowledge leadership at three distinct levels: essence, principles and practices.

■ HE-07

Thursday, 16:00-17:30 - Room 003

Fuzzy Optimization in Supply Chain Management, Production and Logistics

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session
Chair: *Ozlem Defterli*
Chair: *Silja Meyer-Nieberg*
Chair: *Erik Kropat*
Chair: *Mehmet Burak Şenol*

1 - Modified FCM Method to Explore Variations in a Multi-Variable Field
Metin Ger

FCM method has been in use for quite some time, to determine a stable future state of a multi-variable field. Modifications made to FCM method, presented in this study, facilitate the exploration of variation in time of variables constituting the field. As demonstrated, the modifications made to FCM method make it possible to carry out a comparative analysis of a multi-variable field subject to different scenarios. (Joint work with H. Fatih Aydın)

2 - Decision Making in Interface Selection
Mehmet Burak Şenol, Metin Dagdeviren, Mustafa Kurt

Different approaches (Goal programming, ANP, F-PROMETHEE) are offered for the selection of cockpit interfaces in terms of usability. Most of usability evaluation techniques are not analytical; characteristics and number of evaluators affect results. In order to overcome these challenges an Integrated Approach with ANP and Fuzzy PROMETHEE is employed. Goal programming approach is also applicable to the problem, in which objective function weights should be determined by ANP. A user-friendly interface design will improve aircraft usability and safety.

3 - Team-Oriented Assembly Line Balancing Problem: A Fuzzy Approach
Hamid Yılmaz, Mustafa Yılmaz, Merve Kayacı Çodur

In recent years with the advantage of the technology it has become possible to produce goods which are more complex.Therefore line designers allow stations to have several workers in the same station which is called team-oriented assembly line. However, in real life assembly line problems assembly time of tasks can be uncertain. Fuzzy sets theory is frequently used to represent uncertainty of information. This study addresses the team-oriented assembly line balancing problem with fuzzy processing time and a fuzzy linear programming model is formulated for the team-oriented assembly line.

■ HE-08

Thursday, 16:00-17:30 - Room 120

Case Teaching

Stream: Teaching OR/MS
Invited session
Chair: *Peter Bell*

1 - The Perspective of an Instructor New to "Case Teaching"
Mehmet Begen

This presentation will focus on the challenges of some new faculty member learning to teach with cases for the first time.

2 - OR/MS Case Teaching in Engineering Programs
Fredrik Odegaard

In this talk I will discuss some issues and strategies for teaching OR/MS using cases in engineering programs. Case teaching is usually associated with business school programs, but designed properly can (and should) be included in engineering programs as well.

3 - A Review of some of the many Ways to Include Cases in the OR Course
Peter Bell

This presentation will put forward many different ways that cases can be used in the context of teaching OR illustrating the variety of cases available and the richness that these case can bring to the OR course.

■ HE-09

Thursday, 16:00-17:30 - Room 121

Energy Markets

Stream: Technical and Financial Aspects of Energy Problems
Invited session
Chair: *Angelica Gianfreda*

1 - A Two-Step Day-Ahead Electricity Market Model for the Market Coupling between Central Southern, Central Western and Northern Europe
Dario Siface, Alberto Gelmini, Emanuele Maltempi, Emanuele Tresoldi

Coupling the European Electricity Markets is the only way to optimally allocate the cross-border transmission capacity. Computationally, it is impossible to solve the exact mathematical model describing altogether the Italian Uniform Purchase Price and the Central Western and Northern Europe block offers. Thus, the approach developed in this work computes the optimal solution for the Italian market for each import/export level (Net Export Curve - NEC). The NEC is then the input for the Central Western and Northern Europe market solution. The result is the optimal market coupling solution.

2 - A Leader-Followers Model of Power Transmission Capacity Expansion in a Market Driven Environment
Paolo Pisciella, Marida Bertocchi, Maria Teresa Vespucci

A bilevel program with mixed integer structure in both upper and lower level is introduced for analysing the upgrade of the national transmission grid. The upper level defines the transmission company problem and the 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 by providing new Locational Marginal Prices. We illustrate our methodology by means of an example based on the Garver's 6-bus Network.

3 - Comparative Analysis of Pricing Schemes in Markets with Non-Convex Costs
George Liberopoulos, Panagiotis Andrianesis

In markets with non-convex costs (e.g., electricity markets), classical marginal cost pricing may fail to provide sufficient revenues to the market participants, who may not recover their fixed costs. To address this problem, different pricing schemes that lift the price above marginal cost and/or provide side-payments (uplifts) have been proposed. We analyze and compare several of these schemes for a model of two suppliers with symmetric capacities and asymmetric marginal and fixed costs, who compete to satisfy a deterministic inelastic demand of a commodity in a single period.

4 - Power Price Forecasting with Wind Effects
Angelica Gianfreda, Derek Bunn, Dipeng Chen

We present a nonlinear regime switching method for short term power price forecasting to reflect the effects of increased wind generation on price risk. We show that the stochastic nature of wind generation poses a new set of distributional properties for the power price risks. We compare alternative regime switching methods as well as linear methods, and control for the price formation fundamentals of demand and fuels. The approach is applied to the main reference market for Europe, the EEX, with extensive out-of-sample testing.

■ HE-10

Thursday, 16:00-17:30 - Room 122

Workforce Optimization

Stream: Timetabling and Rostering
Contributed session
Chair: *Mike Wright*

1 - Near-Optimal MIP Solutions for Preference Based Self-Scheduling
Eyjolfur Asgeirsson, Gudridur Lilla Sigurdardottir

We look at a variation of preference based scheduling where the schedule is based on a preliminary schedule that is created by the employees. We formulate a mixed-integer program (MIP) to find a feasible schedule that satisfies all hard constraints while minimizing the soft constraint violations as well as satisfying as many of the employees' requests as possible. We show the result from four real world companies and institutions, and compare the results with those of a local search based algorithm that is designed to emulate the solution strategies when the schedules are created manually.

2 - Optimal Sequencing of Unpunctual Patients: Provider's Wait-Preempt Dilemma
Subhamoy Ganguly, Michele Samorani

Even though it is known that patients often arrive early and out of turn for scheduled appointments in outpatient clinics, no research has been undertaken to establish whether an available provider should see an early patient right away (preempt) or wait for the patient scheduled next. In this work, we analytically determine the time intervals where it is optimal to preempt and those where it is optimal to wait. Our analysis indicates that an always-preempt policy is never optimal, although it is a good heuristic under certain circumstances.

3 - Call Centers with a Callback Option
Benjamin Legros, Oualid Jouini, Ger Koole

We consider a call center model with a callback option, which allows to transform an inbound call into an outbound one. The objective of the system manager is to define the optimal call scheduling that minimizes the total expected waiting cost of inbound and outbound calls. Using a Markov Decision Process approach, we numerically characterize a switching curve of the agent reservation for inbound calls.

4 - Optimizing Television Programming and Scheduling
Mike Wright, Mhd Hani Alshami

This paper introduces a television grid optimization model for optimum television programming and scheduling. The methodology we use in our research is to combine both academic work and practitioners' experiences in order to build an innovative model for optimizing the programmes grid and maximizing viewership. The problem has been formulated as an integer program, and the software package used gives us the ability to solve large scale optimization models with thousands of variables and constraints which will certainly help media planners to plan for months ahead, if not years.

■ HE-11

Thursday, 16:00-17:30 - Room 113

Topics in Linear Programming and Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Valentina Cacchiani*
Chair: *Sergio B. Villas-Boas*

1 - Dual-Guided Pivots Rules for Linear Programming
Jean-Bertrand Gauthier, Jacques Desrosiers, Marco Lübbecke

We describe a generic primal algorithm for LPs guided by dual feasibility considerations. The resolution process moves from one solution to the next according to an exchange mechanism that is defined by a direction and a step size. The core component of this direction is obtained via the smallest reduced cost that can be achieved upon dividing the set of dual variables in two subsets: one being fixed while the other is optimized. The Primal Simplex, the strongly polynomial Minimum Mean Cycle-Canceling algorithm devised for network problems and the Improved Primal Simplex are special cases.

2 - The Size Robust Multiple Knapsack Problem
Denise Tönissen, Marjan van den Akker, Han Hoogeveen

The size robust multiple knapsack problem is a variant of the multiple knapsack problem where the knapsack sizes can decrease with a certain probability. We consider this as a recoverable robust optimization problem, where we allow recovery by removing items. Our goal is to maximize the expected value. We consider two decomposition approaches and use branch and price to solve the model. We investigate different variants of the algorithm by solving thousands of instances. We show that the column generation process can be accelerated by a factor ten compared to naive approaches.

3 - A Benders Decomposition Approach for the Minimum Weight Maximal Matching Problem
Z. Caner Taşkın, Tinaz Ekim, Merve Bodur

We investigate the problem of finding a maximal matching having minimum total edge weight on an undirected graph, which is known to be NP-hard. We formulate the problem as an integer programming problem and devise a Benders decomposition approach. The master problem in our approach turns out to be a vertex cover problem while the subproblem is a perfect matching problem that is solvable by combinatorial matching algorithms. Our computational tests on a large suite of randomly generated graphs show that our decomposition approach significantly improves solvability of the problem.

4 - Solving Mixed-Integer Programming with Unconstrained Optimization and Hyperbolic Penalty
Sergio B. Villas-Boas, Renan Pinto, Adilson Elias Xavier, Nelson Maculan

Several practical problems fall into Mixed-Integer Programming problems. In this work we propose a method to solve a class of Mixed-Integer Programming problems by converting the original problem to a set of Unconstrained Optimization problems where the integer decision variables are transformed into specially defined penalty components based hyperbolic function. The unconstrained optimization with special penalty functions produce a solution with real variables, but the integer variables are very close to integer variables.

■ HE-12

Thursday, 16:00-17:30 - Room 004

Project Scheduling and Scheduling

Stream: Project Management and Scheduling
Invited session
Chair:
Chair: *Safia Kedad-Sidhoum*

1 - A Project Payment Scheduling Problem with Discounted Cash Flows
Alican Coemert, Meral Azizoglu

We consider a project payment model with discounted cash flows. We assume that the client payment times are defined in the project contract. The activities are characterized by their processing times and costs that are incurred at their completions. Our problem is to find the client payment amounts and activity completion times so as to minimize the net present value of the client payments and activity costs. We formulate the problem as a nonlinear MIP and solve small problem instances. For moderate to large sized problem instances we propose B&B.

2 - Optimal Bid Unbalancing for Projects with Unit Price Contracts: Time Preferences, Risk Preferences, and the Client's Perspective
Joseph Szmerekovsky, Vera Tilson, Napoleon Tiapo

For the contractor we determine prices on different units of work, given the uncertainty about the final amount of work of different types that will be needed in completing the project. We obtain both the optimal bid quantity and the corresponding optimal unit prices accounting for time and risk preferences. For the client we analyze the client's ability to detect bid unbalancing and adjust estimated work quantities accordingly. Our results are validated using data from North Dakota Department of Transportation construction projects.

3 - Reinforcement Learning Strategy for Solving the Multi-Mode Resource-Constrained Project Scheduling Problem by a Team of Agents
Ewa Ratajczak-Ropel, Piotr Jedrzejowicz

In the paper the strategy for the A-Team with Reinforcement (RL) Learning for solving the MRCPSP is proposed and experimentally validated. To solve the problem a team of asynchronous agents (A-Team) has been implemented using a multiagent system. An A-Team is the set of objects including multiple agents and the common memory which through interactions produce solutions of optimization problems. These interactions are usually managed by the static strategy. In this paper the dynamic learning strategy is proposed. To validate the approach a computational experiment has been carried out.

4 - Single-Machine Earliness-Tardiness Scheduling with Periods of Machine Unavailability
Safia Kedad-Sidhoum, Kerem Bulbul, Halil Şen

The addressed problem is a one-machine earliness-tardiness scheduling where a job cannot be executed in some time intervals called breaks. A job can start before and end after a break assuming an increase of its processing time. Preemption is only allowed if it occurs on a break. Each job has a due date and the objective is to minimize the total earliness and tardiness penalties. We will present a complexity analysis as well as exact solving methods based on structural properties of the optimal solutions for some specific cases such as the common due-date, resumable and non-resumable cases.

■ HE-13

Thursday, 16:00-17:30 - Room 123

Balancing and Sequencing of Assembly Lines 2

Stream: Scheduling
Invited session
Chair: *Alexandre Dolgui*
Chair: *Alberto García-Villoria*
Chair: *Xavier Delorme*

1 - Mixed Model Sequencing Procedure in Case of Paced Assembly Line and Jolly Operators
Marco Bortolini, Maurizio Faccio, Mauro Gamberi

Considering mixed model assembly lines,variations in process times are considered. In un-paced buffered assembly lines these variation are absorbed by buffers with high WIP costs and space utilization. Many companies try to adopt paced assembly line, where the cycle time is controlled by the continuous moving of the products from the first to the last assembly station. Jolly operators support the station's single operator to complete the assembly when the cycle can be exceeded. We aim to introduce an innovative sequencing model for mixed-model paced assembly line using jolly operators.

2 - An Enumeration Procedure for the Assembly Line Balancing Problem with Resource Constraints
Mariona Vila Bonilla, Jordi Pereira

This work studies an assembly line balancing problem in which the assembly work must be assigned to the stations of the line subject to linear constraints on the availability of resources on each station. This work proposes three new classes of lower bounds for the problem. These bounds and some new dominance rules are then used on a station-oriented enumerative procedure. The efficiency of the final algorithm is tested with a series of computational experiments on different benchmark sets and the results are compared with previous enumerative procedures.

3 - Disassembly Line Balancing Problems with Resource Dependent Task Times
Seda Hezer, Yakup Kara

In disassembly line balancing problems (DLBP), it is basically considered that every task's time is fixed. However, there may be different processing alternatives for a task with different times. This problem can be called resource dependent DLBP (RDDLBP). The problem is to assign tasks and resources to workstations that minimize total cost of disassembly. To the best of our knowledge, this study is the first RD-DLBP study. The model's performance is evaluated using test problems.

4 - A Multi-Objective Algorithm for Balancing Reconfigurable Transfer Lines
Xavier Delorme, Alexandre Dolgui, Sergey Malyutin

A multi-objective line balancing problem for reconfigurable transfer lines is studied. These lines are paced and serial, and each station corresponds to one or several parallel CNC (Computer Numerical Control) machines. The objective of this problem is to find a trade-off between the investment cost (mainly the number of stations and of CNC machines) and the throughput (i.e., cycle time). A heuristic algorithm, using several mixed integer programs to solve sub-problems, is proposed to approximate the Pareto front. This algorithm takes advantages of some specific properties of the problem.

■ HE-14

Thursday, 16:00-17:30 - Room 124

Advances in Nonlinear Optimization: Theory and Applications IV (contributed)

Stream: Nonlinear Programming
Contributed session
Chair: *Nima Rabiei*

1 - A Partially Observable Markov Decision Process under Stochastic Convexity as an Optimal Maintenance Problem
Toru Nakai

Consider an optimal maintenance policy for products. During their life cycle, a condition of this item changes according to a Markovian transition rule based on stochastic convexity. On the other hand, a decision also makes a transition, which is determined by a function with convexity and supermodularity. This problem is formulated as a partially observable Markov decision process. The objective of a problem is how much to expend to maintain this item to minimize the total expected cost. A dynamic programming formulation implies a recursive equation about optimal value.

2 - A Stochastic PDE-Constrained Optimization Approach to Vibration Control of a Composite Plate subjected to Mechanical and Electromagnetic Loads
Olesya Zhupanska, Dmitry Chernikov, Pavlo Krokhmal

We consider the problem of optimization and control of "smart", or "multifunctional" mechanical structures under uncertainty. In particular, a PDE-constrained optimization model for vibration control of a composite plate due to an impact load through an application of electromagnetic field is presented. To account for uncertainty in the impact load, a two-stage stochastic PDE-constrained programming problem is formulated. A solution method is presented, and the results of computational study are discussed.

3 - AAR-Based Decomposition Algorithm for Nonlinear Convex Optimization
Nima Rabiei, Jose J Muñoz

We here propose a method for decomposing a class of convex nonlinear programs which are frequently encountered in engineering plastic analysis. These problems have second-order conic memberships constraints and a single complicating variable in the objective function. The method is based on finding the distance between the feasible sets of the decomposed problems, and updating the global optimal value according to the value of this distance. The latter is found by exploiting the method of Averaged Alternating Reflections (AAR), which is adapted here to the optimization problem at hand.

■ HE-15

Thursday, 16:00-17:30 - Room 125

Experimental Research in Management Accounting and Management Control 1

Stream: Experimental Perspectives and Challenges in Management Accounting and Management Control
Invited session
Chair: *Stephan Leitner*

1 - Coordination and Learning in an Experimental Queuing System
Ann van Ackere, Erik Larsen, Santiago Arango

How do people make repeated choices in a service environment where waiting time is a key decision element? Are people in a distributed system with limited information able to coordinate to approach optimal system performance? We study this issue in an experimental queuing setting, with teams of 18 subjects, varying both information and system complexity. While information has little impact on the average system performance there are significant implications for the behavior at the individual level. We also observe that the average performance deteriorates when complexity is increased.

2 - The Impact of Queue Features on Customers' Queue Joining and Reneging Behavior: A Laboratory Experiment
Busra Gencer, Zeynep Aksin, Evrim Didem Gunes, Ozge Pala

In many service settings, customers encounter waits in queues and have to decide between joining and balking, waiting and reneging. This study investigates customers' queue joining and reneging behaviors by using laboratory experiments in which participants experience several observable queues with different characteristics in terms of queue length and service times and decide to join, balk or renege. Findings of this study provide insight into how customers make their decisions in queuing systems and how queue length and waiting time uncertainty affects their joining and reneging behaviors.

3 - The Influence of Corporate Norms and Misconduct on Employee Decision Making
Swetlana Dregert, Peter Letmathe, Ramji Balakrishnan

We study a sender-receiver game in which the sender has to decide whether to share information for a given level of cost and if yes which kind of information (productivity enhancing or decreasing). The receiver decides whether to accept the offered information without knowing the kind of transferred information. We conduct a 2x2 experiment with the existence of a code of conduct (yes-no) as one dimension and reports about misconduct (yes-no) as the other. We find that individual behavior is influenced by intrinsic motivation and inconsistencies between expressed norms and actual firm behavior.

4 - Honesty and Reciprocity in Capital Budgeting: An Experimental Investigation
Andreas Ostermaier, Markus Brunner

Budgets are widely used in firms to control costs, but they may also lead to underinvestment as they prevent costly but profitable projects. We find, in a lab experiment, that this problem is exacerbated by managers who exhibit negative reciprocity and turn down profitable projects to punish superiors for setting budgets. However, managers are reluctant to lie about the costs of projects to make them fail. Cost reports incorporate honesty into budgeting and thus mitigate the effects of negative reciprocity. These findings imply that it is reasonable for firms to combine budgets with reports.

■ HE-16

Thursday, 16:00-17:30 - Room 127

Combinatorial Methods for Data Analysis

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Nikita Ivkin*

1 - Fast Logical Predictors for Genotype-Phenotype Mapping
Galina Iofina, Yury Maximov, Andrey Minaev, Yury Polyakov

In this study we analyse different ways to improve quality of genotype phenotype mapping in RNA viruses problems. We develop learning algorithms that attempt to construct predictors as logical functions of covariates. An important point of our study is metric optimization of the set of initial features using convex programming. We demonstrate the learning algorithm's consistency and effciency on simulated and real sequences. The reported study was supported by RFBR, research projects No. 14-07-31241 _a, 14-07-31277 _a and by RF government grant, ag. 11.G34.31.0073.

2 - Laplacian Matrixes Based Graph's b-Coloring for Clustering
Houria Hablal, Hacene Ait Haddadene, Nabil Belacel

In this work we have developed a clustering method based on graph b-coloring algorithm and Laplacian graph which is a graph associated to Laplacian matrixes. Our method performs clustering into two steps:the construction of a graph based on eigenvectors of Laplacian matrixes and the b-coloring of Laplacians graph in order to divide the vertexes set into clusters. We will perform a comparative study between our algorithm, the spectral clustering and the b-coloring based clustering methods using UCI data sets. The results show that our algorithm has a great potential to solve clustering problem.

3 - A Density and Connectivity Based Decision Rule for Pattern Classification
Tulin Inkaya

In this study we propose a novel neighborhood classifier. Traditional Nearest Neighbor classifier is a distance-based method, and it classifies a sample using a predefined number of neighbors. In this study neighbors of a sample are determined using not only the distance, but also the connectivity and density information. One of the well-known proximity graphs, Gabriel Graph, is used for this purpose. The proposed decision rule is a parameter-free approach, and it yields good results in artificial and real data sets.

■ HE-17

Thursday, 16:00-17:30 - Room 005

Enumeration of Combinatorial Structures

Stream: Graph Searching
Invited session
Chair: *Jan van Vuuren*

1 - Edge Stability and Edge Criticality in Secure Graph Domination
Anton de Villiers, Alewyn Burger, Jan van Vuuren

A subset X of the vertices of a graph G is a secure dominating set of G if X is a dominating set of G and if, for each vertex u not in X, there is a neighbouring vertex v of u in X such that the swap set (X-v)+u is a dominating set of G. The secure domination number of G is the cardinality of a smallest secure dominating set of G. A graph G is q-critical [p-stable] if the smallest [largest] arbitrary subset of edges whose removal from G necessarily [does not] increase the secure domination number has cardinality q [p]. A framework is established for enumerating q-critical and p-stable graphs.

2 - Using Volunteer Computing for the Enumeration of Mutually Orthogonal Latin Squares
Johannes Gerhardus Benade, Alewyn Burger, Jan van Vuuren

Orthogonal Latin squares have application in various scheduling problems. The enumeration of main classes of sets of mutually orthogonal Latin squares, however, remains computationally very difficult. It is proposed that this computational barrier may be overcome by means of a volunteer computing project, which distributes a computation across a number of volunteer hosts. A backtracking algorithm for the enumeration of sets of mutually orthogonal Latin squares is adapted for use in such a large, distributed volunteer computing project and the results of a pilot study are reported.

3 - On a Two-Phase Approach to Enumerating Sets of Mutually Orthogonal Latin Squares
Martin Kidd

In this talk the problem of enumerating equivalence classes of sets of mutually orthogonal Latin squares is considered. An algorithm is presented which determines the number of classes covered by a so-called template, where a template is said to cover a class if its members satisfy a set of class-invariant constraints described by the template. The effectiveness of the algorithm is shown, and some ideas are put forth for finding a set of templates large enough for all possible classes to be enumerated, yet small enough to be tractable in a realistic time-frame using the presented algorithm.

4 - On the Minimum Number of Moves for Solving the WrapSlide Puzzle
Alewyn Burger

WrapSlide is a slide-puzzle consisting of a 6 by 6 grid of tiles in which each quadrant of 3 by 3 tiles are coloured differently. The puzzle can be scrambled into different states by performing a number of moves involving wrapping of tiles. A move consists of sliding either the top, bottom, left or right two quadrants of tiles 1 to 5 units horizontally or vertically. We discuss our attempt to partition the 111733085472015089 non-isomorphic states of the puzzle according to the minimum number of moves to solve each state.

■ HE-18

Thursday, 16:00-17:30 - Room 112

Interactive MCDM

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Murat Koksalan*

1 - The Layouts of Supported and Unsupported Nondominated Solutions in Multi-Objective Integer Programs
Gökhan Ceyhan, Murat Koksalan, Banu Lokman

We address the problem of characterization of nondominated solutions in different multi-objective integer programs. We work on problems with three or more objectives. We study the number of supported and unsupported nondominated solutions, their distributions in the objective space, and the representativeness of supported solutions for different problems. We conduct computational experiments on random instances to demonstrate the effects of objective function types and problem parameters on the efficient sets of these problems.

2 - Probabilistic Sorting under Multiple Criteria
Sinem Mutlu, Murat Koksalan, Yasemin Serin

We consider placing alternatives that are assessed by multiple criteria into preference ordered classes. We develop an interactive probabilistic sorting approach that calculates the probability of each alternative being in each class. We place alternatives into classes if the probabilities of misclassification of all alternatives are below a specified threshold. We demonstrate the performance of the approach on several problems.

3 - Bi-Objective Route Planning for Unmanned Air Vehicles in Continuous Space
Murat Koksalan, Diclehan Tezcaner Ozturk

We consider the route planning problem of unmanned air vehicles (UAVs). We consider the case where a UAV visits all targets and returns to base in a two dimensional continuous terrain. The objectives are to minimize the distance traveled and the radar detection threat. This problem is a bi-objective traveling salesperson problem (BOTSP) with multiple efficient paths between targets. We develop both an exact and a heuristic approach to find the efficient arcs between the target pairs. Using the approximated efficient frontiers of the arcs, we reach the overall efficient frontier of the BOTSP.

4 - Exploiting Robustness Analysis for Triggering Interactive Feedbacks in Multicriteria Disaggregation - Aggregation Approaches
Athanasios Spyridakos, Yannis Siskos, Denis Yannacopoulos, Nikos Tsotsolas, Nikos Tsotsolas

The analysis and picturing of preference models' robustness in Disaggregation - Aggregation approaches can provide useful information about DM's preferences structure and lead to feedbacks for estimating of a representative preference models which is accepted by the DMs. This research work presents a new approach which utilises additional preference information gathered indirectly, 3-D visual techniques and two new types of interactive feedbacks in order to estimate more consistent and robust preference models.

■ HE-19

Thursday, 16:00-17:30 - Room 128

Demand Planning and Pricing

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Contributed session
Chair: *Argon Chen*

1 - Determining an Optimal Hierarchical Forecasting Model Based on the Characteristics of the Data Set
Zlatana Nenova, Jerrold May

High-dimensional pyramidal databases are common in the supply chains of large manufacturing companies. Such organizations often forecast shipments and consumption patterns at different hierarchical levels. In multiple-level supply chains, determining the most appropriate forecast aggregation approach is often a very computationally intensive task. Using data from a large food-processing firm, we built a model that requires, as input, only correlation metrics, and produces an accurate prediction of the optimal forecasting approach.

2 - Agricultural Cooperative Pricing of Premium Product
Nur Cavdaroglu, Burak Kazaz, Scott Webster

We consider the problem of pricing by a cooperative for an agricultural product where: (1) the open-market price for the product depends on yield and on quality and (2) the quality of the product is influenced by farmer investments over the growing season. The cooperative purchases product from its members according to a quality-dependent price schedule, which largely mimics the open market, as observed at a major cooperative we study. We identify a simple pricing scheme that shows potential to improve performance, and we characterize the drivers and the magnitude of performance improvement.

3 - Optimal Demand Planning Hierarchy and Its Applications
Argon Chen

For efficient production and logistic planning and scheduling, an On-Line Analytical Processing (OLAP) tool is often used for analysis of multi-perspective (multi-dimensional) demand aggregation and disaggregation. Demand planners can use the tool to quickly roll up demands to an aggregated level for a total demand or drill down a total demand to detailed demands by different perspectives. For example, a demand planner can roll up (or aggregate) the detailed demand to calculate the total demand of a certain product in North America and Europe for the second half of the year.

4 - Advance Selling in a Supply Chain
Xubing Zhang

This paper develops a bilateral-monopoly supply chain model to investigate advance selling by a seller. It shows that the supplier has an important impact on the seller's advance selling strategy. The seller will use advance selling only if it is able to yield a positive margin, whereas advance selling's ability to expand the market affects the supplier's wholesale price and its decision as to whether to induce the seller's adoption of advance selling. Moreover, a seller in a supply chain may have greater incentives to adopt a spot and advance selling strategy than does a direct seller.

■ HE-20

Thursday, 16:00-17:30 - Room 129

Controlling Electric Vehicles and Battery Storage

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Valerie Thomas*

1 - Scheduling and Long-Term Pricing of Electric Vehicle Charging in Parking Lots with Shared Resources
Ajay Deshpande, Pavankumar Murali

With the growth in the use of electric vehicles (EVs), management of shared charging infrastructure under uncertain customer demands and schedules, and under time-varying electricity prices presents a novel servicing opportunity. We formulate a combined pricing-scheduling model to handle these inherent uncertainties and propose a tractable algorithm to find long-term charging permit prices for different arrival-departure-demand bundles and the corresponding charging schedules.

2 - Battery Storage Bidding with Battery-Life Effects
Boris Defourny, Yuhai Hu

We use dynamic programming to derive bidding strategies for Lithium-ion battery storage where the physical characteristics of the batteries can be irreversibly degraded by extreme but highly profitable charging-discharging patterns.

3 - Grid Integration of Wind and Electric Vehicles
Valerie Thomas, Dong Gu Choi, Frank Kreikebaum, Deepak Divan

We develop serial models to optimize generation capacity over multiple decades, simulate the unit commitment and economic dispatch processes, and solve for the fuel economy of conventional vehicles based on US fuel economy rules. We apply the models to analyze implications of electric vehicles (EVs) . With baseline uncontrolled EV charging, total GHG emissions do not substantially decrease even with high EV adoption. GHG impacts of EVs can be reduced by controlling the time of charging. Consumer expenditures are examined; controlled charging substantially reduces costs.

■ HE-21

Thursday, 16:00-17:30 - Room 006

Cutting and Packing 4

Stream: Cutting and Packing
Invited session
Chair: *José Fernando Gonçalves*

1 - Exact Resolution of the Cover Printing Problem with a Branch and Bound Algorithm
Arnaud Vandaele, Daniel Tuyttens

The Cover Printing Problem is a combinatorial optimization problem. For each book cover we have to produce a given number of copies. On templates, there are four positions that can accommodate covers. A particular number of copies is made of each template to meet the demands. This problem can be linked with cutting problems where the cost increases when a new pattern is used. We study different formulations and the results obtained. In the second part, we developed a specific branch and bound algorithm to solve larger instances. We were able to find optimal solutions of unsolved instances.

2 - A Dominance Criterion for Packing Problems
Michaël Gabay, Hadrien Cambazard, Yohann Benchetrit

We present an algorithm which we use to identify easy subproblems for packing problems. The algorithm is polynomial in the number of bins and item types and is based on a flow computation in a bipartite compatibility graph. It outputs the largest subproblem satisfying the dominance criterion and a feasible solution to this subproblem. The algorithm is well suited to be integrated in a branch-and-bound solver for packing problems and can be adapted to work on many problems, including single or multi-dimensional bin packing, vector packing, cutting stock, packing with conflicts, etc..

3 - An Integrated Facility Layout and Product Range Planning Problem
Bernd Hillebrand, Grigory Pishchulov

We consider a problem of integrated facility layout and product range planning (FLPRP) where material flow may differ across products. To this end, we extend the facility layout problem (FLP). The FLP leads to a quadratic assignment problem for which several linearizations have been proposed in the literature. None of these formulations can however be readily employed for solving the FLPRP with conventional methods. For this reason we introduce a new linearization approach for the FLP that naturally carries over to FLPRP and allows to solve the latter with methods of mixed-integer programming.

4 - A Biased Random Key Genetic Algorithm for the Facility Layout Problem
José Fernando Gonçalves

This paper presents a biased random key genetic algorithm (BRKGA) for the facility layout problem where a set of facilities has to be packed, without overlapping, on a rectangular floor. The objective is to find a packing that minimizes the sum of the weighted distances between the centroids of the facilities. A BRKGA defines the order of placement of each facility, and a local search is used to position each facility. Tests validate the quality of the approach. Supported by Fundação para a Ciência e Tecnologia (FCT) through projects PTDC/EGE-GES/117692/2010 and NORTE-07-0124-FEDER-000057.

■ HE-22

Thursday, 16:00-17:30 - Room 007

Agent Behavior in Markets and Related Subjects

Stream: Algorithmic Game Theory
Invited session
Chair: *Sebastien Lahaie*

1 - Characterization of SMON Mechanisms with Additive Valuations over the Real Domain
Annamaria Kovacs, Angelina Vidali

We are interested in the limits of characterizability of mechanisms with multi-dimensional, additive player-valuations like unrelated scheduling or additive combinatorial auctions. We characterize decisive, strongly monotone mechanisms for two tasks or items as either task independent mechanisms or '(player-)grouping minimizers', a generalization of affine minimizers.

2 - Information Aggregation in Exponential Family Markets
Sebastien Lahaie

We design prediction markets via the mold of exponential family distributions, a popular probability distribution template used in statistics, leading to a variety of market makers for continuous outcome spaces. We analyze the information aggregation performance of such markets under a range of behavioral models, including risk-averse agents, Bayesian agents, and agents who are budget-constrained.

3 - On Manipulation in Prediction Markets when Participants Influence Outcomes Directly
Mithun Chakraborty, Sanmay Das

We introduce a two-stage game-theoretic model of prediction markets where agents directly influence the outcome that the market is designed to forecast but some of the agents may not take participate in the market. We show that this game has two different types of perfect Bayesian equilibria, one collusive and uninformative, and the other partially revealing, depending on the values of certain belief parameters.

■ HE-23

Thursday, 16:00-17:30 - Room 008

Genetic and Population Based Algorithms

Stream: Metaheuristics
Contributed session
Chair: *Miguel Mujica Mota*

1 - A Modified Selection Scheme in Memetic Algorithm for a Nurse Scheduling Problem with Positive Rhythmic Cycle
Razamin Ramli, Ahamad Tajudin Khader, Adli Mustafa

A highly constrained problem of scheduling nurses to shift duties and off days with hospital requirements and individual nurse preferences was studied. In this study, we propose a Memetic Algorithm with a multi-stage procedure introducing a modified selection scheme along with specialized crossover and mutation operators to acquire an efficient nurse work schedule satisfying all requirements including the positive rhythm constraint. Result on the scheme's performance is satisfactory. The schedule fulfills important nurse preferences and provides fairness as well as a balanced schedule.

2 - Firefly Algorithm for Continuous and Combinatorial Dynamic Optimization Problems
Fehmi Burcin Ozsoydan, Adil Baykasoğlu

Firefly Algorithm (FA) is a recent population based metaheuristic technique, which simulates the flashing and communication behavior of fireflies. In the current work, an adaptive FA is proposed to solve continuous and combinatorial dynamic optimization problems. The moving peaks problem is used as testing environment on continuous domain whereas dynamic multidimensional knapsack problem is chosen for combinatorial domain because there exists numerous real life related applications. According to results, adaptive FA achieves high quality results.

3 - Coordinate Strategy to Reduce Computational Effort for Supernova
Eddy Mesa, Juan David Velásquez Henao, Patricia Jaramillo

Computational effort for metaheuristic methods increases with dimensions. Supernova algorithm is a novel metaheuristic. This method showed robustness and quality for different benchmark functions and real-world problems; but the computational time increases exponential proportionally with dimensions and population size. In this work, we present the decomposition by coordinates for supernova algorithm as a strategy to reduce the computational effort. As a result, we compare the computational effort for original and new version using known benchmark functions.

4 - An Evolutionary Algorithm for Check-In Desk Allocation
Miguel Mujica Mota

The work presents an evolutionary approach for the allocation of Check-In Desks in an Airport Terminal. This algorithm has been developed in collaboration with an airport Terminal. The main characteristics of the evolutionary algorithm are presented and the description of the methodology to perform the allocation. The results indicate that a good performance is achieved in order to optimize the level of service inside the terminal.

■ HE-24

Thursday, 16:00-17:30 - Room 212

Algorithms for Stochastic Games

Stream: Dynamic and Repeated Games
Invited session
Chair: *Hugo Gimbert*

1 - Combinatorial Simplex Algorithms Can Solve Mean Payoff Games
Pascal Benchimol, Xavier Allamigeon, Stephane Gaubert, Michael Joswig

A combinatorial simplex algorithm is an instance of the simplex method in which the pivoting depends on certain combinatorial data only. We show that any algorithm of this kind admits a tropical analogue which can be used to solve mean payoff games. Moreover, any combinatorial simplex algorithm with a strongly polynomial complexity (the existence of such an algorithm is open) would provide in this way a strongly polynomial algorithm solving mean payoff games. Our algorithm relies on a tropical implementation of the simplex method over a real closed field of Hahn series.

2 - Analysis of Stochastic Systems Based on Approximation
Blaise Genest

Automata based methods can be used in the analysis of real life system, granted that powerful abstraction refinement techniques are used. Our aim is to propose such an abstraction refinement for stochastic systems, in particular POMDP. The idea is to approximate probabilities. The refinement step will be triggered only if the error made is too big to conclude. An important tool for analyzing the error is the contracting factor. This can be used while approximating the transient values generated by large systems, and also for the steady state behavior.

3 - Two-Player Perfect-Information Shift-Invariant Submixing Stochastic Games Are Half-Positional
Hugo Gimbert

We consider zero-sum stochastic games with perfect information and finitely many states and actions. The payoff is computed by a payoff function which associates to each infinite sequence of states and actions a real number. We prove that if the the payoff function is both shift-invariant and submixing, then the game is half-positional, i.e., the first player has an optimal strategy which is both deterministic and stationary. This result relies on the existence of epsilon-subgame-perfect equilibria in shift-invariant games, a second contribution of the paper.

4 - Exact Algorithms for Stochastic Games and Real Algebraic Geometry
Elias Tsigaridas

Shapley's discounted stochastic games and Everett's recursive games are classical models of game theory describing two-player zero-sum games of potentially infinite duration. We present an exact algorithm for solving such games based on separation bounds from real algebraic geometry. When the number of positions of the game is constant, the algorithm runs in polynomial time and is the first with this property.

■ HE-25

Thursday, 16:00-17:30 - Room 009

Metaheuristics in Autonomous Search

Stream: Applications of Heuristics
Invited session
Chair: *Ricardo Soto*
Chair: *Broderick Crawford*

1 - The Role of Metaheuristics in Constraint Programming with Autonomous Search
Ricardo Soto, Broderick Crawford, Fernando Paredes

Constraint programming is a programming paradigm for solving constraint-based problems that has been successfully used in different application domains. The main idea under this paradigm is to model the problem in terms of variables and constraints and then to launch it in a search engine, usually called solver. Recently, Autonomous Search appeared as a new technique that enables a solver to control and adapt its own configuration based on self-tuning. In this abstract, we illustrate how metaheuristics are able to optimize this self-tuning process of constraint programming solvers.

2 - Self-adaptive Systems: Towards Usable Combinatorial Problem Solvers
Broderick Crawford, Ricardo Soto, Eric Monfroy, Fernando Paredes

New methods in Combinatorial Problem Solving can solve larger problems in different domains. They also became more complex, which means that they are hard to use and fine-tuning to the peculiarities of a given problem, limiting the its use to a small set of experts, and instead black-box solvers with automated search procedure are needed for its broad applicability. We review recent progress on Self-adaptive Systems from the standpoint of the requirement for solver systems accessible and easier to use. A new research field defined to precisely address the above challenge is Autonomous Search.

3 - Software Project Scheduling Problem using Metaheuristics with Autonomous Search
Franklin Johnson, Broderick Crawford, Ricardo Soto

The Software Project Scheduling problem consists of making the appropriate assignment of employees to tasks. This allocation should minimize the duration and cost of the whole project. The main idea is to solve this problem using metaheuristics. Metaheuristics is an incomplete method to solve combinatorial problems. The process to tune and adapt the metaheuristics to a specific problem is very hard work to do, for this reason we introduce the Autonomous Search technique to control and adapt its own parameters or heuristics.

4 - A New Algorithmic Approach for Solving an Inventory Optimization Model
Fernando Paredes, Javier Pereira, Claudio Fuentes, Broderick Crawford, Ricardo Soto

In this work, we develop a new method in order to solve an inventory optimization model which is defined by minimization of the expected value of lost sales for a defined investment and number of order levels, per year. The optimal solution of this optimization model is obtained by solving the associated Karush-Kuhn-Tucker system. Thus, applying the penalty lagrangian method that using autonomous search in the parameters definition. The objective function of the model is pseudo-convex and the constraints are defined by quasi-convex functions, ensuring the existence of the global minimum point.

■ HE-26

Thursday, 16:00-17:30 - Room 010

Nonsmooth Optimization for Learning and Classification

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Antonio Fuduli*

1 - Illumination by Cones and Outliers Detection
Annabella Astorino, Manlio Gaudioso, Alberto Seeger

Given a finite set of points in the n dimensional space, we tackle the outliers detection problem as an illumination one. In particular we want to illuminate the dataset by means of a suitable revolution cone. The specific challenge at hand is to determine the sharpness coefficient, the axis and the apex of the cone. These parameters have to be selected in such a way as to fulfill two conflicting requirements: The cone captures as many points as possible and, at the same time, it has a sharpness coefficient as large as possible. Some numerical experiences are reported.

2 - A New Incremental Piecewise Linear Classifier based on PCFs
Gurkan Ozturk, Adil Bagirov, Refail Kasimbeyli

In this paper, a piecewise linear classifier based on polyhedral conic functions (PCFs) is developed. This classifier finds nonlinear boundaries between classes. Since the number of PCFs separating classes is not known a priori, an incremental approach is proposed to build separating functions. These functions are found by minimizing an error function which is nonsmooth and nonconvex. An incremental procedure is proposed to generate starting points to minimize the error function. The proposed classifier is applied to solve classification problems on 12 publicly available data sets.

3 - Projecting onto Lines Using the L-1 Norm
José Dulá, Paul Brooks

In the case of the L-1 norm, a point in m dimensions projects onto a line by following at most m-1 independent unit directions. Different points may follow different sets of these directions. One objective of this work is to characterize the set of points that use the same set of directions for this projection. Another objective is the characterization of the lines a point can project onto with the L-1 norm using the same directions. These results represent progress towards solving the problem of finding the best-fit line for a point set using the L-1 norm.

4 - A Robust Approach for Spherical Separation
Antonio Fuduli, Annabella Astorino, Immanuel Bomze, Manlio Gaudioso

We propose a robust spherical separation technique aimed at separating two finite sets of points. Robustness is related to the possibility to have some uncertainties or perturbations in the data sets. This may occur, for example, when the data are corrupted by noise or are influenced by measurement errors. Starting from the standard spherical separation, we come out with a model characterized by a non-convex non-differentiable objective function, which we minimize by means of a bundle type algorithm. Numerical results are provided on small and large data sets drawn from the literature.

■ HE-27

Thursday, 16:00-17:30 - Room 213

Decision Analysis for Risk Management

Stream: Decision Analysis, Decision Support Systems
Contributed session
Chair: *Martin Waitz*

1 - Design of a Mobile Spatial Decision Support System for Group Decision-Making on the Analysis of Changing Risk
Roya Olyazadeh, Cees van Westen, Marc Derron, Wim Bakker

In the ongoing CHANGES Project (changes-itn.eu) and the INCREO project (increo-fp7.eu) a spatial decision support system is under development with the aim to analyze changes in hydro-meteorological risk, and support decision makers in selecting the best alternative. Public contribution is the main part of this group decision making. So this paper presents a prototype of a mobile version where public indicates their preference anywhere and anytime. The application is being tested through a case study affected by flooding hoping to have the group decision making more precise and transparent.

2 - Applying Stochastic Analytical Network Process in Strategic Decisions of Portfolio Management
Hannaneh Rashidi Bajgan, Elham Esmaili Najafabadi

Respecting the interrelationship between knowledge areas of projects, advantages form analytical network process (ANP) could be derived to proceed in this stage. The aim of this paper is to use ANP method to solve this problem, in which there is some uncertainty around the input data as well as the portfolio manager's intuitions. Noteworthy, based on my best knowledge, the existing approaches of ANP method are restricted to deterministic environments. Therefore, this paper is presenting a novel approach to be investigated in complex decision making models.

3 - A Methodology for the Integration of Risk Management in R&D Project Selection
Claudio Santos, Maria Madalena Araújo, Nuno Correia

R&D project selection is a key process in organizations. R&D projects have also many associated risks, so their consideration early on projects' life cycle provide more time for managers to act and manage risks. However, reviewed methodologies present few approaches that integrate risk management in project selection. A new multi-criteria R&D project selection methodology that incorporates risk driven by the maturity rate and scale of R&D projects is proposed. It is expected that the methodology will contribute to an improved homogenization of organizational policies towards risk management.

4 - Overcoming the Inability of Private Lenders to Set Proper Interest Rates on Unsecured Peer-to-Peer Lending Markets
Martin Waitz, Andreas Mild

On a typical peer-to-peer lending market, borrowers present their projects and non-institutional lenders decide under what terms they are ready to provide the requested capital. We show that investors fail to transform the available information into proper market activities (i.e. requesting the appropriate interest rates), threatening the sustainability of this new lending concept. We present and test a decision support tool to support users in the estimation of borrowers' risk of default and demonstrate that our system is able to improve investors return significantly.

■ HE-28

Thursday, 16:00-17:30 - Room 130

Applied Aspects of MINLP

Stream: Mixed-Integer Nonlinear Programming
Invited session
Chair: *Inken Olthoff*

1 - A Multi-Objective Mixed Integer Nonlinear Optimization Model for the Aircraft Collision Avoidance
F. Javier Martin-Campo, Antonio Alonso-Ayuso, Laureano Fernando Escudero

The aircraft collision avoidance consists of providing a new aircraft configuration such that every conflict situation is avoided. A conflict takes place when two or more aircraft violate the minimum safety distances that must be kept during their flights. We present a mixed integer nonconvex nonlinear optimization model where three different multi-objective criteria are studied in order to compare comfort versus economic impact. The three possible maneuvers are allowed to be performed. An extensive computational experiment is presented where Minotaur has been the engine solver of choice.

2 - e-OA for the Solution of Bi-Objective Generalized Disjunctive Programming Problems in the Synthesis of Nonlinear Process Networks
Metin Turkay, Ali Fattahi

Although decision making in nonlinear process networks involve more than one criterion, there has been no study in the literature considering the multiple objective case. In this paper, we investigate the bi-objective nonlinear network synthesis problem. We propose an efficient algorithm based on augmented e-constraint and logic-based outer approximation. We provide theoretical characterization of the algorithm and show the efficiency of the solutions generated. We conduct experiments on two benchmark problems to show the performance of our novel algorithm and illustrate the solutions found.

3 - Optimizing Battery Load Schedules
Inken Olthoff

As the influence of renewable energy grows, also the flexible storage of energy in batteries gains in importance. One aspect is the construction of battery load schedules which provide charging and discharging periods while considering the battery and power grid properties. Thereby, our main challenge is to deal with the non-convex loss of energy while discharging the battery. In this talk, we describe the Battery Scheduling Problem and discuss different solving strategies. Taking into account sudden parameters changes, the aim is to find a strategy which finds good solutions in a short time.

4 - Preconditioning of Linear Systems Arising from Interior Point Methods
Luciana Casacio, Aurelio Oliveira, Christiano Lyra Filho

In this work, iterative methods are applied to solve linear systems arising from interior point methods for linear programming problems through a hybrid approach. In the first phase, the PCG is used to solve the normal equations. In the last iterations, the augmented system is rearranged exploiting the basic-nonbasic partitions and a preconditioned Gauss-Seidel method is applied. Computational experiments with problems from Netlib collection have shown promising good performance of the new approach.

■ HE-29

Thursday, 16:00-17:30 - Room 011

Logistics and Blending in Natural Gas and Mining

Stream: OR in Petrochemicals and Mining
Invited session
Chair: *Natashia Boland*
Chair: *Asgeir Tomasgard*

1 - Dynamic Blending with Penalties and Bonuses
Natashia Boland, Amir Salehipour, Martin Savelsbergh

Blending problems are textbook exercises in LP modelling: source materials, each with a given vector of qualities, must be mixed to yield final products having qualities within specified ranges. However when blending in real mining contexts, demand for final products is not static; it arrives over time. Source materials are not available instantaneously, but must be produced at a feasible rate and stockpiled until needed. The cost structure can be complex, with bonuses available for "over spec" and penalties for "under spec" product. Results for LP and MILP models on iron ore data are given.

2 - Simulation Models for Planning an Iron Ore Mine
Jim Everett

In planning an iron ore mine we have a block model of the prospect (comprising hundreds of thousands of rectangular blocks, with grade vectors estimated by interpolation of drilling data), and a target grade (not only in iron but also in a number of contaminants) for a marketable product. The objective is to select ore blocks so as to maximise the tonnage at target grade, and then to find an operationally feasible sequence of the ore blocks so as to mine a stream of ore consistently close to target grade. The paper will describe a set of simulation models designed to achieve these objectives.

3 - Adding Flexibility in a Natural Gas Transportation Network Using Interruptible Transportation Services
Asgeir Tomasgard, Marte Fodstad, Kjetil Midthun

We present a modeling framework for analyzing if the use of interruptible transportation services can improve capacity utilization in a natural gas transportation network. The network consists of two decision makers: the transmission system operator (TSO) and a shipper of natural gas. There are two different types of transportation services: firm and interruptible. Only firm services have a security of supply measure, while the interruptible services can freely be interrupted. The results indicates substantial increased throughput with the introduction of interruptible services.

4 - Constraint Programming for LNG Ship Scheduling and Inventory Management
Vikas Goel, Marla Slusky, Willem-Jan van Hoeve, Kevin Furman, Yufen Shao

We present a constraint programming approach for the optimization of inventory routing in the liquefied natural gas industry. We present two constraint programming models that rely on a disjunctive scheduling representation of the problem. We also propose an iterative search heuristic to generate good feasible solutions for these models. Computational results on a set of large scale test instances demonstrate that our approach can find better solutions than existing approaches based on mixed-integer programming, while being 4 to 10 times faster on average.

■ HE-30
Thursday, 16:00-17:30 - Room 012

Open Source & COIN-OR Optimisation

Stream: Open Source Optimisation
Invited session
Chair:
Chair: *Mike Steglich*

1 - Better Excel Optimisation using OpenSolver & SolverStudio
Andrew J Mason

Excel is an ideal tool for teaching & delivering optimization models. We present two free packages that improve Excel's optimisation capabilities. OpenSolver, http://opensolver.org, is an open-source LP/IP solver that solves large Excel models using the COIN-OR Cbc solver. SolverStudio, http://solverstudio.org, allows modelling languages such as AMPL, GAMS, PuLP or COOPR/Pyomo to be easily used within Excel to specify and solve advanced optimisation models. SolverStudio also supports Gurobi models, the SimPy simulation environment, & cloud-based solving via NEOS.

2 - Dip and DipPy: A Decomposition-based Modeling System and Solver
Ted Ralphs

DIP is a framework for implementing decomposition-based algorithms for solving mixed-integer linear programs. The latest release includes a Python-based modeling language and a fully generic, parallel decomposition-based solver that the user can customize with callbacks for cut and column generation written in Python. We review the framework and give computational results on a variety of instances.

3 - CmplServer - An Open Source Approach for Distributed and Grid Optimization
Mike Steglich

CMPL can be used with the CMPLServer which is an XML-RPC-based web service for distributed optimization. After an overview of the main functionality, the XML-based file formats for the communication between a CMPLServer and its clients are described. Since a CMPL model can be solved on a CMPLServer synchronously and asynchronously, both modes are explained in the next step. Furthermore, it will be discussed how CMPLServers from several locations can be coupled to one "virtual CMPLServer", how a client can connect with it and how optimization jobs are coordinated within the CMPLServer grid.

4 - Extensions to the OSiL schema: Matrix and cone programming
Horand Gassmann, Jun Ma, Kipp Martin, Imre Polik

A lot of attention has been given recently to cone programming and matrix programming, using, for instance, relaxations of hard mixed integer programs using variables whose values are required to form symmetric positive semidefinite matrices or satisfy similar cone constraints. This talk presents efforts to facilitate the formulation of such problems within the OSiL framework, an XML schema used to allow a unified representation format for a large variety of mathematical optimization problem instances. OSiL is part of the OS project, an open source project under the COIN-OR umbrella.

■ HE-31
Thursday, 16:00-17:30 - Room 013

Location Problems in Networks

Stream: Telecommunications and Networks
Contributed session
Chair: *Ivana Ljubic*

1 - A Column Generation Approach for Modelling Deployment of Multi-Tier Cloud Services
Anders N. Gullhav, Bjørn Nygreen

In the provision and deployment of cloud services, the provider must take decisions on where to place the virtual machines of the services, but also decide on the amount of resources allocated the services such that the quality of service is in accordance with the end-users' requirements. In this work, we compare two model formulations of the problem: a direct formulation and a column generation formulation. The results show that the column generation formulation provides better solutions more quickly than the direct formulation.

2 - The Cycle Hub Location Problem
Moayad Tanash, Ivan Contreras, Navneet Vidyarthi

In this talk we present the Cycle Hub Location Problem, in which the set of hubs have to be located and connected by means of a cycle. We present a general family of mixed-dicut inequalities for a flow-based formulation which are very useful to improve the LP bounds of this formulation. These inequalities are embedded into a branch-and-cut method to optimally solve the problem. We also propose a GRASP metaheuristic to efficiently obtain high quality solutions for large-scale instances. Computational results on instances with up to 100 nodes are reported and analyzed.

3 - Exact Approach for the Generalized Regenerator Location Problem
Xiangyong Li, Yash Aneja

We study the generalized regenerator location problem (GRLP) where we are given a set S of candidate locations for regenerator placement and a set T of nodes required to communicate with each other. This problem is to find a minimal number of nodes for regenerator placement, such that for each node pair in T, there exists a path of which no subpath without internal regenerators has a length greater than the limit d. We present a formulation, discuss the facial structure, and develop branch-and-cut algorithms for the GRLP. Computational results are presented to evaluate the proposed methods.

4 - **The Recoverable Robust Facility Location Problem**
Ivana Ljubic, Eduardo Álvarez-Miranda, Elena Fernandez
In this facility location problem, we search for a first-stage solution which is robust against the possible realizations of the input data that are revealed only in a second stage. Instead of looking for a solution that is robust against all possible scenarios (which is the case for many classical robust optimization approaches) we want a solution robust enough so that it can be "recovered" promptly and at low cost in the second stage. A Benders' decomposition approach, incl. dual lifting and zero-half cuts is proposed and tested on a set of carefully designed realistic instances.

■ HE-32

Thursday, 16:00-17:30 - Room 014

Supply Chain Optimization

Stream: Production Management & Supply Chain Management
Contributed session
Chair: *Danny Segev*

1 - **Factory-Crane-Scheduling and Online Optimization with Lookahead**
Jan Necil, Stefan Nickel
We consider a system of factory cranes operating in a continuous casting plant of a steel mill. There are five cranes operating on one lane. Due to physical reasons, some of the cranes can pass each other under certain conditions. Our task is to compute a detailed schedule for the cranes, in such a way that all orders can be processed on time and with minimal effort. In practice this problem has a strong online character. Apart from the static optimization problem several questions arise: What is the optimal lookahead? How often should the algorithm adapt to the current situation and replan?

2 - **Improving the Production Decision Making Process of Frozen Foods Using Mathematical Modelling**
Rodrigo Antonio Sánchez Ramírez, Carolina Urzúa
Managing the food supply chain is a complex process due to the perishable nature of products, where quality deterioration increases as time passes that the product is consumed. For this reason, it is important that the steps involved in the chain are made in a coordinated manner, avoiding delays that reduce quality and cause product losses. For this purpose, we developed a mixed linear programming model for planning the production of frozen berries, which seeks to reduce losses and minimize operating costs in packing plants.

3 - **A Quasi-PTAS for Assortment Planning with Nested Preference Lists**
Danny Segev
We address a fundamental question raised by Goyal, Levi, and Segev (2009) regarding assortment planning under dynamic substitution, with nested preference lists. Here, eps-optimal solutions consisting of roughly 1/eps products were shown to exist, assuming an IFR-distributed number of customers. This leads to an approximation scheme via direct enumeration. Without the IFR assumption, the general problem is wide open. I will present a new approach to compute eps-optimal assortments without probabilistic assumptions, based on approximate DP, condensed distributions, and some additional tricks.

■ HE-33

Thursday, 16:00-17:30 - Room 015

Hyperheuristics: General; and Related Topics

Stream: Hyperheuristics
Invited session
Chair: *Andrew J. Parkes*
Chair: *Patrick De Causmaecker*
Chair: *Daniel Karapetyan*
Chair: *Shahriar Asta*

1 - **Parameter Sweep for the Simplex Method**
Péter Tar, József Smidla, István Maros
Optimization software systems capable of solving large-scale linear programming problems have a wide range of parameters. These parameters are crucial for the performance of the solution algorithm; they heavily affect speed and accuracy. In order to provide the rules of a good parameterization we have implemented our own linear programming solver in a workflow on a desktop grid system for a parameter sweep. Our results are very promising and can be used as a guideline for parameterizing LP systems. „This publication has been supported by the project TÁMOP-4.2.2.C-11/1/KONV-2012-0004"

2 - **Competition Winning Hybrid Heuristic for an Extension of the Resource-Constrained Project Scheduling Problem**
Daniel Karapetyan, Shahriar Asta, Ahmed Kheiri, Ender Özcan, Andrew J. Parkes
This talk presents the algorithm winning the MISTA 2013 Scheduling Challenge. Our approach is a hybrid heuristic addressing an extension of the resource-constrained project scheduling problem. It comprises a Monte-Carlo tree search technique, very large scale neighbourhoods, meta- and hyper-heuristics and highly optimised schedule generator. Finally, the algorithm effectively exploits the features of the problem. We discuss the main components of our method as well as insights into the success of the approach.

3 - **A Simulation Approach to Analyse Rail Capacity at Sydney's Port Botany**
Pascal Van Hentenryck, Daniel Guimarans, Daniel Harabor
We employ a simulation approach to analyse the operations of container-freight trains in and around Sydney's Port Botany. Our objective is to evaluate the current performance of rail, as well as investigating the peak rail capacity of both current and proposed infrastructure. Contrary to popular perceptions, we found that there exists significant unrealised capacity at the port and achieving it depends only on operational changes. Moreover, proposed infrastructural upgrades, including a centralised terminal and duplication of some track, appear to yield little benefit over the medium term.

■ HE-34

Thursday, 16:00-17:30 - Room 016

Decision Making in Finance

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Contributed session
Chair: *Tomás Tichý*
Chair: *Maria Garbuzova-Schlifter*

1 - **Average Time Until First Income Protection Claim**
Isabel Cordeiro
In this paper we calculate the average time until first claim for different deferred periods and ages at which policies are effected. These times are calculated using the most recent graduations of the transition intensities defined for a multiple state model for Income Protection (IP) insurance. We compare these average times with similar times calculated with graduations for an earlier period. All this information can be very useful for insurance companies selling IP policies.

2 - **Analysis of integer programming approaches for index tracking**
Jose Mauricio Brasil Goncalves, Eduardo Uchoa
Stock indices are indicators of the average performance of a stock market. Some funds seek to replicate this performance, adopting a policy of "follow the index". While it could simply acquire all the stocks according to their index proportions, this could be too costly. Alternatively, a mathematical model can be used for selecting a small subset of the stocks that still yields a performance similar to the index. This paper presents extensive comparisons of the practical performance of three different integer programming models on tracking indexes as Bovespa, S&P500, Hang Seng and DAX.

3 - Efficiency Measurement of investment profiles of Savings Funds using DEA
Arik Sadeh

The long term savings is considered to be a safe, stable and with a relatively low return. This savings is intended for retirement years. In an applied DEA research, a series of 100 long term savings funds available in capital markets are investigated. Their investment policies are compared with respect to several quantitative financial indices. The results show that small funds are more efficient than large funds. There is a strong positive correlation between the rate of investment in stocks and funds' return. On the other hand the investment in stocks does not lead to efficiency.

4 - Risk Assessment of Energy Performance Contracting (EPC) projects of the Russian Energy Service Companies
Maria Garbuzova-Schlifter, Reinhard Madlener

The current development of the Russian ESCOs industry is rather slow and most of the ESCOs lack the expertise and experience for an effective risk management of Energy Performance Contracting (EPC) projects. Due to this perception, we interviewed several Russian experts and identified the relevant risk factors of EPC projects in three sectors: industrial, state-financed, and multifamily housing. In order to quantify these risk factors, we conducted a questionnaire-based survey among 230 companies with EPC related businesses in Russia by applying the Analytical Hierarchy Process (AHP) method.

■ HE-35

Thursday, 16:00-17:30 - Room 131

Planning and Control

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Erik Kropat*
Chair: *Silja Meyer-Nieberg*
Chair: *Rudi Verago*

1 - Power-Aware Routing Algorithms in Software-Defined Networks
Wenguo Yang

The feature of centralized network control logic in Software-defined networks (SDNs) paves a way for green energy saving. In this paper, we study global power management optimization at whole network level with consideration of network reliability by rerouting traffic through different paths to adjust the pave of links when the network is relatively idle. A 0-1 integer linear programming model is formulated and two algorithms, i.e., alternative greedy algorithm and global greedy algorithm, are proposed. Simulation results show the effectiveness of our algorithms.

2 - An Extreme-Case Scenario Approach for Data Uncertainty
Rudi Verago, Chungmok Lee, Martin Mevissen, Nicole Taheri

We propose a novel mathematical approach for problems with uncertain right-hand-side data in the constraints. Traditional stochastic approaches often require a large number of scenarios, which results in computationally prohibitive problem sizes. We develop a mathematical reformulation for the two-stage problems whose size is polynomially bound to the problem size, but can implicitly obtain the worst-case performance among the extreme scenarios which are exponentially many. Numerical experiments for well-known applications showing the efficiency of the proposed method will be also given.

3 - A Study on Dual-Command Operations in a Mobile Rack (AS/RS)
Amine Hakim Guezzen, Amina Ouhoud, Sari Zaki

In this paper our interest is concerned with the mathematical modeling of dual-command operations in a Mobile rack Automated Storage and Retrieval Systems (M- AS/RS). The S/R machine could operate either in single command or in dual command. In a dual command, the S/R machine executes a storage operation followed by a retrieval operation in the same cycle. We developed a closed form analytical expression allowing an approximate calculation of the travel time of a Mobil Racks-AS/RS. This expression was compared with an exact discrete expression developed previously by one of the authors.

4 - Maintenance Policies for A System Subject to Continuous Time Markovian Deterioration with Non-Self-Announcing Failures
Büşra Keleş, Salih Tekin, Onur Bakir

In this study, we comparatively evaluate various maintenance policies for systems subject to continuous time Markovian deterioration which may result in non-self-announcing failures. The decision maker inspects the system periodically at the decision epochs, identifies the current state; good, poor, failed and chooses an available action; do-nothing, repair, replace. When the system fails, failure will not be detected until the next inspection epoch. We provide a numerical example to analyze the effect of various cost parameters on the optimum inspection period and policy.

■ HE-36

Thursday, 16:00-17:30 - Room 132

Forest Value Chain Optimization

Stream: OR in Agriculture, Forestry and Fisheries
Invited session
Chair: *Marc McDill*

1 - Routing and Transportation at the Forest Industry
Mikael Rönnqvist, Patrik Flisberg, Marc-André Carle

We describe two transportation applications for a large forest company in Canada. One deals with tactical planning of wood chips between sawmill and paper and pulp mills. Special consideration must be taken into account for the production and assortment mix at the mills. The second deals with detailed truck routing of lumber between sawmill depending on their capacities for drying and planning. Many practical and complex restrictions must be dealt with. We report on savings when comparing manual and optimized plans.

2 - Role of Optimization in Medium to Short-Term Planning of Forest Operations
Bruno Oliveira, Alexandra Marques, Mikael Rönnqvist, Sophie D'Amours

This presentation focuses on the forest management decisions concerning medium- and short-term forest planning. Firstly, the scope of forest tactical and operational planning (FTOP) is bounded by comparison with strategic planning. A classification framework for FTOP problems is presented. Then, the results of a thorough literature review identify the solution approaches commonly used for FTOP. Lastly, the research needs are discussed.

3 - "More than the Sum of its Parts?" — Enhancing Optimisation for the Forest Based Value Chains by Integrating Process Specific Optimisation Solutions
Johannes Scholz, Jussi Rasinmäki, Alexandra Marques, Christian Rosset, Germano Veiga

The state-of-the-art in optimisation for forest-based value chains is to target specific processes along the supply chain, but optimisation covering the whole supply chain is a rarity. The objective of the FOCUS project is to address this issueand develop solutions based on pilot cases in several countries across Europe for supply chains covering end products timber, pulp & paper, bioenergy, and cork. This article explores the proposed distributed system architecture for coupling independent process specific optimisation solutions as an integrated system for supply chain wide optimisation.

■ HE-37

Thursday, 16:00-17:30 - Room 017

Advances on Recovery Inventory Management Policies II

Stream: Recovery Inventory Management Policies
Invited session
Chair: *Andrés Acevedo*

1 - Optimal Ordering Policies and Sourcing Strategies with Supply Disruption
Ke Liu

We discuss a model to facing of demand uncertainty and supplier reliability uncertainty at the same time in a single selling season. In the model, we have two instants to order from two suppliers: the unreliable supplier's reliability is uncertain at instant 1 and is completely observed at instant 2. We present the optimal supplementary order quantities with the realized reliability and give the optimal ordering policies and sourcing strategies at instant 1 under certain conditions.

2 - A Multi-Criteria Collaborative Model for Flood Preparedness
Oscar Rodriguez-Espindola, Pavel Albores, Christopher Brewster

Given the increasing trend of people affected by disasters globally, this research will introduce a bi-criteria preparedness model aiming to maximize the service provided to people affected by floods while making efficient use of resources. The multi-commodity optimization model encompasses the use of resources for multi-agency collaboration in facility location, stock pre-positioning and service allocation to satisfy the immediate needs of affected people. The model is solved to obtain the Pareto frontier seeking to show its application and to provide conclusions about its performance.

3 - Production Planning with Perishable Raw Material Considerations
Andrés Acevedo, Ivan Contreras, Ming Yuan Chen

In many types of industries, it is common to face significant rates of product and/or raw material deterioration. These items are referred to as perishable products. In this study, we discuss about various ways in which perishability can occur in production processes and how this aspect enforces specific constraints on a set of different management decisions. We also propose new modeling approaches to manage product and raw material perishability in production planning problems. Numerical results on a set of instances are reported.

4 - Optimizing the Collection Period of Product Returns in a Closed-Loop Supply Chain
Nizar Zaarour, Emanuel Melachrinoudis, George Kozanidis

We consider the problem of the collection of returned products from consumers and their shipping to manufacturers through initial collection points under freight quantity discounts. The optimal collection period is sought in order to minimize the total inventory carrying costs and shipping costs. Both deterministic and probabilistic models are proposed and solution algorithms are developed.

■ HE-38

Thursday, 16:00-17:30 - Room 214

Multi-Criteria Performance of Funds and Banks

Stream: Operational Research and Quantitative Models in Banking
Invited session
Chair: *Enrique Ballestero*
Chair: *Mila Bravo*

1 - Multicriteria Approach to Bank Credit Scoring
Enrique Ballestero, Sonia Zendehzaban

A Weighted Goal Programming is proposed to help bank managers score credit applications, especially concerning with interest rates. Criteria are guarantees, profile and projects of the applicant, accounting performance, and others. Preferences of the bank manager for these criteria are elicited by Analytic Hierarchy Process. An example in Spain is numerically developed. Potential extensions are: (a) to consider credit characteristics other than interest rates; and (b) to fix prices by companies from quality in competitive markets with product differentiation.

2 - Ranking Spanish Banks from Stress Tests: A Multicriteria Model of Moderate Pessimism
Mila Bravo, Antonio Benito, Germán Benito-Sarriá

This paper deals with a wide set of Spanish banks which should be scored from a multicriteria perspective. Criteria are: (a) results of stress tests defined by The European Banking Authority; (b) expectations elaborated by a Governance committee whose members are Spanish and International authorities. The multicriteria method is Moderate Pessimism Decision Making with veto, as an objective rule which is not colored by the analyst's opinions and preferences. The model is numerically applied through tables.

3 - Compromise Programming Approach to Performance of Bank Funds
David Pla-Santamaria, Javier Reig

This paper aims at evaluating performance of mutual funds managed by banks from the investor's preferences. To score, a Compromise Programming (CP) model is designed with an infeasible ideal representing the best in profitability and safety. Since the CP metric equal to 1 (which involves linear utility) and the infinity norm (which involves degenerate utility) lead to inappropriate utility functions in economics, we use the linear-quadratic metric which satisfies suitable economic properties. The proposal can be extended to corporate performance from accounting and stock market information.

4 - Multicriteria Approach to Socially Responsible Funds Managed by Banks
Ana Garcia-Bernabeu, Blanca Pérez-Gladish

This paper concerns with mutual funds whose bank managers pursue social and environmental (SRI) policies. To measure SRI levels, we design a multicriteria technique, based on screening intensity. This technique helps bank managers advice clients on their investments to select investments in funds from their preferences for SRI criteria. An actual case concerning 110 USA large cap equity mutual funds is developed for some investors' profiles.

■ HE-39

Thursday, 16:00-17:30 - Room 018

Discrete Optimization I

Stream: Discrete and Global Optimization
Contributed session
Chair: *Imke Joormann*

1 - Piecewise Relaxation of Fractional Powers of Linear Fractional Terms
Rosa Iris Núñez-Serna, Juan Zamora-Mata

The mixed integer nonlinear mathematical programming problem addressed in this paper is non-convex due to the presence of fractional powers of fractional terms in the objective function. Its solution using deterministic global optimization techniques requires rigorous methods for obtaining lower bounds for the value of the objective function. The impact of introduce a not equidistant piecewise relaxation scheme of such terms for obtaining tight lower bounds is explored. The use of the proposed strategy is illustrated in the context of efficient use of thermal energy in industrial processes.

2 - Branch Decomposition Techniques for some Matroidal Problems
Illya Hicks

This talk gives a general overview of practical computational methods for computing branch decompositions for matroids and their usage for solving some combinatorial optimization on matroids like integer programming. The concept of branch decompositions and its related invariant branch width were first introduced by Robertson and Seymour in their proof of the Graph Minors Theorem and have been generalized for any symmetric submodular set function which connectivity functions of matroids.

3 - On the Relation of Flow Cuts and Irreducible Infeasible Subsystems
Imke Joormann, Marc Pfetsch

Infeasible network flow problems can be characterized via cut-inequalities of the Gale-Hoffman theorem. Written as a linear program, irreducible infeasible subsystems (IISs) provide a different means of infeasibility characterization. We answer a question left open in the literature, by showing a one-to-one correspondence between IISs and Gale-Hoffman-inequalities in which one side of the cut is connected. We also give a polynomial-time algorithm that computes some IIS using a single max-flow computation and show strong NP-hardness of finding a minimal cardinality IIS in this special case.

4 - A Problem Related to the Integer Partitions
Zahra Yahi, Sadek Bouroubi

In our presentation we study the number of some kinds of non-isometric quadrilaterals inscribed in a regular n gon for which we give a closed formula with some auxiliary results using a partition function.

■ HE-40

Thursday, 16:00-17:30 - Room 019

Prescriptive Analytics: Smart Solutions to Real-World Problems II

Stream: Meta-Analytics: A Marriage of Metaheuristics and Analytics
Invited session
Chair: *Stefan Voss*
Chair: *Stefan Lessmann*

1 - Loan Recovery Modelling: Challenges for Predictive and Prescriptive Analytics
Christophe Mues, Lyn Thomas, Mee Chi So

Under Basel II and III, banks are building models to estimate LGD, i.e., the percentage of the loan exposure that they won't be able to recover in the event of a loan default. Similarly, within the collections department of the bank, predictive models are used to estimate either the probability of a certain recovery post-default or its size, to allocate resources and decide on the collection strategy. This talk will address some of the challenges in building recovery prediction models and how they may be used as inputs to a prescriptive analytics task: optimising the collections process.

2 - Matheuristics Applications in Maritime Shipping
Stefan Voss

We describe a generic framework to apply matheuristics for combinatorial optimization. In a first part this framework is discussed using various technologies that may efficiently be hybridized in one way or another. Examples incorporate the idea that a metaheuristic acts at a higher level and controls the calls to the exact approach, or that the exact method acts as a guiding process and calls and controls the use of a metaheuristic. Examples are provided using, e.g., POPMUISIC. Specific results outperforming best known literature benchmarks are provided for some problems in maritime shipping.

3 - Multicriteria Optimization for Cost-Sensitive Ensemble Selection in Business Failure Prediction
Koen W. De Bock, Stefan Lessmann, Kristof Coussement

Business failure prediction (BFP) remains a key instrument for financial decision makers. In BFP, misclassification costs are usually asymmetric and hence, expected misclassification cost (EMC) is often a more appropriate metric to focus upon than accuracy for the evaluation and comparison of algorithms. In this study, multi-criteria optimization through NSGA-II is deployed as a meta-heuristic in ensemble selection (ES) to produce both diverse and cost-conscious ensemble classifiers. Experiments conducted on a large set of datasets demonstrate and benchmark the proposed technique.

4 - Adaptive Hypermedia Model for Generation of Interactive Interfaces Applied to Digital TV
Arthur Gomez, Luan Carlos Nesi

Nowadays, with the technological advances the users need for individualization in the supply and access to multimedia content. Thus, this paper proposes a system for generating adaptive interfaces for Digital TV through a user model made with the formalism of networks stochastic automata learning, together with a process of generating the layout using metaheuristics. As a result, we contemplate a range of devices, being able to follow not only a market-trend, but also socially.

■ HE-41

Thursday, 16:00-17:30 - Room 216

Stochastic Vehicle Routing

Stream: Stochastic Models for Service Operations
Invited session
Chair: *Michel Gendreau*

1 - Single-VRP with Simultaneous Delivery and Uncertain Pickup Data
Nadine Wollenberg, Michel Gendreau, Rüdiger Schultz

In this talk we will present an exact algorithm for a stochastic extension of the VRP with simultaneous delivery and pickup. The quantities to be delivered are fixed, whereas the quantities to be picked up are given by a limited number of scenarios. Due to possible route failures, compensation strategies need to be considered. The stochastic model is formulated as a two-stage stochastic program with recourse and solved by means of the integer L-shaped method. To strengthen the lower bound on the recourse cost the concept of partial routes is adapted.

2 - The Vehicle Routing Problem with Stochastic Two-Dimensional Items
Jean-François Côté, Michel Gendreau, Jean-Yves Potvin

We consider a stochastic vehicle routing problem where a discrete probability distribution characterizes the two-dimensional size of a subset of items to be delivered. The sizes of these items become known when it is time to load the vehicles. A penalty is incurred if not all of them can be loaded in a vehicle. The objective is to minimize the sum of the routing and expected penalties. The problem is modeled as a two-stage stochastic program and solved with the integer L-shaped method. Some new inequalities and lower bounds are proposed. Computational results are reported on new instances.

3 - A Priori Optimization with Recourse for the Vehicle Routing Problem with Hard Time Windows and Stochastic Service Times
Fausto Errico, Guy Desaulniers, Michel Gendreau, Louis-Martin Rousseau

The VRPTW-ST differs from other routing problems with stochastic times for the presence of hard time windows. We model the VRPTW-ST as a two-stage stochastic program and define two recourse policies to recover first stage infeasibility. We solve the VRPTW-ST by exact branch-cut-and-price algorithms. Our development included finding tight bounds on partial route reduced costs to efficiently prune dominated labels in the column generation subproblem. Results on benchmark data show that our methods are able to solve instances with up to 50 customers for both recourse policies.

■ HE-42

Thursday, 16:00-17:30 - Room 215

Decision Analysis & Decision Making Approaches

Stream: Decision Support Systems
Invited session
Chair: *Isabelle Linden*
Chair: *Shaofeng Liu*

1 - Use of Contabilometria as a Decision Making in the Sector Accounting in VL Technology Company LTDA the Municipalities Princesa Isabel - PB
José Jefferson Marques de Sousa

The Contabilometria is a new area of accounting knowledge, that seeks the application of quantitative methods in the solution of financial problems, which can be seen as a provider of tool information. Within this context, the aim of this study was to identify what improvements the use of Contabilometria brings to the accounting information to support the management process, the Company VL TECHNOLOGY LTD in the town of Princesa Isabel- PB. We conclude that the Contabilometria enables the use of accounting data, such as information tool designed for the future.

2 - Using the Analytic Hierarchy Process Decision Analysis to Better Understand Consumers Intentions to Revisit a Green Hotel
Chiao-Chen Chang

The purpose of this study was to examine the influencing factors of green hotel revisiting intentions from a hotel perspective. The survey data were conducted from a selection of green Taiwanese hotels, and were analyzed by the analytic hierarchy process (AHP) decision analysis to explore revisiting intentions in the context of green hotels. The results of the AHP decision analysis revealed that "communication and involvement" and the "green commitment of top managers" were the most important factors for green hotels from a hotel's perspective.

3 - Timing and decision making
Gil Greenstein

This research presents a model and an analysis of timing aspects of decision making under uncertainty. The model is built under the following assumptions: information resources become more accurate over time, the value of utility functions deteriorate over time, and decision makers could examine information once before making a decision. Moreover, the model describes human behavior under the assumption of "Bounded rationality", by suggesting that a decision maker sticks to a rigid decision rule. The model sets an analytical framework for an adaptation process of a decision rule over time.

4 - Decision Making and the Big Data Era
Fatima Dargam

Currently data heavily, constantly, and globally flows into all areas of our economy. Individuals and mainly organizations have to tackle the problem of processing large data in support of their respective needs and operations, aiming at improving their manageability and efficiency. Big Data urges for advances in technology and cannot count anymore with classical database tools to manage and analyze information data-sets. This work positions the importance of Decision Making and DSS to exploit Big Data analysis so that organizations can get ready to compete with high productivity.

■ HE-43

Thursday, 16:00-17:30 - Room 217

Scheduling Problems in Water Distribution System Management

Stream: OR in Water Management
Invited session
Chair: *Maddalena Nonato*

1 - A Practical Approach for Large Scale Optimal Pump Scheduling with Operational Constraints
David Raz, Ariel Daliot

Optimizing the operation of water distribution systems through scheduling of pumps with operational constraints, to minimize energy costs, usually results in highly nonlinear or mixed integer optimization problems which are impractical for large setups, especially where near real-time operation is required. We propose an approach to solve this problem, involving an iterative heuristic and a linear programming model. The approach is demonstrated and evaluated on a practical setup. An extension for the case of cost structure involving multiple suppliers and aggregative costs is also presented.

2 - The Operational Costs Minimization in Water Supply Systems (WSS) Using Cascade Optimization Techniques
Bernardete Coelho, António Andrade-Campos

Operational costs in WSS constitute a large quota of the global costs. Pumps control optimisation can provide considerable improvements on the WSS efficiency since, most of the times, their operation reveals to be inefficient. A methodology to optimise the speed and the operating time of variable-speed pumps is proposed. For the automatic application of such methodology in distinct WSS, a numerical tool combining EPANET 2.0 with an optimisation module was developed. Sequential optimisation techniques are applied to benchmarking networks, which are also tested with each algorithm individually.

3 - Path Relinking and MILP Hybridized Genetic Algorithms for Scheduling Countermeasures to Contamination Events
Maddalena Nonato, Andrea Peano, Marco Gavanelli

Once a drinking water network is contaminated, teams of technicians are dispatched on site to close valves and open hydrants to deviate water flow, isolate contaminated sectors, and expel contaminated water, so that the volume of consumed contaminated water is minimized. The schedule of these operations has a great impact on such volume, but realistic solutions must take into account the team traveling time from one site to the next. We present a genetic algorithm hybridized with Mixed-Integer Linear Programming and enhanced by path-relinking. Computational results on realistic data are shown.

4 - Simulation Optimization Approach for Pump Scheduling in Water Networks
Joe Naoum-Sawaya

We present a simulation optimization appraoch for the pump scheduling problem in water networks. The proposed approach combines CPLEX and EPANET simulator. CPLEX is used to efficiently find candidate pump schedules that are then evaluated for cost and feasibility using EPANET. The proposed approach overcomes the difficulty of using the typcial nonlinear equations that model the hydraulics of water networks. Results from real water networks are reported.

■ HE-44

Thursday, 16:00-17:30 - Room 218

Optimization Practices for Sustainable Community Development

Stream: Quality and Performance Measurement in Humanitarian Relief Chains
Invited session
Chair: *Sadia Samar Ali*
Chair: *Gerhard-Wilhelm Weber*

1 - Energy: Environmental Impact and Economic Growth in Developing Economies (Nigerian experience); An Operational Research Approach
Aniefiok Udo, Kingsley Imoh

Economic growth requires larger inputs of energy and materials and these generate larger quantities of waste by-products. Increased extraction of natural resources, accumulation of waste and concentration of pollutants will overwhelm the carrying capacity of the biosphere and result in the degradation of environmental quality. Are there trade-off between economic growth and environmental quality? This paper attempts to answer this question using systematic econometric technique. It reveals that energy promotes economic growth, environmental degradation; therefore, energy efficiency is needed.

2 - Industrial Heritage and Educational Polygon for Development Strategies
Vladimir Hain

Industrial heritage provides one of the most important records on development during the last two centuries. Currently, it is a complex multidisciplinary and multi-criteria societal problem with a dynamic process of future development. Educational Polygon is a model and operational tool, to stimulate social, economical and political decisions for the purpose of protection of heritage in a new creative way. By application of "polygonal method" and OR we can effectively learn and explore new values in order to educate the general public and develop city in the spirit of local cultural diversity.

3 - Closed-Loop Supply Chain Decision Models with Trade-in
Zhaowei Miao

Three kinds of closed-loop supply chain decision models with trade-in are developed in this paper, including the centralized return model (C), the retailer return model (R), and the manufacturer return model (M). By Stackberg game, we find under different conditions of parameters, there may exist three kinds of optimal return strategies, i.e., no return, partial return, and full return. Moreover, for the profits obtained by the manufacturer and the whole supply chain system, Model C dominates Model M and Model M dominates Model R; for the retailer's profits, Model M is dominated by Model R.

4 - Carbon Footprint Calculation and Monitoring in Freight Transport Operations: A Systemic Approach
Vasileios Zeimpekis, Konstaninos Mamasis, Dimitris Drosos, Ioannis Minis

To meet the EU carbon targets for 2020, it is required to reduce CO2 emissions from transport operations substantially. To this end, we present a web-based platform for carbon footprint calculation that can be used by shippers, carriers, 3PL providers, and forwarders that operate in PECs IV, V and VII. The platform adopts the EN 16258 standard as well as the EMEP/EEA emission inventory guidebook in order to support both energy as well as activity-based calculations. A benchmarking tool has also been developed to provide emission analytics at company, sector, corridor, and country level.

■ HE-45

Thursday, 16:00-17:30 - Room 219

Location Problems / Supply Chain

Stream: Hybrid Heuristics
Invited session
Chair: *Nader Azizi*

1 - A Comparison of Heuristics Approaches to the Reliability Redundancy Allocation Problem
Edward Pohl, Thomas Talafuse

The Redundancy Allocation problem (RAP) involves selecting the optimal combination of components and redundancy levels to maximize system reliability subject to a variety of constraints such as weight, volume, and cost. This problem has been shown to be NP-hard in the literature. The use of genetic algorithms and ant colony optimization (ACO) has been shown to be effective for this problem. In this talk we compare the performance characteristics of an ACO on the RAP with those of a particle swarm optimization algorithm and the recently developed bat-inspired algorithm.

2 - A Hybrid Genetic-Simulated Annealing Algorithm for the Supply Chain Network Design
Beyzanur Cayir, Bilal Ervural

The structure of SCN problems are combinatorial and NP hard. In this study the problem has a non-linear structure and an optimum solution could not be found in a polynomial time with using exact algorithms. To solve this NP-hard problem, an effective hybrid genetic simulated annealing algorithm is developed. This paper proposes a new Hybrid Genetic and Simulated Annealing Algorithm to find the set of optimal solutions for the multistage SCN design problem. Computational results show that the hybrid algorithm achieves a better solution than produced by simulated annealing or genetic algorithm.

3 - A Hybrid Particle Swarm Optimization with Genetic Mutation for the Supply Chain Network Design
Bilal Ervural, Beyzanur Cayir

In this study, to solve such a hard SCN design problem a hybrid particle swarm optimization algorithm that uses the mutation process of GA to improve the basic particle swarm optimization (PSO) algorithm is proposed. The main idea of the hybridPSO is to combine the particle swarm with genetic algorithm mutation operator. Consequently, the proposed hybrid algorithm has balance capability between global and local searching. The validity of the hybridPSO algorithm is tested and compare with basic PSO. Computational results show empirically that the proposed hybrid method outperforms significantly

4 - Hub-and-Spoke Network Design with Reliability Consideration: A Particle Swarm Optimization Approach
Nader Azizi, Said Salhi

Many enterprises including airlines and package delivery companies have adopted the topology of hub-and-spoke for their networks. In such networks, even a minor disruption in hubs may lead to significant revenue loss as well as customer dissatisfaction. To maintain network operations following an unexpected hub failure, we propose new models to consider a backup facility for each demand point in the network. Due to complexity of the problem, two particle swarm optimization algorithms are developed to solve some problem instances.

Friday, 8:30-10:00

■ FA-01

Friday, 8:30-10:00 - Room 118

Network Capacity and Utilization

Stream: Railway and Metro Transportation
Invited session
Chair: *Leo Kroon*

1 - Simultaneous Network Expansion and Global Frequency Setting on Railway Systems
Francisco Lopez-Ramos, Esteve Codina, Ángel Marín

This work presents a mathematical model which integrates the railway network expansion (RNE) and frequency setting (FS) phases. The RNE builds the new lines considering a set of points that can work either as stations or just as pass-through points, whereas the FS assigns vehicles and frequencies to the whole railway lines while meeting capacity constraints. The model is applied to two real-sized underground networks and is solved by means of a Specialized Benders Decomposition which takes advantage of some state-of-the-art enhancements as well as some ad hoc techniques.

2 - Allocating the Railway Capacities to Extra Trains
Soon-Heum Hong, Bum Hwan Park

We suggest an optimization model and a column generation based approach to allocate the residual railway capacities to extra trains. Our model considers a railway network where the various kinds of rolling stocks are operated together which needs the model capable of separately setting the operational allowances for the shift of times to each train type. For our model, we developed a solution approach to combine a generic column generation with a heuristic for diversified columns and faster convergence. Finally, we present some experimental results applied to the Korean railway network.

3 - Integer Programming Model for Planning Accompanied Combined Transport Operations in India
Amit Upadhyay, Nomesh Bolia

Roll-on-Roll-off (RORO) is the name for Accompanied Combined Transport service in India. Given its resounding success in Konkan Railway, RORO services are planned on a large scale on the dedicated freight corridors in India. We consider peculiar operational constraints to optimally design RORO services. We propose an integer programming model to design RORO train services with multiple handling points and assign the demands to the trains with focus on resource utilization. Computational experiments with realistic data are presented and show that substantial gains are possible with our model.

■ FA-02

Friday, 8:30-10:00 - Room 111

Vehicle Routing Problems 1

Stream: Combinatorial Optimization
Invited session
Chair: *Irene Loiseau*

1 - A Decomposition Approach for the Inventory Routing Problem
Carlos Franco, Verena Schmid

We propose a solution approach for the inventory routing problem that is based on column generation. We propose a mathematical formulation based on a subset of all possible routes. For solving the mathematical model we used column generation for generating attractive routes iteratively. We relaxed the mathematical formulation and obtain the dual information. With the dual information we solve the subproblem that is formulated as a shortest path problem but we generate multiple routes for each iteration. The routes added are the ones that have negative reduced costs.

2 - A Multi-Depot Vehicle Scheduling Problem in a Public Transportation System in Quito
Luis Torres, Ramiro Torres

We propose an integer programming model to solve a vehicle scheduling problem in a real-life public transportation system, the METROBUS in Quito. This model is formulated as a multi-commodity flow problem, minimizing the total operational cost and the unused vehicle time at the terminals. We present a heuristic method to obtain feasible solutions, as well as a lower bound derived from a mincost flow relaxation. Computational results for real data with up to 1500 timetabled trips are reported, which show a remarkable potential in resource savings with respect to the current schedule.

3 - An Unsupervised Fuzzy Clustering Approach to the Capacitated Vehicle Routing Problem
Henrique Ewbank, Peter Wanke, Abdollah Hadi-Vencheh

This paper uses unsupervised fuzzy clustering as the cornerstone of a proposed three-stage heuristic to solve the capacitated vehicle routing problem with homogeneous fleet. Results for eighty-five known instances in literature indicate 5% error in average. They also suggest a relationship between the most adequate fuzziness parameter m and the descriptive statistics of the demands of each point and their distances to the central depot within each instance. The neural network trained to predict the most adequate m-parameter based on these descriptives reported a pseudo R-squared of 90.6%.

■ FA-03

Friday, 8:30-10:00 - Room 001

Hub Location

Stream: Location
Invited session
Chair: *Francisco Saldanha-da-Gama*

1 - Hub Location with Profits
Armaghan Alibeyg, Ivan Contreras, Elena Fernandez

We present Hub location Problems with Profits, where it is not necessary to provide service to all demand nodes. A profit is associated with each flow between pair of nodes. The goal is the simultaneous optimization of the collected profit, the set-up cost of the hub network and the routing cost for routing the flow. Potential applications appear in the design of airline and ground transportation networks. Mathematical models and a unifying Lagrangean relaxation approach are presented to solve this class of problems. Numerical results on a set of benchmark instances are reported.

2 - Formulation and Solution of an Unreliable Hub Location Problem
Trung Hieu Tran, Jesse O'Hanley, Maria Paola Scaparra

We investigate the uncapacitated single allocation p-hub location problem with independent hub failures. A mixed integer nonlinear programming model is formulated to support planners to obtain robust optimal solutions. A linearization technique is developed to solve the problem to optimality. Our approach is based on the use of a specialized flow network to evaluate compound probability terms. A tabu search algorithm with parallel computing is proposed to find optimal to near optimal solutions for large instances. Preliminary results show the efficiency of our linearized model and algorithm.

3 - Capacitated Multiple Allocation Hub Location with Service Level Constraints for Multiple Consignment Classes
Sachin Jayaswal, Navneet Vidyarthi

We present a model for designing a capacitated multiple allocation hub location problem with a service level constraint, defined using the distribution of time spent at hubs, for each of two priority classes of consignments. The network of hubs, given their locations, is modeled as spatially distributed preemptive priority M/M/1 queues. The problem is challenging to solve, especially in absence of any known analytical expression for the sojourn time distribution of low priority customers in a preemptive priority M/M/1 queue.

4 - Multi-Period Hub Network Design Problems with Modular Capacities
Francisco Saldanha-da-Gama, Sibel A. Alumur, Stefan Nickel, Yusuf Seçerdin

We propose a MILP modeling framework for multi-period capacitated hub location. We include hub network design decisions and address both the single and multiple allocation cases. Capacities are modular. The objective is to minimize the total cost over the planning horizon while determining, in each time period, the location and capacity of the hubs, the allocation of the demand nodes to the located hubs, the hub links that should operate between hubs, and the routes of flow between the origin-destination pairs. We report the results of extensive computational tests using the CAB data set.

■ FA-04

Friday, 8:30-10:00 - Room 119

Strategic Traffic Planning

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Gideon Mbiydzenyuy*

1 - Estimation of European Freight Logistics Network Using an Integrated Multistage Logistics Network Model
Ronald Halim, Lorant Tavasszy

While there are many logistic models developed to design the global production networks of individual firms, there are very few models developed to estimate the international freight network in a region. This research puts forward an integrated multi-stage logistic model used to estimate the European freight network. In particular, the model estimates 1) the number and locations of the distribution centers in Europe 2) the freight transportation network between the ports, DCs and consumption regions. Using an evolutionary metaheuristic, a promising estimation of the network has been generated.

2 - Price of Anarchy for Non-atomic Congestion Games with Stochastic Demands
Bo Chen, Chenlan Wang, Xuan Vinh Doan

We generalize the notions of user equilibrium and system optimum to non-atomic congestion games with stochastic demands. We establish upper bounds on the price of anarchy for three different settings of link cost functions and demand distributions, namely, (a) affine cost functions and general distributions, (b) polynomial cost functions and general positive-valued distributions, and (c) polynomial cost functions and the normal distributions. All the upper bounds are tight in some special cases, including the case of deterministic demands.

3 - Analysing Design Alternatives for Services Based on Intelligent Transport Systems using an Integer Linear Optimization Model
Gideon Mbiydzenyuy

This article proposes an Integer Linear Optimization Model (ILOM) for supporting strategic decisions related to design, implementation, and integration of services based on Intelligent Transport Systems (ITS). The model involves abstracting ITS services as collections of mandatory and optional functional elements and the service value as a collection of impacts elements. Impacts and functional elements are abstracted to sub-elements with each abstraction layer creating hierarchical and non-hierarchical dependencies. By modeling various layers, ITS service designs are analyzed using ILOM.

■ FA-05

Friday, 8:30-10:00 - Room 002

Yardside Operations

Stream: Port Operations
Invited session
Chair: *Iris F.A. Vis*

1 - Integrated Crane Scheduling and Yard Allocation for Indented Berths
Iris F.A. Vis, Evrim Ursavas, Hector Carlo

Indented berths are a structural innovation in container terminals that allow simultaneous loading and unloading of vessels from both sides. Recent indented berth implementations have been limited by special requirements and challenges for the management of quay cranes and the yard area. In this study, a mixed integer programming model tackling the problem of scheduling quay cranes and the yard allocation is formulated. The model is tested using real and internally generated data.

2 - Container Yard Template Planning under Uncertainty
Lu Zhen

A yard template determines the assignment of spaces (subblocks) in a yard for arriving vessels. The fluctuation of the demand for freight transportation brings new challenges for making a robust yard template when facing uncertain maritime market. A model is proposed for yard template planning with considering random numbers of containers that will be loaded onto vessels that visit the port periodically. Traffic congestions in the yard and multiple cycle time of the periodicities for vessel arrival patterns are also considered in the model. Moreover, a meta-heuristic method is developed.

3 - White Box Optimization of Container Transport Planning
Bart Van Riessen, Rudy Negenborn, Rommert Dekker

An integral approach of the routing of inland container transportation is vital in order to maintain reliable and sustainable inland connections. We propose an online method for allocating incoming transport orders directly to available inland services, resulting in a stable solution without the necessity of continuous planning updates. In our research we use a supervised learning algorithm to find structural patterns in the shadow prices of offline optimal plans. This allows a substantive analysis of the offline optimization results and translates the offline model into online decision rules.

■ FA-06

Friday, 8:30-10:00 - Room 211

Matheuristics I

Stream: Matheuristics
Invited session
Chair: *M. Grazia Speranza*

1 - A Matheuristic for the Multi-Vehicle Inventory Routing Problem
Claudia Archetti, M. Grazia Speranza, Natashia Boland

The Multi-vehicle Inventory Routing Problem (MIRP) is the problem of determining for each time of a discrete horizon the quantity to deliver to customers and the routes at minimum cost. This includes the inventory costs at all nodes and the costs of the vehicle routes. No stock-out is allowed at the customers and the vehicle capacity constraints are satisfied. We present a matheuristic where three different mathematical programming models are embedded in a heuristic scheme. Computational results are presented for a large set of benchmark instances and compared with state of the art results.

2 - Upper and Lower Bounding Procedures for the Optimal Management of Water Pumping and Desalination Processes
Sandra Ulrich Ngueveu, Bruno Sareni, Xavier Roboam

We consider the problem of water production optimization for autonomous water pumping and desalination units supplied by renewable energy sources, designed to be a viable solution to fresh water scarcity for remote areas. Nonlinear gyrators as well as the nonlinear efficiency of energy and flow transfers model the mechanical-hydraulic power conversion systems involved. We present a generic formulation and resolution algorithms based on piecewise bounding and integer linear programming to solve to optimality the global optimization problem of finding an optimal energy management strategy.

3 - A Matheuristic for a Long-Haul Freight Transportation Problem: Synchronizing Resources through Multiple Transshipment Locations
Fábio Moreira, Pedro Amorim, Luis Guimarães, Márcio Antônio Ferreira Belo Filho, Bernardo Almada-Lobo

Cost pressure fostered a change in the logistics paradigm and transfer points are being deployed for long-haul freight transportation to introduce extra flexibility. In this talk we address the operational planning challenges emerging from this new paradigm, which has its potential benefits at risk by the additional difficulty to simultaneously synchronize all resources, satisfy all constraints and fulfil all customer orders in time. In order to tackle a real-world problem we developed a matheuristic that explores the structure of a novel MIP to deliver superior quality solutions.

4 - Kernel Search: A General Heuristic Approach to MILP Problems
M. Grazia Speranza

The Kernel Search has been successfully applied to several MILP problems. It is a general and simple heuristic framework. The basic idea is to consider the problem variables through the solution of a sequence of MILP problems, each restricted to a subset of variables. An overview of the Kernel Search will be provided. Specific heuristics will be presented for the Capacitated Facility Location Problem and for the Single Source Capacitated Facility Location Problem. Computational results will be shown on a large set of benchmark instances with up to 1000 facilities and 1000 customers.

■ FA-07

Friday, 8:30-10:00 - Room 003

Optimal Control with Applications

Stream: Optimal Control
Invited session
Chair: *Gernot Tragler*

1 - When Does Better Product Quality Imply Higher Price?
Régis Chenavaz

In an optimal control framework, we model the intertemporal behaviour of the firm that sets directly product pricing and indirectly product quality through product innovation; the production cost is based on product quality. We analyse the conditions under which better product quality implies higher price. For general demand functions, price dynamics is ambiguous, and price may decline even if both quality and cost rise. For additive separable demand functions, price dynamics emulates quality dynamics. For multiplicative separable demand functions, price dynamics mimics cost dynamics.

2 - Necessary Conditions for Optimal Control Problems in Discontinuos Dynamic Systems
Ekaterina Kostina

Optimal control of systems of differential equations with state dependent discontinuities are widely used to describe numerous applications in natural sciences and engineering, where, e.g., there is a necessity to model dynamics with different scales or with jumps. We discuss necessary optimality conditions for optimal control problems of such systems with special attention to the case when an optimal trajectory slides on the discontinuity surface. This is a joint work with Olga Kostyukova.

3 - Dynamic Information Acquisition in LQG Control Problems
Thomas Weber, Viet Anh Nguyen

This paper provides a solution to the linear-quadratic-gaussian (LQG) control problem with dynamic information acquisition. At each time, the decision maker determines whether to obtain an informative signal about the state at a chosen costly confidence. Information collection is optimal whenever the variance of the state estimate lies above a decision threshold. Analytical expressions are obtained for the optimal feedback control law, the optimal state-control trajectory, including the optimal variance of the observations. Several applications in management science are discussed.

4 - Optimal Control of Violence During Insurgencies
Gernot Tragler

We present an optimal control model for popular behavior in times of insurgencies, during which the population supports either the regime or the insurgents. The behavior of the affected people is influenced by the rate of violence each of the conflicting parties involved may use. The model is discussed from the regime's point of view, where the control variables are the intensity and targeting accuracy of violent actions against the insurgents. The state variables describe the dynamics of supporters of the regime and of the insurgents. Several scenarios are discussed.

■ FA-08

Friday, 8:30-10:00 - Room 120

Dynamic Programming

Stream: Dynamic Programming
Invited session
Chair: *Frank Ciarallo*

1 - Control Loop Elements in Fluid Systems via Mixed-Integer Linear Programming
Philipp Pöttgen, Lena Altherr, Thorsten Ederer, Ulf Lorenz, Peter Pelz

To optimize technical systems with a reasonable accuracy, dynamic effects during their operation have to be considered. In particular, time-dependent behavior of control loop elements has to be taken into account by the optimization model. We present a mixed-integer linear program for the optimal control problem with binary control variables exemplified by a fluid system. This formulation allows the inclusion of combinatorial decisions such as variation of the network topology. Furthermore, we are able to appraise feasible solutions using the global optimality gap.

2 - Multiperiod Multiproduct Advertising Budgeting: A Stochastic Optimization Model
Cesar Beltran-Royo, Laureano Fernando Escudero, Huizhen Zhang

We propose a stochastic optimization model for the Multiperiod Multiproduct Advertising Budgeting problem, so that the expected profit of the advertising investment is maximized. The model is a convex optimization problem that can readily be solved by plain use of standard optimization software. The model has been tested for planning a realistic advertising campaign. In our case study, the expected profit of the stochastic approach has been favorably compared with the expected profit of the deterministic approach, providing a quantitative argument in favor of the stochastic approach.

3 - Decision Processes in Route Following with Imperfect Information
Frank Ciarallo, Victor Middleton

We study decision processes of an agent following a route, when the knowledge of the network is imperfect. The agent has a parallel, imperfect representation of the network. Using a multiple criteria decision framework the agent attempts to recognize its surroundings in the actual network. The agent must reconcile what it observes as it moves in the network with its internal representation using network topology and other features, assess the state of progress on the route, and choose its next actions. We evaluate the character of information and decision parameters needed to maximize success.

■ FA-09

Friday, 8:30-10:00 - Room 121

Optimization of Electric Power Networks

Stream: Technical and Financial Aspects of Energy Problems
Contributed session
Chair: *Javier Salmeron*

1 - The Structural Impact of Renewable Energy Support Schemes on Electricity Markets — A Generation Capacity Expansion Model with Ramping and Strategic Bidding

Ingmar Ritzenhofen, John Birge, Stefan Spinler

Renewable portfolio standards and feed-in-tariffs are widely used policy instruments to promote investments in renewable energy sources. Regulators continuously assess these instruments along the main electricity policy objectives — affordability, reliability, and sustainability of electricity supply. We quantitatively assess these policies along these dimensions using a long-term electricity capacity expansion model with ramping, strategic bidding, and price-elasticity of demand. We compare the performance of our model to existing quantitative generation capacity expansion models.

2 - Optimal Management of Distributed Energy Resources Considering Power Flow Restrictions

Guillem Vinals

A generic energy management system for hybrid AC/DC microgrids is presented consisting of renewable and conventional generation, energy storage and electric vehicles. To minimize costs while considering the power system limits, bus voltages and power restrictions in the electric lines are included, as well as capability curves of electrical machines. Under these constraints a mixed-integer nonlinear problem is obtained. To solve it, an algorithm is designed to find a feasible initial point reformulating the problem into a convex optimization problem and a mixed-integer linear problem.

3 - Enhanced Optimal Power Flow for Real Time Application

Konstantin Vandyshev, Dion Gijswijt, Karen Aardal

The aim of the work is to develop a modular set-up of the OPF, which may solve large real-life models within a very short time (15 minutes). We enhance OPF with transformer tap ratio and phase shift angle optimization, HVDC lines and shunt elements. Additional modules are heuristic topology optimization method and security constrained OPF. Our methodology encompasses different flexibilities for sacrificing certain accuracy in order to get solution faster. For numerical experiments we apply our methodology to a test system, which describes 6 European countries.

4 - Electric Power Grid Interdiction: The Value of Spare Transformers

Javier Salmeron, Kevin Wood

We develop a new attacker-defender (AD) model for an electric power transmission grid having an inventory of high-voltage transformer (HVT) spares. Under various states of repair and load, the defender optimizes (i) the quick, post-attack replacement of disabled HVTs with spares, and (ii) power flows. Global Benders decomposition, with a mixed-integer subproblem, solves the AD model; special enumerative techniques can help solve both the master problem and subproblem. Computational tests demonstrate how the model could help guide inventory strategies for spares in an adversarial setting.

■ FA-10

Friday, 8:30-10:00 - Room 122

Timetabling

Stream: Timetabling and Rostering
Contributed session
Chair: *Öznur Şengel*

1 - Finding Robust Timetables for Project Presentations of Student Teams

Can Akkan, M.Erdem Külünk, Cenk Kocas

An approach to identifying robust solutions to discrete optimization problems is proposed through a timetabling problem faced by one of the authors. The problem requires grouping of student teams considering a set of diversity criteria and then assigning these groups to feasible time–slots to present their projects. An MIP formulation of the problem is developed which is then solved using CPLEX. A set of solutions provided by the solution pool feature of CPLEX are mapped to a network and well-known social network analysis metrics are then used to identify high quality robust solutions.

2 - A Linear Mixed-integer Model and Tabu-search Based Improvement Procedure for Realistic Examination Timetabling Problems

Lisa Katharina Bergmann, Kathrin Fischer, Sebastian Zurheide

An exam timetable has to satisfy a vast variety of requirements to be feasible and convenient to all involved parties. Most of the literature on this topic only covers the basic constraints. Here, a linear model is presented which considers many additional requirements as soft constraints. Using a penalty-approach, it is assured that timetables meet the actual demands of teachers and students. A tabu-search approach is used to solve a real planning situation. It leads to feasible timetables that satisfy many of the soft requirements and thus can enhance the students' and teachers' contentment.

3 - Assistant Assignment to Final Exams

Öznur Şengel, Melike Günay

In this study, we develop a system that provides a solution to assign assistants for each final exam in universities. One of the common problems about this scheduling system is deciding the most suitable assistant when more than two overseers were recommended and there is more than one exam in the same time slot. Through the work, we consider few assumptions and constraints, related to final exam timetable and weekly schedule of assistants. We use a search algorithm to find which assistant is suitable for which exam and an optimization algorithm is used to find a best solution for assignment.

■ FA-11

Friday, 8:30-10:00 - Room 113

Combinatorial Optimization Applications in Industry and Services

Stream: Combinatorial Optimization
Invited session
Chair: *José Fernando Oliveira*

1 - Coffee Aggregate Production Planning

Diana Yomali Ospina Lopez, Maria Antónia Carravilla, José Fernando Oliveira

Coffee is one of the most important commodities in the world trade. It has been marketed by two ways: green coffee beans and processed coffee. The general coffee production process includes: storage, roasting, grinding, blending and packaging. These processes must operate appropriately and provide accurate information to obtain the best performance. Our research aims to model the aggregate production planning in the coffee company and evaluate the influence of acquisition strategies of the green coffee beans on both the perecibility and on the total production cost and demand satisfaction.

2 - A Mathematical Programming Approach to Mixed Model Assembly Line Balancing and Sequencing

Doğan Aybars İlhan, Tuğçe Hoşgör, Fadime Üney-Yüksektepe

In this study, mixed model assembly line balancing and sequencing problems are aimed to solve simultaneously. Balancing is to assign tasks to workstations subject to cycle time and precedence constraints for minimizing work overload. Sequencing is to find launching sequence of models assembled on the line by minimizing total amount of uncompleted work. A Mixed-Integer Linear Programming model is developed to provide the solution of the problem. The developed model is implemented in a real life automotive manufacturer's assembly line balancing problem by using GAMS 23.0 and CPLEX 12.0 solver.

3 - A Mathematical Railway Model for Allocation of Limited-Stop Service Stations to Minimize Total Travel Time

Hidetoshi Miura, Toshio Nemoto

We propose a mathematical model to study allocation limited-stop service stations to minimize total travel time. Travels of users are described on a single railway model with two terminal stations and n way stations. Travel demand between any two stations are equal and constant over the railway model. There are two trains types: local train stopping at all stations and a limited-stop service skipping some stations. We show an optimal allocation of limited-stop service stations and shortened total travel time. Furthermore, the model gives the optimal number of limited-stop service stations.

4 - An Agent-based Approach to Schedule Crane Operations in Rail-Rail Transshipment Terminals

Sam Heshmati, Maria Antónia Carravilla, José Fernando Oliveira

The study considers scheduling the cranes operation in Rail-Rail Transshipment Terminals (RRTTs) from an operational point of view, while minimizing the total transshipment time. The study introduces an agent-based approach for the container transshipment processes in RRTTs where intelligent crane agents decide and plan their own schedule. The idea is to put forward an agent-based approach by systematically analyzing cranes' behavior. Finally a comparison of the agent-based system with more traditional approaches for real-time transport planning based on OR algorithm is provided.

■ FA-12

Friday, 8:30-10:00 - Room 004

Discrete-Continuous Scheduling

Stream: Scheduling under Resource Constraints
Invited session
Chair: *Jan Weglarz*
Chair: *Yakov Zinder*

1 - A Matheuristic Approach to Capacity Planning Problem in Mineral Supply Chains

Yakov Zinder, Joey Fung, Gaurav Singh

Determining capacity improvement initiatives to meet a forecasted demand is a crucial problem for all supply chains. The cost and long lead-time associated with building additional infrastructure makes this problem even more crucial for mineral supply chains. Motivated by the recent trend of matheuristics, this paper presents a hybrid optimisation procedure that combines MILP and metaheuristics, where both complement and guide each other towards better solutions. Computational results using data from the world's largest coal supply chain based in Australia are also presented.

2 - Solving some Discrete-Continuous Project Scheduling Problems with Discounted Cash Flows

Grzegorz Waligora

Discrete-continuous project scheduling problems with positive discounted cash flows and the maximization of the net present value (NPV) are considered. Activities are nonpreemptable, and the processing rate of each activity is a continuous, increasing and concave function of the amount of the continuous resource allotted to the activity at a time. Three common payment models are analyzed. Formulations of mathematical programming problems finding optimal continuous resource allocations for the payment models are presented, and a general methodology for solving the defined problems is discussed.

3 - Scheduling Computational Jobs with Varying Power Availability

Rafal Rozycki

We consider a problem of scheduling preemptable, independent jobs on parallel, identical machines under an additional, continuous, renewable resource to minimize the schedule length. The considered problem is a generalization of discrete-continuous scheduling problems, where a total amount of the resource available at a time is constant. Here we assume that this amount varies over time. The lengths of the availability intervals, as well as the amounts (nonnegative and constant) of the resource in each intervals are known, in advance. We propose a general methodology for solving the problem.

4 - Simulated Annealing Approach to Metascheduling of Workflow Applications in Computational Grids

Marek Mika

Computational grid is a computing environment dedicated to execute applications with large computational requirements. An example of such complex application executed in grid is a workflow. It consists of various precedence-related transformations (tasks) performed on certain data. These tasks communicate with each other in order to transfer some data files. Usually, workflow applications are very time consuming. Thus, it is very important to allocate tasks to resources and schedule them to minimize the makespan. We use simulated annealing as a heuristic approach in this metascheduling phase.

■ FA-13

Friday, 8:30-10:00 - Room 123

Scheduling Applications 1

Stream: Scheduling
Invited session
Chair:
Chair: *Alexander Lieder*

1 - Scheduling Set-Up Operations in a Multi-Machine Environment when only One Set-Up Operator is Present

Daniel Schnitzler, Dirk Briskorn

There are a limited number of machines which have pre-assigned tasks. The tasks on a machine have to be processed in a given sequence. For each task, the machine has to be set up. Only one machine can be set up at a given time. Different goals are pursued (e.g., reduce makespan). Since standard solvers are only able to tackle small problems, a genetic algorithm and a tabu search were developed, which can solve problems with up to 100 machines and 1000 tasks. Different variants of the metaheuristics were tested with the help of random instances and instances from which the solution is known.

2 - Finding Optimal Tour Plans of a Cargo Ship under Deadline Restrictions

Stefan Bock

In this talk, the finding of an optimal tour plan of a single cargo ship is considered. Specifically, a schedule is sought that minimizes the total sum of request waiting times at the inland ports while all deadlines are met. This problem is equivalent to the Line-TRP with general processing times and deadlines whose complexity status has been open for a long time. It is shown that this problem is strongly NP-hard. In order to generate an optimal tour, a new Branch&Bound algorithm is introduced that applies a specific enumeration scheme as well as lower bounds and dominance criteria.

3 - Scheduling Part Feeding from Line-Integrated Supermarkets to Mixed-Model Assembly Lines

Simon Emde, Nils Boysen

Line-integrated supermarkets constitute a novel in-house parts logistics concept for feeding mixed-model assembly lines. In this context, supermarkets are decentralized logistics areas located directly in each station. Here, parts are withdrawn from their containers by a dedicated logistics worker and sorted just-in-sequence (JIS) into a JIS-bin. From this bin, assembly workers fetch the parts required by the current workpiece and mount them during the respective production cycle. This presentation treats the scheduling of the part supply processes within line-integrated supermarkets.

4 - Efficient Task Scheduling in Long-Term Care Facilities
Alexander Lieder, Dennis Moeke, Raik Stolletz, Ger Koole
Care workers in nursing homes are responsible for providing services to clients and cause the largest share of operational costs. In order to deliver high-quality service, it is important to assign each task to a qualified care worker and to a point in time according to the client's preferences. We present a dynamic programming approach that generates optimal task schedules. Using data from practice, we evaluate the runtime performance of this approach. A sensitivity analysis shows effects of optimal task schedules on the required workforce.

■ FA-15

Friday, 8:30-10:00 - Room 125

Experimental Research in Management Accounting and Management Control 2

Stream: Experimental Perspectives and Challenges in Management Accounting and Management Control
Invited session
Chair: *Stephan Leitner*

1 - Heuristic Methods for Picking Items for Experimental Sets
Rachel Bunder, Natashia Boland, Andrew Heathcote
Psychologists are often required to create sets of items to be used in experiments. Such sets are used to test how factors affect some situation, e.g., to see how humans respond to short words compared to long words. These sets must 'match', i.e., be as similar as possible, on all other attributes that could affect response. Previously, we have explored definitions of similarity for experimental data sets and have developed a MIP to solve this problem, which struggles when solving larger problems. We explore a variety of heuristic methods, comparing the results to existing metaheuristics.

2 - The Impact of Visualizing Causal Relations on Dynamic Decision Making
Michael Leyer, Jürgen Strohhecker
According to natural decision models, good decisions are mainly dependent on understanding the consequences of chosen options. Thus, receiving information on causal relations between options and results should be helpful. Using a capacity management simulator, we conducted laboratory experiments with two levels of complexity in which participants had to make decisions repeatedly. Results are showing not only key performance indicators on the user interface but also visualizing causal relations between them leads to better decisions. The results are stronger in the more complex situation.

3 - Impact of Information Overload on Escalation of Commitment
Peter Rötzel
Escalation of commitment explains why decision-makers are tempted to reinvest further resources in a losing course of action. While previous studies focus on the quality of information, there is a lack of research on how different information quantities affect escalation of commitment. Our study shows how information overload influences escalation of commitment and how information overload interacts with the decision-maker's earlier decisions. Our results indicate that decision-makers who face information overload increase their reinvestment even when the decision consequences are positive.

■ FA-16

Friday, 8:30-10:00 - Room 127

Pattern Recognition

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Ivan Reyer*
Chair: *Vadim Strijov*

1 - On Fingerprint Image Compression Method based on NMF
Congying Han, Tiande Guo

A new method for fingerprint compression is proposed. A general model that can be used to describe many existing algorithms, such as PCA, SVD and NMF is given. Based on the model, a modified NMF algorithm is used to train and compress images of fingerprint. A large number of tests show the new algorithm is valid for fingerprint compression. In particular, the method has a good performance for fingerprint with small size.

2 - Short-Term Forecasting of Musical Compositions Using Chord Sequences
Mikhail Matrosov, Vadim Strijov

The objective is to predict a sequence of chords. It is treated as multivariate time series of discrete values. A chord is represented as an array of half-tone sounds within one octave. We utilize a classifier based on probability distributions over chord sequences that are estimated both on a big training set and some revealed part of the forecasted melody. It shows robust forecasting on a set of 50 000 midi files. The novelty is model selection algorithm and invariant representation of chords. The same technique can be used to predict or synthesize various types of discrete time series.

3 - Parametric Shape Descriptor based on a Scalable Boundary-Skeleton Model
Ivan Reyer, Ksenia Zhukova

A parametric shape descriptor containing the set of convex vertices of a polygonal figure approximating the raster image and estimations of significance for curvature features corresponding to the vertices is suggested. The significance estimations are calculated with use of a family of boundary-skeleton shape models generated by the polygonal figure. Applications of the shape descriptor to face profile segmentation and content based image retrieval are presented.

4 - Customer Loyalty in Internet Service Provider Companies
Ilayda Ulku, Mehmet Yahya Durak, Fadime Üney-Yüksektepe

Internet is a basic standart of life and there are numerous service providers to make people safe, they try to service best quality and performance. Due to competition, providers try to prevent losing customer. In this research, a questionnaire is applied to get and analyze customer information, behavior and loyalty status of the churn possibility. This study deals with existing data mining algorithms to introduce the important factors for the churn prediction.

■ FA-17

Friday, 8:30-10:00 - Room 005

Graph Searching Games

Stream: Graph Searching
Invited session
Chair: *Nancy Clarke*

1 - Ambush Cops and Robbers on Graphs with Small Girth
Nancy Clarke

In this variation of the game with two robbers, the cops win by moving onto the same vertex as one of the robbers after a finite number of moves. The robbers win by avoiding capture indefinitely or by both moving onto the same vertex as the cop. (Otherwise, the robbers are on distinct vertices.) We present results on graphs with small girth.

2 - Structures and Strategies in the Game of Cops and Robber
Kerry Ojakian

This work is in-progress. In the game of Cops and Robber a graph is called k-cop win if k cops are sufficient to catch the robber. I will discuss two research directions. First, is there a "nice graph-theoretic" characterization of the k-cop win graphs, one that goes beyond the existing characterization, to refer more explicitly to the structural properties of graphs? Second, if k cops play in an optimal fashion, their position should get strictly "better" with every round of play. I consider ways to make this intuition precise. In short, we want to understand the nature of k-cop win graphs.

3 - An Algorithmic Method for Constructing Forbidden Minors
Oznur Yasar Diner, Dariusz Dereniowski, Danny Dyer

The edge search problem is a combinatorial game played on graphs. Our main interest lies on the edge search number which is an invariant that is inherited by minors. This leads to the conclusion that the set of forbidden minors for k-searchable graphs are finite when k is fixed; however these minimal minors are not known except for just a few initial cases. In this talk we propose an algorithm that constructs the set of forbidden minors for diconnected k-searchable reduced series-parallel graphs and give the entire list for each k that is less than or equal to 4.

4 - A Variable Neighborhood Search for the k-Metric Dimension Problem
Mirjana Cangalovic, Jozef Kratica, Vera Kovacevic Vujcic

For a given connected graph G a set of vertices S is a k-resolving set if any pair of vertices of G is resolved by at least k elements of S. A k-resolving set of minimum cardinality is a k-metric basis and its cardinality is the k-metric dimension of G. The problem of finding the k-metric dimension of G is known to be NP-hard. For this problem we propose a Variable Neighborhood Search heuristic with a suitable chosen neighborhood structure and an efficient local search procedure. Experimental results are presented on two different ORLIB classes of graphs: crew scheduling and graph coloring.

■ FA-18

Friday, 8:30-10:00 - Room 112

Applications of Multiobjective Optimization I

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Ceren Tuncer Sakar*

1 - A Multi-Objective Mixed-Integer Mathematical Model for one Dimensional Cutting Problem
Duygu Demirci, Nergiz Kasimbeyli

In this work, a one-dimensional cutting and assortment problem is studied. The purpose of this paper is to develop a mathematical model without the use of cutting patterns as model parameters. We propose a new, multi-objective linear integer programming model in the form of simultaneous minimization of contradicting objectives related to the total trim loss cost and the total cost of using different lengths of stock rolls to be maintained as inventory, in order to fulfill a given set of cutting orders. We also consider to minimize the total amount of excess demand for cutting orders.

2 - Multiple Objective Energy and Environmental Policy Research
Şahan Yıldız, Murat Koksalan, Ebru Voyvoda

Energy policy decisions require considering multiple objectives as energy sector is closely related with economy, environmental quality and security of energy resources. We develop a multi objective decision support system for Turkey. We first characterize the efficient set using maximizing total consumption, minimizing greenhouse gas emission and minimizing imported energy cost objectives. We next investigate the effects of policy tools such as taxing, quotas, price subsidy to reach the policy maker's targets. We also investigate robust policies against external energy price shocks.

3 - An Interactive Approach to Multicriteria Multi-period Portfolio Optimization
Ceren Tuncer Sakar, Murat Koksalan

Portfolio optimization is the problem of allocating funds between investment instruments. We use stochastic programming with scenario trees to model a multi-period portfolio optimization problem with expected return, Conditional Value at Risk and liquidity criteria. Our interactive approach in this setting produces an increasingly concentrated set of solutions around the decision maker's choices in successive iterations. Rolling horizon trees are considered for decision makers whose preferences and financial conditions change over time. We experiment with stocks traded on Borsa Istanbul.

■ FA-19

Friday, 8:30-10:00 - Room 128

Bi-objective Optimization: Methods and Applications

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Vladimir Korotkov*

1 - A Lexicographic Optimization Approach to the Bi-Objective p-cent-dian Problem
Sune Lauth Gadegaard, Lars Relund Nielsen, Andreas Klose

The p-median and the p-center problem are two of the most widely studied facitlity location problems. The p-median problem seeks to place a set of p facilities in such a way the total distance from customers to facilities are minimized, thus focusing on efficiency. The p-center problem, however, minimizes the largest distance from a customer to a facility, whereby the focus is on equity. These two of objectives will be combined in a bi-objective model, and the entire set of non-dominated outcome vectors is computed using an algorithm based on lexicographic branch and bound.

2 - A Bi-Objective Location-Allocation Model for Intermodal Terminals
Martine Mostert, Sabine Limbourg

Intermodal transport is an efficient solution for reducing greenhouse gases of freight transport. Intermodal transport requires intermodal terminals where the transfer between modes can occur. The location of these terminals is a key factor for achieving economic and environmental competitiveness. We present a bi-objective model for the intermodal terminal location-allocation problem. The focus is on road and on intermodal rail and inland waterway transportation. Operational costs and CO2 emissions are minimized. Intermodal global performances are assessed for the Belgian case study.

3 - Surgical Team Rostering Problem Considering Break Windows
Christine Di Martinelly, Nadine Meskens

Considering the established surgical schedule, the objective of this research is to build surgical teams and their weekly timetable considering breaks. The surgical teams involve different categories of personnel, including surgeons, anesthesiologists and nurses. The mixed-integer programming model builds nurse rosters considering their availabilities and legal constraints. We are using a bi-criteria approach that maximizes the team affinities while minimizing the nurses' total waiting time. The model is solved using an e-constraint approach and is tested on instances of a Belgian hospital.

4 - Stability of Bi-objective Investment Problem with Extreme Optimism and Extreme Pessimism Criteria
Vladimir Korotkov, Vladimir Emelichev, Yury Nikulin

We investigate stability of the bi-objective Boolean investment problem with criteria of extreme optimism for the profit and extreme pessimism for the risk, i.e., the cases when a Pareto optimal portfolio is chosen either with the maximum profit in the best market situation or the minimum risk level in the worst case market situation. We obtain lower and upper bounds on the stability radius of the investment problem that is the supreme level of initial date perturbations for which the Pareto set in the perturbed model does not contain new efficient portfolios.

■ FA-20

Friday, 8:30-10:00 - Room 129

Energy Trading

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Nicola Secomandi*

1 - Price Determinants and their Impact on Day-Ahead and Intraday Market Prices: Explaining the Differences
Christian Pape, Simon Hagemann, Christoph Weber

The formation of spot electricity prices is influenced by a complex interaction between different determinants. Their identification is not straightforward and challenges researchers and decision makers in the same way. Compared to the literature about day-ahead prices, prices in intraday markets have not been extensively studied so far. Therefore, the determinants in the German electricity spot markets are analysed in this work. The target is to enhance market understanding of price determinants in electricity spot markets and to build up a basis for further intraday price modelling.

2 - Rethinking Risk Trading in an Electricity Market Context
Edward Anderson

Forward trading takes place at various time horizons in an electricity market context. These financial transactions are used to reduce risk for market participants. The forward contracts also turn out to be important in determining market power. We will review the frameworks that can be used to analyse this risk trading and show how a small number of traded instruments in a context with private information (different firms have different forecasts) lead to outcomes that differ from a conventional analysis.

3 - Analysis and Enhancement of Practice-based Policies for the Real Option Management of Commodity Storage Assets
Nicola Secomandi

Practitioners manage commodity storage assets using the rolling intrinsic (RI) and rolling basket of spread options (RSO) policies. This talk provides novel structural and numerical support for the use of the RI and RSO policies, and enhances them by developing a simple and effective dual upper bound to be used in conjunction with these policies. Moreover, this talk emphasizes the superiority of the RI policy over the RSO policy and proposes an improved variant of the RSO policy.

■ FA-21

Friday, 8:30-10:00 - Room 006

Cutting and Packing 5

Stream: Cutting and Packing
Invited session
Chair: *Andréa Vianna*

1 - Cutting Stock Problem with Rectangular and Irregular Pieces
Andréa Vianna, Adriana Cherri

In this work we present a study and resolution method for the cutting stock problems involving rectangular and L-shaped pieces. To solve this two-dimensional cutting stock-problem we modify and use the AND/OR Graph approach and a heuristic procedure. Our strategy consists in combine rectangular and L-shaped items in plates in order to minimize the waste. To verify the performance of the proposed strategy, computational tests were realized with examples randomly generated.

2 - A Partition-based Heuristic Algorithm for the Large-scale Rectilinear Block Packing Problem
Yannan Hu, Hideki Hashimoto, Shinji Imahori, Mutsunori Yagiura

The rectilinear block packing problem is a problem of packing a set of rectilinear blocks into a larger rectangular container, where a rectilinear block is a polygonal block whose interior angle is either 90 degrees or 270 degrees. This problem involves many industrial applications. In this paper, we propose a partition-based heuristic algorithm based on the bottom-left strategy. The computational results show that the proposed algorithm is especially effective for large-scale instances.

3 - Approaches to Enhance the Efficiency of Cutting Stock for Furniture Production
Socorro Rangel

A usual criterion to solve the cutting stock problem (CSP) is to minimize total waste. When the cutting stage becomes a bottleneck in a production process, it is important to also maximize the cutting machine productivity. A review is made of recent contributions to the CSP with both optimization criteria, taking into account that the cutting machine productivity can be improved if plates are stacked and cut simultaneously according to the same cutting pattern. Mathematical models and procedures to solve the problem are presented in the context of furniture production.

4 - Integrated Cutting and Production Planning in a Home Textile Manufacturing Company
Elsa Silva, José Fernando Oliveira, Maria Antónia Carravilla

In this paper we consider the problem of minimizing the waste of textile material, while taking into account the overall costs of the production process, in a Portuguese textile manufacturing company. Planning production comprises different decisions: the definition of the widths and lengths of the fabric rolls to be produced, the number of fabric rolls to use from stock or to purchase and the definition of the cutting patterns to apply to each width of the fabric roll, so that waste is minimised. We propose an ILP model, solved by a column generation method, to tackle the problem.

■ FA-22

Friday, 8:30-10:00 - Room 007

Game Theory and Customer Behavior in Service Systems

Stream: Game Theory and Service Management
Invited session
Chair: *Pengfei Guo*

1 - Service Systems with Boundedly Rational Customers
Tingliang Huang, Ying-Ju Chen

We study service systems where customers lack full capability or ample opportunity to perfectly infer the service quality or waiting time, and thus can only rely on past experiences and anecdotal reasoning to make their joining decisions.

2 - Why Queues are often too Long or Too Short? Strategic Behavior of Loss Averse Customers in a Queueing System
Liu Yang, Pengfei Guo, Yulan Wang

We consider a queueing system where customers are loss averse wrt. a reference point determined by their recent expectations. Customers are reference dependent in both service price and waiting time. We first study customers' queue joining strategies and found that in the equilibrium, the queue length is polarized compare to the case without reference effect. In particular, when the traditional predicted queue-length is long, the actual queue length with reference effect is longer, and vice versa. We then study a server's pricing decision in both monopoly and duopoly markets.

3 - Equilibrium Queueing Strategies When Service Quality is Unknown to Some Customers
Pengfei Guo, Moshe Haviv, Yulan Wang

We study customers' queueing strategy in a one-server system given that service quality is unknown to some customers. We consider both unobservable and observable queues and assume that customers are homogeneous on both service reward and delay sensitivity. We find that the effective arrival rate for servers can at times be decreasing with the potential arrival rate. Interestingly, under certain conditions a low-quality server has a higher incentive to reveal its queue length than a high-quality server does.

4 - Seeking Stable Flows in a Multi-Agent Network with Controllable Capacities
Cyril Briand, Nadia Chaabane, Marie-José Huguet

A multi-agent transportation problem is considered where a set of selfish agents is able to control the capacities of a set of arcs inside a transportation network, incurring a cost proportional to the chosen capacities. A customer agent is willing to maximize the product flow transshipped from a source to a sink node through the network. She offers a reward proportional to the flow the other agents manage to provide. This reward is shared among the agents according to a sharing policy. The focus is put on finding stable strategies (i.e., Nash equilibria) and optimal sharing policies.

■ FA-23

Friday, 8:30-10:00 - Room 008

Metaheuristics for Vehicle Routing

Stream: Metaheuristics
Contributed session
Chair: *Luis Moreno*

1 - The k-dissimilar Vehicle Routing Problem
Luca Talarico, Kenneth Sörensen, Johan Springael

In this work we define a new problem, the aim of which is to find a set of k dissimilar alternative solutions for a vehicle routing problem on a single instance. This problem has several practical applications in the cash-in-transit sector and in the transportation of hazardous materials. A min-max mathematical formulation is developed that minimizes the objective function value of the worst solution. An iterative metaheuristic to generate k dissimilar alternative solutions is also presented and tested using large and medium size benchmark instances for the capacitated vehicle routing problem.

2 - A Tabu Search Heuristic for the Vehicle Routing Problem with Time Deadlines and Asymmetric Distances
Pelin Ekmen, Necati Aras, Deniz Aksen

A metaheuristic method based on Tabu Search algorithm for The Vehicle Routing Problem with Time Deadlines and Asymmetric Distances is proposed to determine near-optimal tours by formulating a mixed integer linear model. The algorithm is tested on randomly generated asymmetric instances derived from the Solomon benchmark problem instances. Two mathematical models are constructed to solve this problem. They are solved by CPLEX 12.5 solver within GAMS suite 24.0 and compared with the results obtained by the Tabu Search heuristic.

3 - An Algorithm for the Traveling Salesman Problem (TSP) using a Heuristic Selection of the Set of Solutions Based on a Relevance Matrix
Luis Moreno, Javier Diaz, Juan Esteban Calle Salazar

Based on the known priority rule for the TSP that searches the closest not visited neighbor for each location (myopic strategy), a deterministic algorithm is proposed that goes over the whole solution space (permutations) in order to look not only for the solution proposed by the mentioned priority rule, but a set of them, ordered from the best to the worst candidate solutions according to a function defined by a relevance matrix. The algorithm is adjusted to search for only a predefined a priori number of solutions and then a 2-opt process is applied to each of the selected solutions.

■ FA-24

Friday, 8:30-10:00 - Room 212

Dynamic Stochastic Programming and Option Pricing

Stream: Actuarial Sciences and Stochastic Calculus
Invited session
Chair: *Daniel Sevcovic*

1 - Value of a Firm with Suspension and Exit Options
Manuel Guerra, Cláudia Nunes, Carlos Oliveira

We consider the problem of the optimal strategy for a company that adapts to random fluctuations in demand by suspending/restarting its activity, having also the possibility of irreversible cessation. Activity and temporary suspension incur specific running costs, while change in status have specific spot costs. We discuss the structure of the optimal strategy and present some examples.

2 - Extensions of the Barles and Soner Model for Derivatives Pricing with Transaction Costs
Pedro Pólvora

The pricing of derivatives with transaction costs is one of the most important extensions of the traditional Black-Scholes model. The Barles and Soner model is a model to price those derivatives, initially it was developed for an European Call option and using an exponential utility function. In this paper we shall explore extensions of this model.

3 - A Method of Solving Hamilton-Jacobi-Bellman Equation with Constraints via Riccati Transformation
Daniel Sevcovic, Sona Kilianova

We propose and analyze a method based on the Riccati transformation for solving Hamilton-Jacobi-Bellman (HJB) equation, arising from a problem of optimal portfolio construction. We show how the fully nonlinear HJB equation can be transformed into a quasi-linear parabolic equation for which we prove existence, uniqueness and derive useful bounds of classical Holder smooth solutions. We furthermore construct a fully implicit iterative numerical scheme based on finite volume approximation of the governing equation. We compute optimal strategies for a portfolio investment problem.

4 - Modelling Returns Distribution by Adapting the Geometric Brownian Motion: An Empirical Study for Capturing Irrational Behaviour in Finance
Muhammad Bilal Shakeel, Gurjeet Dhesi

An innovative extension of Geometric Brownian Motion model is developed by incorporating extra weighted information factors represented by mixture of power and trigonometric functions. Simulations based on these modified models, with optimal weighting factors selected by goodness of fit tests, outperform the basic Geometric Brownian motion model in terms of fitting the returns distribution of historic data price indices. Furthermore we attempt to provide a schematic interpretation of the weighted information factors in relation to irrational behaviour in Finance.

■ FA-25

Friday, 8:30-10:00 - Room 009

Various Applications of Heuristics

Stream: Applications of Heuristics
Invited session
Chair: *Geir Hasle*

1 - Location and Relocation Models for Wildland Fire Planning
Amelia C. Regan, Joseph Chow

In our earlier work, a location and relocation model were proposed for air tanker initial attack basing in California for regional wildland fires that require multiple air tankers that may be co-located at the same air base. Based on input from US Forest Service researchers, this work presents several modeling and algorithmic extensions of that k-server p-median location model.

2 - Knapsack-Based Window Frame Cutting Plan Algorithm
Byung-In Kim, Youngmin Ki

A real-life window frame cutting problem, in which four types of bars (U, B, L, R) for each order should be cut from raw bars, is solved. The four types need to be assigned to the same raw bar if possible; otherwise, they should be assigned to nearby bars. Furthermore, it is not desirable to cut the same bar type continuously (e.g., B-B-B) from a raw bar. We develop a knapsack based heuristic for the problem to minimize the trim loss as well as the same bar type sequence, and raw material bar spreading degree. The proposed approach performs well and it is being used in a real-life company.

3 - An Adaptive Iterated Local Search for the Mixed Capacitated General Routing Problem
Geir Hasle, Mauro Dell'Amico, José Carlos Díaz Díaz, Manuel Iori

We study the Mixed Capacitated General Routing Problem (MCGRP) in which a fleet of capacitated vehicles has to serve a set of requests by traversing a mixed weighted graph. The requests may be located on nodes, edges, and arcs. We propose a new Iterated Local Search metaheuristic for the problem. Computational experiments show that the proposed metaheuristic is highly effective on five published benchmarks for the MCGRP. The metaheuristic yields excellent results also on seven standard CARP datasets, and good results on four well-known CVRP benchmarks.

4 - An Optimization Based Method for Designing Road Networks that are Robust Against Incidents
Maaike Snelder, Ben Immers, Henk van Zuylen, Bart van Arem

In many road networks all over the world unexpectedly large delays occur as a result of unforeseen disturbances like incidents. Robustness measures like adding spare capacity and buffers can be taken to reduce these delays. In this paper a robust network design method is proposed that considers these measures. The method combines optimization and evaluation models. An application to a test network shows the quality of the method. An application to the road network of Amsterdam shows that large improvements in the network performance can be realised with a positive benefit-cost balance.

■ FA-26

Friday, 8:30-10:00 - Room 010

Equilibrium and Variational Inequalities (contributed)

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Anulekha Dhara*

1 - A Projection Method for the Constrained Equilibrium Problem
Susana Scheimberg, Paulo Sergio Marques Santos

We consider the Constrained Equilibrium Problem, CEP, which consists in finding a point x* in the intersection of two nonempty, closed and convex subsets of a Hilbert space, C and D, such that x* is a solution of an equilibrium problem on C. It generalizes the Constrained Variational Inequality Problem considered by Censor, Gibali and Reich (Optimization, 2012). In this work, an algorithm based on a modified Mann scheme, using projections onto each set is proposed to solve the CEP. Convergence properties of the algorithm are established under few assumptions. Numerical results are reported.

2 - On Vector Equilibrium Problems Given by a Sum of Two Functions
Livia-Mihaela Miholca, Gabor Kassay

In 1994, Blum and Oettli obtained existence results for (EP) in the case where the function involved is a sum of two functions, and the assumptions are required separately on each of these functions. Later, Kazmi (2000) extended some of the results of Blum and Oettli for vector equilibrium problems. It turns out that many of the assumptions imposed by Kazmi are too strong. The aim of this note is to relax several of these assumption without loosing the results. The special case of reflexive Banach spaces is also studied, where we make use of the fact that closed balls are weakly compact.

3 - On Gap Function for Variational Relation Problem
Anulekha Dhara

Recently in 2008, Luc introduced a class of problems, namely variational relation problems. A lot of work has been done towards the study of solution for this class of problems using fixed point approach. In this work, a gap function is constructed to study the existence of solution for the class of variational relation problems. In gap function approach, an optimization problem is constructed wherein the solution of the optimization problem leads to the solution to the original variational relation problem. The properties of gap function are also looked into.

■ FA-27

Friday, 8:30-10:00 - Room 213

Infrastructure Development and Environment 1

Stream: Infrastructure Development and Environment
Invited session
Chair: *Subhash Datta*
Chair: *Laura Lotero*

1 - Multi Criteria Multi Facility Location in Rajasthan
Subhash Datta

A problem-structuring method with MCDA was used to select different facilities based on the needs of the rural area under consideration. A facility location model was created and algorithms developed to provide a solution for locating facilities in 45 villages of Niwai block, Tonk district, Rajasthan. 16 facilities were chosen for consideration, each falling into 1 of 5 groups: healthcare, education, connectivity, agriculture and drinking water. Alternative scenarios for locating facilities were generated and explored, providing a base for micro-level planning at the block level in a district.

2 - Porous Network Characterization in Granular Assemblies: A Graph Theory Approach
Diego Recalde

The micro-scale porous network of numerically generated granular assemblies is characterized by using a novel and promising computational approach that exploits the capabilities of graph theory and computational geometry. The solution to a wide variety of problems ranging from CO2 sequestration to landslides mitigation, highly depends on the understanding of the nature of the flow through the porous media. The methodology approximates edaphic qualities of agricultural soils, specifically drainage capacity, as it is affected by fly ash coming from the eruption of a nearby volcano.

3 - Analysis of the Robustness and Vulnerability of the Urban Public Transportation in Medellin
Laura Lotero, Patricia Jaramillo, Rafael Hurtado

Transportation networks are critical infrastructure systems for human beings, therefore the analysis of vulnerability or robustness of these networks is a major issue, especially in engineering. In this presentation we take into account the fluxes and the topology of the transportation network in order to analyze the robustness and vulnerability of the major urban public transportation system of Medellin, Colombia.

4 - Usability of the Structured MCDM Methodology in Supporting Problem Structuring and Improving Participation in Tanzania Rural Communities
Joe Kakeneno, Cathal Brugha

We present the results of an empirical study on how the Structured MCDM methodology could support problem structuring and improve rural community participation in Africa. A model which is based on a generic structure is flexible and transferable to similar problem contexts and various situations; and it can easily support distributed participatory decision-making or be integrated in a Participatory Decision Support System. We question the current view of problem structuring. The study adds to the emerging research and debate on participatory process design, implementation and evaluation.

■ FA-28

Friday, 8:30-10:00 - Room 130

MINLP in the Oil and Gas Industry

Stream: Mixed-Integer Nonlinear Programming
Invited session
Chair: *Andrew Conn*
Chair: *Eduardo Camponogara*

1 - Modeling of Flow Splitting for Production Optimization in Offshore Oil Fields
Eduardo Camponogara, Thiago Silva, Alex Furtado Teixeira, Snjezana Sunjerga

Unlike in satellite oil wells, the wells that produce to subsea manifolds are equipped with routing valves that can direct the production to multiple headers. However, the existing models for production optimization do not account for splitting of flows and require the wells to be connected to a single header. To this end, this work develops a nonlinear model of flow splitting which is approximated with piecewise-linear functions, resulting in an MILP program which is solved with optimization software available off-the-shelf. The accuracy of the splitting model is demonstrated by simulation.

2 - Biobjective Optimization for General Oil Field Development Problems
Louis J. Durlofsky, Obiajulu Isebor

An approach for biobjective optimization of oil field problems is presented. The MINLP problem includes categorical (well type), discrete (location) and continuous (pressure) variables. A single-objective product formulation, which systematically combines the two objectives in a sequence of problems, is applied for the biobjective problem. The core optimizer includes stochastic search (PSO) and local convergence (MADS) characteristics. Results will be presented for maximization of both long and short-term reservoir performance and optimization of field development under geological uncertainty.

3 - Model-Based Production Optimization Applied to a Gas Offshore Field
Thiago Silva, Alex Furtado Teixeira, Snjezana Sunjerga, Eduardo Camponogara

The search for improvements in the production efficiency and operational cost is one of the main challenges for the production engineers. The use of a decision support system based on mathematical optimization can help them to maximize the production, while at the same time satisfying constraints imposed by the wells, subsea manifolds, pipelines and the platform process plant. This talk will present the development of a decision support system based on mathematical optimization designed to support the engineers responsible for an offshore gas field in the production optimization process.

■ FA-29

Friday, 8:30-10:00 - Room 011

Societal Complexity and Economy

Stream: Methodology of Societal Complexity
Invited session
Chair: *Dorien DeTombe*

1 - A Proposition of Thetical and Antithetical Business Management
Eizo Kinoshita

The author discusses the theme of "Thetical and Antithetical Business Management." The thetical business management signifies "a management style which enables such formulation as to make consumers' minimum amount of service goods expenditure an objective function, while making a minimum guaranteed level of expenditure concerning service goods a constraint condition at the same time." On the other hand, the antithetical business management is "a management style which enables such formulation as to make consumers' maximum satisfaction concerning service goods an objective function.

2 - Informatization of the money will impact the social system and existing money value
Shunei Norikumo

This study is to clarify social impact. That rapid informatization of money influences exiting money value along with the development of information technology. On the surface, we can explain that electronic money revitalize our economic activity, However the money we pay when we buy a bread and the money we pay to buy some items on online games are different, This study is to define the difference between them and how this influences in Our society.

3 - Reporting and Misreporting Behavior — A Review of Experimental Studies in Decision Theory
Ulrike Leopold-Wildburger

This paper focuses on reporting behavior under information asymmetry within a company. Manipulation and misreporting of information are some of the central topics in operations research literature. We investigate our research from the experimental perspective of management accounting and from behavioral research. Experimental studies are classified in a broad literature review, and the major findings are discussed in the context of honesty in decision making. The complexity indicates strong integration between economical and non-economical (psychological and social) theories.

4 - The Emancipatory Systems Methodology for Addressing Coercive Organizational Problems
Slavica P. Petrovic

Creatively dealing the with coercive management problem contexts, in which power sources can be identified, implies the emancipatory paradigm and employment of corresponding systems methodology. Pursuant to its philosophical foundations and methodological development, Critical Systems Heuristics (CSH) enables to reveal the normative content of organizational systems designs. Through use of critically heuristic categories and dialectical debate between those involved and those affected by the designs, CSH seeks to - in application - support the process of improving position of all stakeholders.

■ FA-31

Friday, 8:30-10:00 - Room 013

Networks and Queueing Systems

Stream: Telecommunications and Networks
Contributed session
Chair: *Jorge Sá Esteves*

1 - Performance Evaluation of a Computer Network
Salima Kendi, Salima Touati, Louiza Bouallouche-Medjkoune, Djamil Aïssani

The purpose of this work is the performance evaluation of a specific computer network (study of a practical case). For this, we have modeled the system by a Markovian queueing network (Jackson network). The performances are obtained analytically and by simulation. Based on the obtained results, we propose a resizing of the main router and the main server (increasing of their transmission capacity).

2 - Multi-Class M/G/1 Queue with Exponentially Distributed Impatient Times
Yutaka Sakuma

We study a stationary multi-class single-server queue with impatient customers. Customers in each class arrive according to an independent Poisson process. Service times of customers are i.i.d. to a general distribution which may depend on customer's class. Arriving customer has a waiting time limit until his/her service begins, where the waiting time limit has a class-dependent exponential distribution. For this queueing model, we obtain the waiting time and queue length distributions, and give a computational algorithm to compute the probability mass function of the queue length.

3 - Diffusion Approximations and Optimality of Scheduling Algorithms for Processor-Sharing Queues in Random Fading MIMO Channels
Wanyang Dai

We study the diffusion approximations and asymptotic optimality of scheduling algorithms for generalized processor-sharing queues in a random environment. Such a queueing system typically appears in multi-input multi-output (MIMO) wireless channels under random fading with cooperation and admission control. Two service rate scheduling algorithms designed by the immediate queue length and the current channel state information (CSI) are considered. How to use the optimality of the first algorithm to prove the counterpart of the second one under certain constraint of RTR is presented.

4 - Server Allocation using an Analytic Generalization of Erlang's Functions
Jorge Sá Esteves

An analytic function which is a hybrid of Erlang B and C functions is proposed. A fluid model describing the steady state of a generalized multiserver queueing system is introduced. A bicriterion optimization problem related to the server allocation between generalized Erlang queueing systems is formulated. This model is useful in telecommunications networks design. Two objectives are considered: the overall efficiency and a measure of equity among users. An algorithm for traveling on the set of Pareto optimal solutions is proposed. Some computational results are presented.

■ FA-32
Friday, 8:30-10:00 - Room 014

Supply Chain Management

Stream: Production Management & Supply Chain Management
Contributed session
Chair: *Elodie Adida*

1 - Does the Company Size Affect the Purpose of Patent Application? Case of the Korean Electronics Industry
Seongtaek Park, Solyi Kim, Tae-Sung Kim

This article focuses on the patent application case study. Currently, companies are aware of the need for the importance of the patent and patent management. This research was started to get related appropriate data for the purpose of a patent application. So, it draws 5 influencing factors by using the Delphi method and analyzing the previous studies. Then, the priorities were drawn out using the Delphi method in the form of rankings for professionals in companies. As a result of this analysis on the purpose of a patent application, there is a difference between businesses.

2 - Capturing Dynamics and Integration in Supply Chain
Jian Cui

Capturing dynamics and integration in supply chain is a major challenge for companies to maintain the competitiveness in today's global market environment. An innovative two-stage stochastic mixed integer programming formulation in rolling horizon settings is employed to capture the uncertainties and updates of the system, together with developed models integrating production and sale, transportation networks with revenue management. The simulation results indicate the significant reduction on the bullwhip effect on deterministic scenario and further reduction on stochastic scenario.

3 - Evaluating the Supply Chain Cost of Strategic Product Platform Decisions
Maud Van den Broeke, Robert Boute, Behzad Samii

Our research provides a model to evaluate strategic product platform decisions, such as how many and which platforms to develop and which products to derive from which platforms. We consider the costs originating from various supply chain activities: development, ordering, purchasing, inventory holding and customisation costs. The value of our integrated cost model is demonstrated in a real business case at a global electronics manufacturer.

4 - Competition and Coordination in a Two-Channel Supply Chain
Elodie Adida, Amy David

We study competition and coordination in a supply chain in which a supplier both operates a direct channel and sells its product through multiple competing retailers. We study analytically the supply chain with symmetric retailers and find that the supplier generally prefers to have as many retailers as possible in the market. We find that the two-channel supply chain may be subject to inefficiencies not present in the single channel chain and study coordination. We propose a linear quantity discount contract and demonstrate its ability to perfectly coordinate the asymmetric supply chain.

■ FA-34
Friday, 8:30-10:00 - Room 016

Managing Knowledge

Stream: Knowledge in Organizations
Invited session
Chair: *A. D. Amar*

1 - Data Science: Best Practice & Governance
Sayara Beg

Data Science: Best Practice and Governance in Analytics — will describe how the Analytics, and the recent Big data revolution, has given rise to the new role of the 'Data Scientist'. It will explore core elements such as expertise, knowledge of tools and interpersonal skills that are expected from a Data Scientist today, and how those core elements have evolved over time. It will conclude with why the need for best practice, ethic and governance has now become immediately urgent and how this urgency can be addressed.

2 - What's Wrong with Big Data?
Victor Tang

Conventional wisdom says that size, complexity, and technologies are at the core of Big Data. We argue that there is something much more fundamental and profound than these obvious symptoms. Were it not so, we would call astronomy "Big Stars", physics "Big Atoms", and medicine "Big Cells". This paper will explain why we don't. We frame and discuss our GigaNano Hypothesis to argue, illustrate, and help us develop a deeper understanding of Big Data and its implications. Our discussion will be grounded on precise and unambiguous definitions and inter-disciplinary first principles.

3 - OR and Quality of Healthcare: An Application of DEA to the South African private hospital industry
Kathryn Dreyer, Shivani Ramjee

We analyse the selection and inclusion of quality-of-care measures in a risk-adjusted DEA model, which is used to evaluate the efficiency of South African hospitals. One of the biggest challenges faced is addressing the multidimensional nature of quality and ensuring that the quality measure included is representative of operational reality. Results reveal that omitting quality can bias individual efficiency scores. Three different quality measures were examined. The choice of measure impacts efficiency scores, emphasising the need for a comprehensive quality measure.

4 - Managerial Perceptions in Knowledge Management Implementation: Results from a Case Study and a Survey
A. D. Amar, Souad Mohamed, Elayne Coakes, Andrew Leslie

Employing case study of an insurance company and a knowledge management (KM) survey of over 1000 respondents, we study managers' perceptions of KM prior to its implementation. Using content analysis to organize contextual data, we determine perceptions of benefits of KM, barriers to its implementation, and the requirements for its practice; and find that managers strongly align KM with communication. Organizational structure is not an issue. We narrate managerial misconceptions contrasting knowledge and communication, and indicate how organizations can have the knowledge shared effectively.

■ FA-35

Friday, 8:30-10:00 - Room 131

Advances in Forecasting and Stochastic Programming Applications

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Jonas Christoffer Villumsen*

1 - Forecasting Container Throughput at Tanjung Priok Port, Indonesia, using Univariate Forecasting Models
Gu Pang

We forecast the container throughput at the Indonesia's largest seaport Tanjung Priok Port. We carry out the analysis by applying univariate forecasting models. We test monthly data (2003-2013) and compare the forecasts based on mean absolute error, mean absolute percentage error and root mean squared error. Our aim is to find a model provides the most accurate forecasts of Tanjung Priok Port's container throughput, and specifically of each of the four terminals. Moreover, our results provide essential insights into the port's capacity planning and construction of new container terminals.

2 - Investment in Reconfigurable Electricity Networks under Uncertainty
Jonas Christoffer Villumsen, Jakub Marecek, Mathieu Sinn, Martin Mevissen

We study investment into switching equipment and line capacity of electricity networks, which employ dynamic reconfiguration of the network topology. We consider two models: Maximisation of reliability indices under uncertainty about line failures and minimisation of capital and operational cost under uncertain load and injection from renewables. Both models result in two-stage stochastic programs with discrete decisions at both stages. We demonstrate a novel framework for hedging against uncertainty on both models.

3 - Recent Advances in Simulation Optimization Using Direct Gradients
Michael Fu

We overview several recently proposed new methods for employing direct gradient methods such as perturbation analysis and the likelihood ratio methods into existing simulation optimization approaches such as response surface methodology, stochastic kriging, and stochastic approximation. The first two settings combine performance estimates with the direct gradient estimates to obtain better functional fits. The last setting can be viewed as a way to combine the traditional Kiefer-Wolfowitz and Robbins-Munro algorithms; for higher dimensions the method of simultaneous perturbations is employed.

4 - Forecasting the Demand of Technical Resources based on Project Pipeline Data
Ta-Hsin Li

In large enterprises, projects are often managed through a pipeline system in which work items are planned and scheduled for start in the future. The planned work in the pipeline serves as a forecast of demand on different technical skills, based on which technicians with the right skills are recruited. We propose an analytical model for the statistical behavior of scheduled start date to produce a better forecast of planned work. We also propose an analytical framework for incorporating unplanned work (future work which is not captured by the present pipeline) into the forecast.

■ FA-36

Friday, 8:30-10:00 - Room 132

Applications in Agriculture

Stream: OR in Agriculture, Forestry and Fisheries
Contributed session
Chair: *Concepcion Maroto*

1 - Impact of the Spatial Arrangement of Agricultural Land Uses on Ecosystem Services at the Landscape Scale.
Justice Nana Inkoom, Susanne Franke, Christine Fürst

The relationship between agricultural land uses and its impact on ecosystem services including nutrient cycling is complex. Research on the use of size, shape, and spatial interactivity to assess the impact of agriculture land uses on the landscape's capacity to provide ecosystem services remains scanty. To formulate a methodology that corresponds to this complexity, landscape metrics and mean enrichment factor approaches are explored as neighbourhood interactive assessment tools to evaluate the mutually interactive impact of agriculture land uses on ecosystems functioning using GISCAME.

2 - Land Use Optimization to Meet Environmental and Economical Demands
Tijana Vulevic, Nada Dragovic, Mirjana Todosijevic

Rational and efficient use of land in mountain region is possible through land allocation to the different land uses (e.g., orchards, pastures, crops). The aim of this paper is to find optimal land use pattern for land in the Tresnjica Watershed in Western Serbia satisfying economical and environmental demands. Required balance between two objectives: profit maximization and soil erosion minimization is achieved using linear programming method. To establish constraints functions, land use suitability evaluation was determinate using information such as aspect, slope and elevation.

3 - Branch-and-Price-and-Cut for Sustainable Crop Rotation Planning
Laurent Alfandari, Agnès Plateau, Xavier Schepler

We study a multi-periodic crop planning problem in agriculture. Crop cultivation and fallow periods are scheduled on land plots so as to minimize the total surface area of land used, while satisfying crop demands every period. We prove NP-hardness, and propose a 0-1 Linear Programming compact formulation based on crop-sequence graphs. An extended formulation is then provided. A Branch-and-Price-and-Cut algorithm is presented with adapted branching rules and cutting planes. Numerical experiments on instances varying the number of crops, periods and plots show the efficiency of the approach.

FA-37

Friday, 8:30-10:00 - Room 017

Importance of Information In Inventory Management

Stream: Recovery Inventory Management Policies
Invited session
Chair: *Ozgen Karaer*

1 - Enabling Horizontal Collaboration in Agricultural Supply Chains under Incomplete Information

Andrew Mason, Rene Villalobos, Hector Flores

Recent tendencies on agricultural supply chains have forced small producers to form partnerships in order to compete with larger operations. Unfortunately, such collaboration requires a significant degree of horizontal coordination, which is hard to attain when there is asymmetric information and competitive behavior within the organization. In order to coordinate production and make the supply chain more efficient, an auction based mechanism for horizontal coordination is proposed such that the aggregate actions of farmers are aligned with demand, and overall profits are maximized.

2 - Information Sharing in Competing Supply Chains with Cost Reduction Efforts

Albert Ha

We investigate the incentive for vertical information sharing in two competing supply chains where the manufacturers can take efforts to reduce production costs. The retailers have private demand information and engage in either Cournot or Bertrand competition. We characterize the equilibrium information sharing decisions and conduct sensitivity analysis to investigate the impact of several parameters.

3 - Understanding the Risks and Benefits of Radio Frequency Identification (RFID) for an Apparel Retailer

Ozgen Karaer

One of the main promises of Radio Frequency Identification Technology (RFID) is reduction in inventory record inaccuracy at retail stores, which in turn will diminish stockouts and result in a more responsive inventory management system. Though reduction of stockouts is widely accepted, the sales increase that could be observed, especially in the long run is not that clear. In this work, we investigate the sales impact of RFID for a retailer that sells seasonal merchandise, such as apparel retailers. We also analyze the risks associated with imperfect RFID performance.

4 - Information Technology Role in Sustainable Supply Chains

Zeynep Ata

Sustainable SCs are essential to delivering long-term profitability and are a crucial environmental and social responsibility for organizations. Members of a SC are linked by information, material and capital flows. Information is referred to as the glue that allows SC drivers to work together with the goal of creating an integrated, coordinated SC. The aim of this study is to draw from previous studies that explore the areas of SCM, sustainability and IT, and then to contribute to literature by examining the role and importance of IT strategy on achieving and improving sustainability in SCs.

FA-38

Friday, 8:30-10:00 - Room 214

Counterparty Risk and Decision Support Systems

Stream: Operational Research and Quantitative Models in Banking
Invited session
Chair: *Caslav Bozic*
Chair:

1 - Parametric and Nonparametric Modeling of LGD for Third-Party Buyers

Abdolreza Nazemi, Markus Hoechstoetter, Caslav Bozic

In contrast to recovery rate modeling of bonds, research on personal loans and retail credit is sparse which is of extreme interest, however, for third-party buyers. This study is based on data from a leading German debt collector with over three million defaulted consumer credits from two different industries. This paper analyzes statistical and data mining methods such as GLM, neural network, K-nearest neighbor, CHAID, CART, and Support Vector Machine.

2 - Stochastic Technical Analysis for Decision Making on the Financial Market

Mher Safarian, Markus Hoechstoetter

The determination of change-points in regimes poses still one of the greater problems in finance. While there exists an analytical solution when the change-point distribution is known a-priori, the realistic situation, i.e., no such a-priori information is known, cannot be solved for analytically. For this reason, we analyze distribution-free methods of 'immediate' detection of change-points. We find that there are non-parametric versions of some popular parametric methods.

3 - Regression Models for Censored and Ordered Dependent Variables Applied to Recovery Rates in Consumer Credit

Johannes Kriebel, Werner Stahel, Markus Hoechstoetter

This work discusses the modeling of recovery rates in the subfield of consumer debt from a third-party buyer perspective. It is based on a study conducted in the year 2013. Three linear models and two machine learning models were applied. Suggestions for model improvements were presented using residual analysis and using the Random Forest. The models were evaluated using cross-validation and new data sets. Errors were larger overall when predicting the outcome of new data. The predictive quality on whole portfolios of observations was decent and improved slightly using the tools suggested.

FA-39

Friday, 8:30-10:00 - Room 018

Discrete Optimization II

Stream: Discrete and Global Optimization
Contributed session
Chair: *Frank Gurski*

1 - Online Parallel Machine Scheduling with Equal Processing Times and Eligibility Constraints

Zhaohui Liu

We consider the online parallel machine scheduling problem with eligibility constraints. The jobs have equal processing times and arrive over time. The objective is to minimize the makespan. We study the cases of nested, GoS and tree-like eligibility constraints, and develop optimal online algorithms for them.

2 - Algorithms for the FIFO Stack-up Problem

Frank Gurski, Jochen Rethmann, Egon Wanke

Palletizers are widely used in delivery industry. We consider a large palletizer where each stacker crane grabs a bin from one of k conveyors and positions it onto one of p pallets. Each pallet is destined for one customer. A completely stacked pallet will be removed automatically and a new empty pallet is placed at the palletizer. The FIFO stack-up problem is NP-hard in general. We introduce a digraph model and linear programming models for the problem. Based on this characterizations we give fpt-algorithms and xp-algorithms for various parameters, and approximation results for the problem.

3 - Maximum Generalized Assignment with Convex Costs

Stephan Westphal, Marco Bender

We consider a generalization of the maximum generalized assignment problem. We relax the hard constraints for the bin capacities, and introduce for every bin a cost function that is convex in the total load on this bin. These costs are subtracted from the profits of assigned items, and the task is to find an assignment maximizing the resulting net profit. We show that even restricted cases of this problem remain strongly NP-complete, and identify two cases that can be solved in strongly polynomial time. Furthermore, we present a (11/e)-approximation algorithm for the general case.

4 - On Generalised Blossom Inequalities for the Matchoid Polytope
Konstantinos Kaparis, Adam Letchford, Yiannis Mourtos

We generalise Edmond's blossom inequalities for the b-matching polytope, to the so-called matchoid polytope and prove that any non-dominated 0 1/2 cut with 0 or 1 coefficients, is a generalised blossom inequality (GBI). We establish that GBI separation is NP-hard in the general case and we outline conditions under which GBIs define facets. Finally, we present a heuristic separation scheme for GBIs and a computational study that illustrates the strength of the proposed cutting planes.

■ FA-40

Friday, 8:30-10:00 - Room 019

Quantitative Models for Performance and Dependability I

Stream: Quantitative Models for Performance and Dependability
Invited session
Chair: *Vassilis Kostoglou*

1 - Individual Choice and Payoff in Passenger Train Congestion: An Experiment
Clint Pennings, Paul Bouman, Jan van Dalen

To understand congestion in passenger trains, the heterogeneity of the population is vital: individual characteristics and payoffs lead to different observed behavior. We conducted an experiment which is based on an extension of the El Farol Bar Game, a popular minority game. Our extension introduces multiple train services and individuals can optimize a criterion of their own choice. Using psychological traits of the respondents, we construct various dynamic models to explain user behavior and assess the impact of additional information and their previous experience on their choice behavior.

2 - Information Visualization and Cost-benefit Analysis as Decision Support Tools in the CHANGES Spatial Decision Support System
Irina Cristal, Julian Berlin, Wim Bakker, Cees van Westen, Stefan Greiving

This research contributes to the development of the CHANGES Spatial Decision Support System, a web-based system aiming for natural risk assessment and evaluation of optimal risk reduction alternatives. The main concern of the study is to exploit the cost-benefit analysis in the context of geo-visualization. Moreover, the large amount of risk-related data is analyzed in accordance to its representational goal. Particular attention is paid to the comparison methods as being the key visual instruments in facilitating the decision making process.

3 - Personalized User Information on a Decision Support System Supporting the Choice of Higher Education Specialty
Vassilis Kostoglou, Nikolaos Ploskas, Michael Vassilakopoulos

The vocational orientation of lyceum graduates and students is one of their main priorities. A web based Decision Support System (DSS) has been implemented, supporting youngsters in the choice of their higher education profession and informs them about their department's vocational prospects. This paper presents additionally the personalized user information that such a system should provide. The DSS guides the user through wizards and successive questions to enter his personal information and then builds a user profile in order to present suggestions depending on the information provided.

4 - A Case Study of Compromising Prioritization Method to Identify Key R&D Quality Criteria
Deok-Hwan Kim

This study aims to identify key R&D quality criteria (i.e., elements or activities in R&D which affect the quality of the results critically) using the prioritization method proposed by Kim et al. (EJOR, 2010). The prioritization method determines a priority sequence of alternatives based on paired comparisons to compromise type I and type II errors so that may provide a relatively robust priority against the uncertainty in input information. In this study, the alternatives for R&D quality criteria are prioritized based on a survey on eighteen experts on R&D quality.

■ FA-41

Friday, 8:30-10:00 - Room 216

Auction Theory and Practice

Stream: Auctions
Contributed session
Chair: *Brian Baisa*
Chair: *Martin Bichler*

1 - Bundling Strategies in Online Auctions
Yingqian Zhang, Sicco Verwer

We study the bundling strategy for online auction with different types of (multi unit) items. These items can be sold simultaneously or sequentially, separately or as a bundle. Given data collected from an online auction site, we investigate bidding behaviors of the bidder with different bundling strategies. We then study how to use historical bidding data to design the bundling of the items to maximize the revenue of the seller. We compare its performance with existing bundling strategies.

2 - Nash Equilibria of Sealed-Bid Combinatorial Auctions
Marion Ott, Marissa Beck

We characterize the sets of Nash equilibria (NE) of the combinatorial Vickrey auction (VA), bidder-optimal core-selecting auctions (BOCS), and the pay-as-bid auction (PAB). All of the NE of the PAB are NE of every BOCS, and all of the latter's NE are also NE of the VA. Analyzing the possible NE outcomes, we find that any assignment and payments that generate individually rational payoffs (IR) are the result of some NE of the VA and of every BOCS. A necessary and sufficient condition for an outcome to result from an NE of the PAB is stricter than IR but still allows payoffs outside of the core.

3 - A Comparison of the Uniform Price and Vickrey Auctions on General Preference Domains
Brian Baisa

I compare bid behavior in uniform price and Vickrey auctions when bidders have private values and multiunit demands. I remove quasilinearity and allow for preference domain that includes quasilinearity and also allows budget constraints, financial constraints, risk aversion and/or wealth effects. I show that truthtelling is not a dominant strategy in the Vickrey auction. Instead bidders truthfully report demand for their first unit and overstate demands for all other units. This result mirrors the incentive for demand reduction in uniform price auctions shown by Ausubel and Cramton (2002).

4 - Split-Award Procurement Auctions — Can Bayesian Equilibrium Strategies Predict Human Bidding Behavior in Multi-Object Auctions?
Martin Bichler, Stefan Mayer, Kemal Guler

We analyze how equilibrium predictions can explain human bidding behavior in multi-object auctions. We focus on two sealed-bid split-award auctions with ex ante split decisions as they can be regularly found in procurement practice. These auction formats are straightforward multi-object extensions of the first-price sealed-bid auction. We first derive the risk-neutral Bayes Nash equilibrium strategies and find that, although the two auction mechanisms yield the same expected costs to the buyer, other aspects of the two models, including the equilibrium strategies, differ significantly.

■ FA-42

Friday, 8:30-10:00 - Room 215

Qualitative Multiple Criteria Decision Making I

Stream: Qualitative Multiple Criteria Decision Making
Invited session
Chair:
Chair: *Marko Bohanec*

1 - Qualitative Multi-Attribute Decision Method DEX: Theory and Practice
Marko Bohanec, Nejc Trdin

DEX is a qualitative multi-attribute decision method, aimed at evaluation and analysis of decision alternatives. Conceptually, DEX is a combination of multi-criteria decision analysis and expert systems. DEX's models are hierarchical and composed of qualitative (symbolic) variables, whose interrelations are modeled with decision rules. DEX and the supporting software DEXi were used in many practical applications. The purpose of this work is threefold: (1) formal description of DEX, (2) overview of its practical applications, and (3) research and development challenges for the future.

2 - Application of Qualitative Multi-Attribute Decision Model for Patient's Health Status Evaluation
Uros Rajkovic, Olga Sustersic, Vladislav Rajkovic

Evaluation of patient's health status is usually based on different signs and symptoms which have to be aggregated in final estimate of patient's status. This can be viewed as a multi attribute decision making (MADM) problem. In this contribution we present the implementation of Henderson's theoretical model of basic living activities for patient health status evaluation. Qualitative MADM methodology DEX is used, which facilitates user friendly acquisition and explanation of expert knowledge. Practical evaluation of our solution confirmed the added value in transparency of patient's status.

3 - Comparative Evaluation of Various Energy Options using Qualitative Multi-Attribute Models
Branko Kontic, Marko Bohanec, Nejc Trdin, Davor Kontic, Sonja Zagorc-Kontic, Marusa Matko

The topic of the paper is comparative evaluation of various energy options. It is treated from the strategic evaluation point of view focusing on the constituents of sustainability appraisal. The latter examines differences between the approach, which builds on specific indicators like climate change, ecology, air quality, health and well being, etc., and the approach, which rather applies more general interpretation based on rationality, feasibility, and uncertainties of energy options. The evaluation was supported by qualitative multi-attribute modeling method DEX.

4 - Solving the Ranking Problem in DEX Methodology Using Copulas
Biljana Mileva-Boshkoska, Marko Bohanec

We provide a solution for ranking of qualitative multi-attribute options modeled with DEX methodology. In DEX, the attributes form a hierarchical structure which solves the problem of sorting the options into preferentially ordered classes. To obtain full option ranking within each of the classes for nonlinear non-monotone options, we employ copula functions. The property of full option ranking is relaxed in cases of symmetric attributes, and its solved by introducing exchangeable copulas. The solution is demonstrated on real and artificial cases.

■ FA-43

Friday, 8:30-10:00 - Room 217

Water Distribution Network Design and Management

Stream: OR in Water Management
Invited session
Chair: *Derek Verleye*

1 - A Stochastic Programming Approach to Water Resources Management Evaluating Costs and Risks
Paola Zuddas, Alexei Gaivoronski, Giovanni Sechi

In this paper we consider the problem of water resources management when data uncertainty occurs. We develop a cost/risk optimization model that can assist the manager of the system in its decision balancing the level of target delivery to the users and the level of risk that this delivery will not be met. We obtain a target barycentric value with respect to selected decision variables and a reduction of the risk of negative consequences derived from unmet resources demand. We show results of some numerical experiments in real physical systems.

2 - Optimal Placement of Isolation Valves on Water Distribution Networks
Andrea Peano

Water Distribution Networks for urban water supply need to be sectorised by means of isolation valves so that, in case of damage, any pipe can be disconnected from the source, dewatered and repaired, by closing the isolation valves of its sector. A limited number of isolation valves must be optimally located on the network so that the maximum unsatisfied demand is minimized. This is a generalization of the well-know Graph Partitioning problem, since "unintended isolation" must be considered. We present and discuss pros and cons of different solution approaches.

3 - Solving Multi-Period Water Production and Distribution Problems in Large-Scale Networks
Derek Verleye, El-Houssaine Aghezzaf

We present a complete model for the optimal planning of water production and distribution in a large-scale water supply network. Since this network is mesh-structured, energy conservation laws must be satisfied. Nonlinear pressure loss restrictions are hereby introduced, which require an adapted solution approach. Furthermore the model contains binary variables. We device an algorithm that decomposes our problem into multiple "tractable" subproblems and efficiently handles the difficult constraints. Results on a real-world network are discussed and compared with other solution approaches.

4 - Heuristics and Decomposition Techniques for Large Multi-Period Network Planning Problems
Simon Dunstall, Nahid Jafari, Tarek Elgindy, Andreas Ernst, Melanie Ayre, Asef Nazari

We report on the application of heuristics and decomposition techniques to solve multi-period network planning problems arising in electricity systems, water networks and freight transport. Mixed-integer programming formulations of these problems result in very large instances. These instances can be solved by the direct application of commercial solvers, but can require several days of computing time. The heuristics and decomposition techniques reduce and limit the time required, which is especially important for industrial users of network planning software systems.

Friday, 10:30-12:00

■ FB-01

Friday, 10:30-12:00 - Room 118

Getting the Decisions Right, Fast (IBM)

Stream: Sponsored Sessions
Sponsored session
Chair: *Susara van den Heever*
Chair: *Sofiane Oussedik*

1 - Getting the Decisions Right, Fast
Susara van den Heever, Sofiane Oussedik

Recent CPLEX and Decision Optimization Center developments will be presented as well as insights on recent work on handling uncertainty, automatically and interactively. The presentation will also include use cases that highlight the ease-of-use of the development environments and seamless integration to build interactive optimization based applications that accomplish key business objectives and deliver the right solutions to the user.

■ FB-02

Friday, 10:30-12:00 - Room 111

Vehicle Routing Problems 2

Stream: Combinatorial Optimization
Invited session
Chair: *Irene Loiseau*

1 - The Vehicle Routing Problem with Minimizing Environmental Pollution
Lorena Pradenas, Mauricio Bravo, Víctor Parada

The objective of this work is to propose an approach to freight transport planning routes (vehicle routing), with pickup and delivery of products to customers in certain time windows with several goals, among which are pollution reduction and conducting negotiations with various transportation firms. To solve the problem first we set out to develop a multiobjective mathematical model which will be solved by an exact method to test the model with small size instances. After, we used a multiobjective metaheuristic method to solve instances of medium and large size.

2 - A Multiple Ant Colony System for the Prize Collecting Location Routing Problem
Irene Loiseau, Daniel Negrotto

Given a set of possible customers and their demands, and potential locations for distribution centers, the Prize Collecting Location Routing problem consists of choosing the depots to be opened, and drawing the routes to visit some of the customers. Not all customers have to be visited and each one has a prize associated when is visited. To deal with this problem we developed a Multiple Ant Colony algorithm that searches solutions by means of two different colonies, one focusing on the location problem and the other dealing with the routing problem. Preliminary results are very promising.

3 - Outsourcing regional commercial cash operations in the Chinese Banking Industry
Zhu Nan, Qiu Hong

The problem of outsourcing the commercial cash operations of the Chinese commercial banks to third-party companies in Chinese regions is studied. We present a mixed integer linear programming model of this problem for identifying the minimum total cost of cash transport, storage and sorting of the regional commercial cash service network between the Chinese Central Bank and commercial banks. It is concluded that it would often be beneficial to the Chinese commercial banks, from the point of view of cost reduction to outsource their cash operational activities.

■ FB-03

Friday, 10:30-12:00 - Room 001

Location (contributed)

Stream: Location
Invited session
Chair: *Ricardo Aceves-García*

1 - Problem Size Reduction in a Large Multi-Period Location-Allocation Problem
Guina Sotomayor Alzamora, Leonardo Lustosa, Fernanda Raupp, Carlos Eduardo da Camara Pereira

Despite advances in general methods and specific techniques of mathematical programming, its application to location problems still presents challenges. Among these is the frequently large volume of data involved. In this work we discuss problems encountered in developing a preliminary design and economic evaluation of an asphalt distribution system for the Brazilian market. The study comprised a year of seasonal demand dispersed in some 2800 municipalities. Among the solutions adopted some are believed to be original, and despite their ad hoc character, seem to be more generally applicable.

2 - Multi-Period Facility Location Problem with an Uncertain Number of Servers
Amit Vatsa

This work takes motivation from rural healthcare in developing countries. We look at staffing Primary Health Centers (PHCs) with doctors to achieve maximum population coverage over a planning horizon. Number of doctors joining in each period of the planning horizon is uncertain. It needs to be decided in which sequence the PHCs should be assigned with a doctor. We use minimization of maximum regret to model the problem and give a local search and three tabu search implementations. Experiments show that tabu search outperforms CPLEX 12.4 when the problem increases to practical size.

3 - Solution to the Capacitated Location Problem Using Separable Cross Decomposition
Ricardo Aceves-García

Applying the strategy of cross decomposition to the location problem, it is operated simultaneously its primal and dual structure, which results in a successive solution of two subproblems and the reduction of the number of master problems. When it incorporates the Lagrangian separable relaxation in this cross-scheme, ensuring that the sub problems keep all the original restriction without losing some of them, the need to resolve some of the master problems is removed and it is obtained a simple strategy solution and efficient, resolving two transport subproblems.

■ FB-04

Friday, 10:30-12:00 - Room 119

Traffic Management

Stream: Traffic Flow Theory and Traffic Control
Invited session
Chair: *Michael O Oladejo*

1 - Analysis of Road Traffic Accidents in Antalya Province (Turkey) using Geographical Information Systems
Ela Ertunc, Tayfun Cay, Omer Mutluoglu

In this study, a general statistical analysis has been made in a GIS environment of road traffic accidents occurred in 2009 and 2010 years in Antalya Province Center. Also, traffic accidents have been analyzed by correlating environmental factors with parameters situated in a traffic accident data set. As a result, at the intersections in Antalya Province Center, there were identified 41 accident hot spots for the year 2009, and was identified 57 accident hot spots for the year 2010. A total of 23 intersections were defined as accident hot spots in both years.

2 - Convergence Analysis on Advanced Traffic Assignment Algorithms
Seungjae Lee, Jooyoung Kim, Shinhae Lee

We have compared the convergence of some advanced algorithms embedded in commercial software in order to solve the equilibrium road traffic assignment. We have tested traffic assignment algorithms in Emme, Cube and Transcad. Convergence performances are compared from simple networks to large scale networks. In simple contrived networks, we can test if the algorithms are able to converge into a known solution. In large scale networks, we can test if the algorithms calculate reasonable solutions by comparing base scenario and do-alternative scenario.

3 - Optimal Transportation Network using Challenges as Catalytic Factors
Michael O Oladejo, Jighjigh Abraham Tamber

Derivation of optimal transportation network using challenges of obstacles, attacks and terrorism as factors by dynamic programming embedded with obstacles and advantages.

■ FB-05

Friday, 10:30-12:00 - Room 002

Quayside Operations

Stream: Port Operations
Invited session
Chair: *Evrim Ursavas*

1 - Berth Allocation Problem under Stochastic Nature
Evrim Ursavas, Xiang Zhu

Berth management drives the port management process and the major objective for this process is to determine the optimal location and optimal berthing time for the vessels. In this study, we propose a framework based on stochastic dynamic programming approach to model the berth allocation problem and compute optimal polices under stochastic arrival and handling times. A heuristic based relaxation is proposed to confront dimensional computational complexity. We illustrate our methodology via a case study.

2 - Solving the 3D Stowage Planning with Quay Crane Scheduling by Representation by Rules and Genetic Algorithm
Anibal Azevedo, Andrea Oliveira, Cristiano Morini, Luiz Salles Neto, Antônio Chaves, Antônio Moretti

This paper formulates and proposes a framework for solving the 3D Stowage Planning for Container ship (3D SPC) integrated with the Scheduling of Quay Cranes (SQC) problem. The 3D SPC and also SQC problems are combinatorial ones which justifies not only the applications of meta-heuristics, but also a different way to represent the solution, called representation by rules. The robustness of the developed representation is attested in a problem with 30 ports, 1500 TEUs ship, 2 Quay Cranes which binary representation demand 40,545,000 binary variables to represent just one solution for the 3D SPC.

3 - On the Complexity of Container Stowage Planning Problems
Dario Pacino, Kevin Tierney, Rune Jensen

The optimization of container ship and depot operations embeds the k-shift problem, in which containers must be stowed with at most k rehandles. We first solve an open problem showing that changing from uncapacitated to capacitated stacks reduces the problem complexity from NP-complete to polynomial. We then examine the complexity of an abstraction of the current state-of-the-art container ship stowage planning, the hatch overstow problem. We show that this problem is NP-complete, which means that even abstract formulation of container ship stowage planning is intractable.

4 - Optimizing Lock Operations: A Combinatorial Benders' Approach
Jannes Verstichel, Patrick De Causmaecker, Greet Vanden Berghe

We consider the operation of ship locks with one or more parallel chambers, which can transfer several ships in a single lockage operation. The corresponding lock scheduling problem consists of three strongly interconnected sub problems: lockage scheduling, chamber assignment, and ship positioning. An efficient Combinatorial Benders' decomposition is developed. Experiments on a large test set show that this decomposition method strongly outperforms an existing monolithic approach, especially for instances with a complex ship positioning sub problem.

■ FB-06

Friday, 10:30-12:00 - Room 211

Matheuristics II

Stream: Matheuristics
Invited session
Chair: *Michel Gamache*

1 - A Hybrid Method for the Probabilistic Maximal Covering Location-Allocation Problem
Marcos Antonio Pereira, Leandro Coelho, Luiz A. N. Lorena, Ligia C. de Souza

This paper presents a hybrid algorithm that combines a metaheuristic and an exact method to solve the Probabilistic Maximal Covering Location-Allocation Problem. A linear programming formulation for the problem presents variables that can be partitioned into location and allocation decisions. This model is solved to optimality for small and medium-size instances. For larger instances, a flexible ALNS heuristic was developed to obtain location solutions, whereas the allocation subproblems are solved to optimality. An improvement procedure based on an integer programming method is also applied.

2 - A Hybrid Algorithm for the Robust Graph Coloring Problem
Javier Ramirez, Roman Anselmo Mora-Gutiérrez, Eric Alfredo Rincón-García, Antonin Ponsich, Aana Lilia Laureano-Cruces

A hybrid branch and cut algorithm, which generates initial solutions and solves the problems after branching by musical composition method, is proposed in this paper to solve the robust graph coloring problem [1], which is a generalization of graph coloring problem. An experimental result shows that this algorithm is better than other algorithms presented on the literature. References: [1] Javier Yáñez, Javier Ramırez, The robust coloring problem, European Journal of Operational Research, Volume 148, Issue 3, 1 August 2003, 546-558.

3 - A Matheuristic for the Bi-Objective Arc Routing Problem
Igor Coelho, Daniel Porumbel, El-ghazali Talbi, Luidi Simonetti, Luiz Satoru Ochi

The bi-objective arc routing problem consists of a set of weighted arcs that must be serviced by vehicles of limited capacity, minimizing the longest tour and also the sum of all traversed arcs. This problem has many practical applications such as garbage collection and it is a NP-Hard problem. We tackle it by means of an indirect representation based on permutations and propose matheuristics that integrates an exact decoder with classical multi-objective frameworks. Results show that the proposed approach is well-suited for this problem and it is extensible to other optimization problems.

4 - Tabu Search Algorithm for the Optimal Planning of a Marketing Campaign on Search Engines
Michel Gamache, Alain Hertz, Mehdi Jaoua

In this paper, we present a tabu search algorithm for the optimal planning a marketing campaign on search engines. This type of problem consists in maximizing a certain criterion (e.g., the number of clicks leading to the company website), while ensuring a certain level of quality (minimum number of impressions, minimum number of conversions) without exceeding a daily budget. The neighborhood, as well as methods of diversification and intensification that led to the construction of this resolution approach will be presented.

■ FB-07

Friday, 10:30-12:00 - Room 003

Theory of Optimal Control

Stream: Optimal Control
Contributed session
Chair: *Klara Mizhidon*

1 - On One Application of Convex Optimization to Stability Problems
Şerife Yılmaz, Taner Büyükköroğlu, Vakif Dzhafarov

One of the most important problems of control theory is the control of switched systems. This problem is related to the common quadratic Lyapunov function problem and one way to solve it is LMI (Linear Matrix Inequalities) approach. On the other hand this approach requires a huge number of parameters and is not effective when the number of subsystems and matrix dimensions increase. In this report we give alternative methods for testing stability of switched systems. These methods are based on the convexity property of the maximum eigenvalue function of symmetric matrices.

2 - About an Approach to Indentify Linear Dynamic Systems
Elena Madaeva

This presentation proposes an approach to identify linear stationary dynamical systems to construct the control model. This approach is based on measurement results of phase coordinates of the system at certain time intervals. The identification of matrix systems according to the proposed approach is reduced to constructing and to solving of the matrix linear algebraic equation. Constructing the equation is found by interpolating initial tabulated solutions of the Cauchy problem. We provide examples and numerical calculations.

3 - Pontryagins Maximum Principle for Optimal Control Problems with Infinite Horizon
Nico Tauchnitz

In this talk we consider a class of infinite horizon optimal control problems with a nonlinear dynamical system. For typical applications it is demonstrated that the state variables belong to a Weighted Sobolev space. Making appropriate assumptions on the growth of the data of the problem we can prove Pontryagins Maximum Principle as necessary condition for a strong local minimum. The obtained maximum principle includes transversality conditions as well.

4 - Conditions for Satisfying Phase Constraints in a Control Problem
Klara Mizhidon, Arsalan Mizhidon

In this work, we propose an analytical and numerical method for constructing a desired law of motion of a dynamical system. By desired control we mean admissible control that keeps the system in the phase constraints under constantly acting disturbances. External disturbances are described by polyharmonic functions. Consider an auxiliary optimal control problem with functional depending on weight coefficient. The choice of coefficient provides construction of desired law of motion. The theoretical justification of the proposed approach is presented.

■ FB-08

Friday, 10:30-12:00 - Room 120

Dynamic Programming and Multicriteria DSS

Stream: Dynamic Programming
Invited session
Chair: *Lidija Zadnik Stirn*

1 - Decision Support System (DSS) Based on Dynamic Programming with Fuzzy Returns for Optimal Management of Natural Resources
Lidija Zadnik Stirn

Paper presents a DSS for evaluation of feasible management scenarios (integrative, segregative, mixed) of renewable natural resources over long time horizon, regarding essential future economic, ecological and social demands, and conflicting stakeholders' and distinctive groups' interests. Time perspective is captured by the use of discrete dynamic programming, while the management goals are denoted by fuzzy indicators. Membership function and fuzzy operators combine the scenarios/goals and indicators. The DSS is illustrated on a sustainable management of Natura 2000 forestland in Slovenia.

2 - Graphing Tri-Criterion Nondominated Surfaces
Maximilian Wimmer, Ralph E. Steuer

This talk emphasizes on the geometry and properties of the nondominated surfaces in tri-criterion portfolio selection. It is demonstrated how the single hyperboloids that are usually computed in parameter space can be converted into decision space, i.e., into the form x'Qx + x'P + R = 0. Furthermore, a principle axis transformation is performed to transform the hyperboloids into normal form that is required for detailed graphs. In the talk, many graphs are used to illustrate.

3 - Maximising Diversity in Combinatorial Scenario Spaces
Christian Carling, E Anders Eriksson

Scenario Diversity Analysis is a form of Morphological Analysis (MA) where variables can be nominal, as in standard MA, or ordinal. When ordinality is relevant for the problem domain it is of interest to assess policies against sets of maximally diverse scenarios. We present a formal model for this type of problem based on order theory, which enables an effective algorithm for finding optimal scenario sets. Mixing genetic and greedy optimisation techniques, the algorithm performs well compared to current methods and is particularly effective for complicated, non-convex scenario spaces.

■ FB-09

Friday, 10:30-12:00 - Room 121

Electricity Networks

Stream: Technical and Financial Aspects of Energy Problems
Contributed session
Chair:
Chair: *Wanshan Zhu*

1 - Combinatorial Optimization Enhances the Energy Output of Electric Power Networks
Christiano Lyra Filho, Celso Cavellucci, Fábio Usberti, José Federico Vizcaino

Energy is continuously dissipated in electric power networks. Reduction of these losses can be regarded as a hidden source of energy; in Brazil, the reduction of each percentage point is equivalent to the output of a 1000 MW hydro plant. The talk discusses combinatorial optimization problems that provide alternatives to reduce losses in electric distribution systems and gives an overview of two reference problems in this area: finding minimum loss paths for energy flows and reducing losses by the control of reactive power flows. It considers solution techniques and fathoms new ideas.

2 - Lying Generators
Dávid Csercsik

We consider an optimal power flow (OPF) scenario in which the generation values regarding the OPF are calculated by a central authority and a centralised mechanism is applied for the determination of generator payoffs. We analyze the situation when generators may provide false information about their production parameters and thus manipulate the OPF computation in order to potentially increase their resulting profit. We consider several central payoff mechanisms and compare their vulnerability. Furthermore we analyze the effect of cooperation and mutual information of generators.

3 - Seasonal Transmission Switching with N-1 Reliability Requirements
Jorge Valenzuela, Masood Jabarnejad, Jianhui Wang

A new control paradigm that switches transmission lines into/out of service has been proposed to improve the economics of electric power systems. In this presentation, a large-scale mixed integer programming model is described where the transmission switching occurs at the beginning of a time period and remains unchanged during that period. The objective of the optimization model is to minimize the total energy generation cost over the season subject to loads a and N-1 reliability requirements. A decomposition approach is developed to solve the optimization problem efficiently.

■ FB-10

Friday, 10:30-12:00 - Room 122

Team and Assignment Optimization

Stream: Timetabling and Rostering
Contributed session
Chair: *Wilmer Atoche*

1 - Genetic Algorithms Applied to Management of Customer Portfolio and Management of Daily Schedules for a Bank Sales Workforce
Ricardo Soares Boaventura, Christina Marques Testa, Keiji Yamanaka

The problem of defining the Daily Schedule for employees to sell products is strategically important for companies to minimize cost, increase efficiency and profit. This problem is similar multi-traveling salesman/vehicles problems, with the difference of selecting clients according to higher profitability and strategies. The daily goal is to discover the best route to be built for visiting clients always starting and returning in the same point. The proposed system was developed using the techniques of genetic algorithms and can be accessed via the Web and is linked to Google Maps.

2 - An Application for a Laboratory Assignment with Rotations
Takeshi Koide

An application based on spreadsheet software is developed for an assignment in a course in author's department. The course aims to provide experiences of research activities to junior students and the students are assigned to three different laboratories. The assignment task is conducted by a faculty member, who has to consider student's preference of laboratories and as well as the capacities of laboratories with rotations. The assignment is modeled as a mixed-integer programming problem and the developed application seeks an optimal solution for the problem.

3 - Optimal Allocation of Football Team
Wilmer Atoche

The purpose of this paper is to demonstrate the use of optimization tools applied to obtain an ideal football team. The assessment of each football player is its performance parameters at each position of the football field and using integer linear programming, one can optimize the initial alignment, changes of team players that can be performed during the game and other applications.

4 - About Some Characteristics that are common in Optimization Projects Involving Human Resources
Juan Manuel Garcia Lopez

Various classes of Operations Research problems deal with Human Resources. Examples are Timetabling, Task Scheduling, Rostering, Shift assignment or Routing. Unlike other scarce material resources, Human Resources are of a special nature, forcing them to be managed carefully when implementing a project. If one of those projects is modeled ignoring their special characteristics, the likelihood of stakeholder's dismissal of the solution increases. This presentation shares some project management lessons learned while implementing various optimization projects dealing with Human Resources.

■ FB-11

Friday, 10:30-12:00 - Room 113

Euclidean Distance Geometry and Applications

Stream: Combinatorial Optimization
Invited session
Chair: *Nelson Maculan*
Chair: *Antonio Mucherino*

1 - Some Notes of Euclidean Distance Geometry and Graph Theory Involving Telecom, Computer Networks and Molecular Biology Applications
Rosiane deFreitas, Bruno Cardoso Dias, Nelson Maculan, Carlile Lavor

In this work, the relationship between Euclidean distance geometry and graph theory will be explored, where some operational research problems will be considered, involving theoretical models and computational techniques proposed for channel allocation problems in wireless networks, detection of malicious code in computer systems, and determining of the 3D structure of protein molecules. Implicit enumeration algorithms will be presented, addressing issues of feasibility and optimality of solutions, with emphasis on the method of branch-prune-and-bound.

2 - New Developments on the Application of the Hyperbolic Smoothing Technique to Solve the Distance Geometry Problem
Helder Venceslau, Adilson Elias Xavier

In the very beginning, the Hyperbolic Smoothing (HS) Technique was employed to solve distance geometry problems (DGPs) mainly as a heuristic tool, but some of its basic properties had already been established, remarkably its convexification power in a limit situation. Recent research has shed some light on the convergence process, which helps to explain its high success rate compared to the resolution of the classical minimum sum-of-squares formulation of the problem. Latest theoretical and computational developments regarding the application of HS to solve DGPs will be presented.

3 - Numerical Solution of The Euclidean Steiner Tree Problem in n-Space
Virginia Costa, Brígida Sartini, Marcia Fampa, Nelson Maculan

The Euclidean Steiner tree problem (ESTP) in Rn consists of finding a tree of minimal Euclidean length that spans a given set of points in Rn, using or not additional points. Only a few papers consider the exact solution for the ESTP in Rn (n>2) and there are just two works that considered a mathematical programming formulation for the ESTP. One of them presented a convex mixed-integer formulation that could be implemented in a Branch and Bound (B&B) algorithm. This work presents techniques to improve the performance of the B&B algorithm in order to implement this formulation.

4 - Molecular Distance Geometry and Atomic Orders
Antonio Mucherino

The Molecular Distance Geometry Problem (MDGP) is the one of finding the conformation of a molecule while exploiting the available distances between some pairs of its atoms. The MDGP is NP-hard and is usually reformulated as a global optimization problem in a continuous space. We are working on a subclass of instances for which this space can be discretized, and on a branch-and-prune (BP) algorithm for their solution. In order to perform the discretization, MDGP instances have to satisfy some assumptions, that strongly depend on the order in which the atoms of the molecule are considered.

■ FB-12

Friday, 10:30-12:00 - Room 004

Scheduling Models in Operational Decision Making

Stream: Scheduling under Resource Constraints
Invited session
Chair: *Joanna Jozefowska*
Chair: *Francisco Ballestin*

1 - ORAS: Route Optimization System for the Hospital at Home Service
Sacramento Quintanilla, Francisco Ballestin, M.Pilar Lino, M. Angeles Pérez, Vicente Valls

ORAS is a mobile route-planning application developed for use in the home hospitalization (HH) service. Doctors and nurses who provide HH services must travel by taxis to different homes where their patients are hospitalized. The software is designed to show daily the most efficient route to be taken by each doctor and nurse and to update in real time the information about the routes. A graphic visualization is used to show the routes taken by each taxi or person. The core is a set of algorithms that achieves a significant reduction in both cost and staff waiting times.

2 - Decomposition of a Storage and Retrieval Problem in a Warehouse
M. Angeles Pérez, Francisco Ballestin, M.Pilar Lino, Sacramento Quintanilla, Vicente Valls

We work with a warehouse where some forklifts have to store and retrieve pallets, with the objective of performing the given orders in the minimum time possible. The warehouse works with random storage: any pallet can occupy different positions. In our problem three block of decisions have to be made: 1) in which position to store or retrieve a pallet, 2) which forklift is going to work with each pallet, and 3) when exactly each order is going to be performed. We decompose our problem into three different subproblems to solve it. Each of the subproblems is assigned to one block of decisions.

3 - Metrics and Approximated Solution of Machine Scheduling Problems
Alexander Lazarev

In this paper, we propose a new approximation scheme for scheduling problems. The scheme is based on search for the polynomially solvable instance which has a minimal distance in the metric from the original instance. One can also improve the scheme by constructing new metrics and finding new polynomially solvable cases of scheduling problems.

4 - Scheduling an Injection Plant with Order Dependent Setups
Joanna Jozefowska, Marek Goslawski, Marcin Kulus, Jenny Nossack

A scheduling problem observed in an injection molding plant is presented. The problem involves time consuming changeover operations. The objective is to maximize the plant productivity. Scheduling constraints follow from limited availability of staff responsible for the changeovers. A two stage approach is proposed. At the first stage jobs are assigned to machines and the order of jobs on each machine is fixed. At the second stage the operators are assigned to machines. The schedules are compared with schedules generated by a dedicated greedy heuristics and by an experienced dispatcher.

■ FB-13

Friday, 10:30-12:00 - Room 123

Scheduling Applications 2

Stream: Scheduling
Invited session
Chair:
Chair: *Greet Vanden Berghe*

1 - Scheduling Patients for Surgery
Chris Potts, Marion Penn, Paul Harper

Patients are referred to hospital for surgery and a scheduling policy determines the day of their operation. Emergencies must be treated immediately, while other patients have due dates that depend on their condition. Scheduling rules depend on whether the booking for a patient is immediate or can be delayed, the priority rule among patients to be booked, and the order in which potential booking dates are searched. Using data from a case study, we evaluate our scheduling rules using: due dates being met; average patient waiting time; operating theatre overruns; and fairness to patients.

2 - Hot Strip Mill Scheduling under Consideration of Energy Consumption
Karen Puttkammer, Matthias Gerhard Wichmann, Thomas Spengler

In steel industry hot rolling is an energy intensive process as steel slabs need to be heated before being rolled on the hot strip mill. The energy consumption is determined by the production schedule. Due to rising energy prices decision support for the hot strip mill scheduling problem (HSMSP) under consideration of energy consumption becomes necessary. This contribution is based on a new MILP formulation. Therein the energy requirement for heating is modeled according to causation. We propose a problem specific heuristic solution approach and present first numerical results.

3 - Reception, Mixture and Delivery of Crude Oil in a Terminal
Bernardo Zimberg, Eduardo Camponogara, Enrique Ferreira

This paper refers to the reception, mixture and delivery of crude oil. Each tank at the terminal receives different qualities from different cargos that arrive in predefined periods. Transfer is allowed between tanks and the main pipeline to the refinery. There is a schedule of crude oil quality mixtures and volumes required by the refinery. The problem consists in finding an optimized schedule that meets the constraints. An MILP model is proposed, analyzed, and solved for a specific case. The tool can be applied to determine the optimal schedule of crude oil operations over a time horizon.

4 - Optimal Scheduling for Storage and Retrieval of Assembly Blocks in Temporary Storage Yard for Shipbuilding Process
Byung-Hyun Ha, Jung-Ryoul Son

This paper studies scheduling of storing and retrieving assembly blocks in a temporary storage yard for shipbuilding process. The objective is to minimize the number of relocations of blocks subject to the storage and retrieval time windows being satisfied. We show the problem is NP-hard and present a mixed-integer programming model based on multi-commodity network flows. The revised models are proposed by investigating the properties in the problem. To overcome the computational inefficiency, an A* algorithm is devised and the performance is validated through the numerical experiments.

■ FB-14

Friday, 10:30-12:00 - Room 124

Shop Scheduling

Stream: Scheduling
Invited session
Chair: *Waldemar Kaczmarczyk*

1 - Some Finite Planning Horizon Inspection Models with Non-Negligible Inspection Times
Honest Chipoyera

Finite planning horizon Inspection models with non-negligible inspection times are developed for a system whose time to failure has a known probability distribution. Two scenarios are explored: 1) inspections take place while the system is running, 2) whenever the system has to be checked, it is switched off completely. For these two scenarios, two sub-scenarios each are studied: a) all inspections are of the same fixed duration and b) inspection times are random variables following a known probability distribution. Maximization of profit is used as the sole optimization criterion.

2 - Makespan Poorly Approximates Machine Utilization in the Flow Shop System
Waldemar Kaczmarczyk

Maximization of machine utilization is the most popular objective in production scheduling. It is, however, usually replaced by minimization of the schedule length which is unambiguously defined and easy to compute. First, we show that for the flow shop problem makespan poorly approximates machine utilization, because it ignores overlapping of consecutive schedules. Next, we propose new method to estimate machine utilization which considers production over multiple periods (shifts). Finally, we show that maximal utilization may be achieved with relatively simple algorithms.

3 - Decoupling time and cost in project performance management
Homayoun Khamooshi

The EVM and its derivatives (e.g., Earned Schedule) use cost as a proxy to measure schedule performance to control duration of the project. In this research the authors have decoupled new schedule performance measures to evaluate efficacy and efficiency of the schedule and planned duration at any level of the project. These new indices are easy to understand, have a wider application, and can be used by contractors, clients and the scheduling offices to assess and measure schedule performance. The technique is called EDM (Earned Duration Management).

4 - Minimising the Sum of Total Tardiness and Earliness in a Flow Shop Scheduling using Hybrid Genetic Algorithm
Ashwani Kumar Dhingra, Sunita Dhingra

Present work considers the flow shop scheduling problems for minimizing the sum of total tardiness and earliness under sequence dependent setup time (SDST). Hybrid Genetic Algorithm (HGA) has been proposed in which the generation of seed sequence has been obtained from the earliest due date (EDD) rule denoted as HGA (EDD), EDD followed by NEH procedure denoted as HGA (NEH_EDD) and simple GA. From the comparative analysis, it has been found that HGA (NEH_EDD) provides the superior results for minimizing the sum of total tardiness and earliness criteria for SDST flow shop scheduling problems.

■ FB-15

Friday, 10:30-12:00 - Room 125

Experimental Research in Management Accounting and Management Control 3

Stream: Experimental Perspectives and Challenges in Management Accounting and Management Control
Invited session
Chair: *Stephan Leitner*

1 - Diagnostic Study about the Utilization of Shared Service Centers for Municipalities of Southern Brazil
Gustavo Krüger, Rogrigp Correa

This paper aims to diagnose the use of Shared Services Centers (SSC) by the Brazilian municipalities. To achieve this goal, a survey was performed covering the 102 most populous counties in southern Brazil, using the questionnaire as a tool for data collection. The main findings show that were not identified SSC constituted under the sample surveyed and that virtually 100% of the managers participating in the research has no knowledge about SSC, even though the SSC is, nowadays, a practice widely adopted internationally, according to a study of Krüger, Corrêa and Vanti (2013).

2 - Slovak Business Cycles in the Post-Communist Era
Martin Lukáčik, Karol Szomolányi, Adriana Lukáčiková

Computing Slovak average PPP converted GDP per capita; considering a Slovak population size we state, that Slovak economy is small, emerging and open. However, computing cyclical properties of the chosen variables we state that Slovak business cycles suit for an open, rich economy more. Using VAR specification we consider that production shocks are main source of the Slovak business cycles. The small open real business cycle model is suitable to explain Slovak business cycles. Calibrating parameters of the model, we state that the model better fits data when we use the CES production function.

3 - Experimental Evaluation of a Set of Multi-Criteria Decision Making Methods
Sajid Siraj, Alessio Ishizaka

Three multi-criteria decision making (MCDM) methods have been experimentally evaluated for their usefulness in solving a specific problem. Participants were asked to rank five available coffee shops using the MCDM tools. Their rankings were also recorded before and after the experiment. A voucher was offered for the shop suggested by the initial or MCDM ranking. If the subject showed dissatisfaction with the choice, s/he was offered an exchange for a small fee. The results were statistically compared in order to determine how the decision evolves with the use of these MCDM tools.

■ FB-16

Friday, 10:30-12:00 - Room 127

Industrial Applications of Machine Learning

Stream: Intelligent Optimization in Machine Learning and Data Analysis
Invited session
Chair: *Anton Khritankov*

1 - Customer Churn Analysis in Telecommunication Industry
Mehmet Yahya Durak, Ilayda Ulku, Fadime Üney-Yüksektepe

Churn management is an important issue for telecom companies. In Turkey since 2009, it has been possible to change the GSM operator without changing the cell phone number. Thus, competition increases and customer loyalty become more important. In this research, a questionnaire is applied to obtain the real data of GSM users' information and behavior of the churn possibility. Hence, this research analyzes the obtained data by using existing data mining algorithms in order to determine the important factors for the churn prediction and to find the possible customer behaviors about loyalty.

2 - Data Mining Application for Production Systems: R2R Controller Design in Multi-Item Production Systems
Cheong Sool Park, Youngji Yoo, Jun Seok Kim, Sung-Shick Kim, Jun-Geol Baek

In the paper, we propose a R2R control model for multi-item production systems. In the multi-item environment, the types of products or types of layers are rapidly changed run-by-run or by time and also the status of facilities are changed run-by-run. So we propose a new R2R control model which is able to explain both effects of the types of products and the status of equipment by time. The proposed model consists of the term of general effects, types of products or layers effects and time effects. The recursive estimation method distributes cause and effects to each term.

3 - Strategic Indicators for Science and Technology Competency Analysis
Sejung Ahn, Oh-Jin Kwon, Dohyun Kim, June Young Lee, Kyung-Ran Noh

It is very important to identify the current position and trends of each national science and technology for the R&D planning. In particular, the accurate analysis and diagnosis based on objective information is essential. For this, the information analysis should be performed through multilateral aspects using a variety of indicators. In this research, strategic indicators were investigated for science and technology competency analysis using journal publications. By applying these indicators to bio- and nano-technologies, the national research profiles were identified.

■ FB-17

Friday, 10:30-12:00 - Room 005

Combinatorial Structures

Stream: Graph Searching
Contributed session
Chair: *Nancy Clarke*

1 - On Efficient Unique Maximum Matching Algorithms
Eugen Mandrescu, Vadim Levit

If the matching number and the vertex cover number of a graph G are equal, then G is called a Konig-Egervary graph. Bartha (2010) conjectured that a unique perfect matching in a graph G, if it exists, can be found in linear time in terms of the size of G. In this research we validate this conjecture for both Konig-Egervary graphs and unicylic graphs. More specifically, we use a variation of Karp-Sipser leaf-removal algorithm (1981), which ends with an empty graph if and only if the original graph is a Konig-Egervary graph with a unique perfect matching.

2 - Mathematical Programming Models and Relaxations for the Minimum Hub Cover Problem
Belma Yelbay, S. Ilker Birbil, Kerem Bulbul

We introduce a new combinatorial optimization problem, named minimum hub cover (MHC) problem. MHC problem is solved to increase the efficiency of query processing over graph databases. This problem is known to be NP-hard. We first give an integer programming formulation and then introduce several relaxations based on linear programming and semi-definite programming. After discussing the relations among these formulations, we present a comprehensive computational experiment to investigate the empirical performances of the proposed mathematical models.

3 - An Improved Iterated Greedy Algorithm for the Minimum Weighted Dominating Set
Salim Bouamama

In this contribution we consider the implementation of an improved iterated greedy algorithm for the minimum weighted dominating set problem (MWDS). MWDS is a classical, NP-complete optimization problem in graph theory with many applications such as clustering in wireless networks, formation of a routing backbone and multi-document summarization in information retrieval. Given a graph with weighted vertices, the goal of MWDS is to find a subset of vertices with minimum total weight such that each vertex of the graph is either in the subset or adjacent to at least one vertex in the subset.

■ FB-18

Friday, 10:30-12:00 - Room 112

Applications of Multiobjective Optimization II

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Guilhem Raffray*

1 - A Multiobjective Resource Allocation Problem in Project Scheduling
Chao Chen, Guangquan Cheng, Baoxin Xiu, Jincai Huang, Weiming Zhang, Cheng Zhu

Resource allocation involves allocating finite resources to the activities of a given baseline schedule which obtains by the RCPSP-schedule. The objective of our research is to develop a multiobjective optimization approach for the resource allocation problem. A multiobjective optimization heuristic which incorporates problem specific knowledge is then designed to obtain the Pareto optimal solutions. Finally, extensive computational results obtained on a set of benchmark problems are reported.

2 - Shape Optimization of Rotating Disks
Dmitry Khominich, Fedor Gubarev, Alexis Pospelov

The methodology for structural design of rotating disks was developed. The disk was considered as axisymmetric rotating part of aircraft engines subjected to thermal, inertial, blade and fit forces. Methods of static stress analysis and low-cycle fatigue life prediction were used to predict disk performance. The goal was to determine the shape of the disk cross section with minimum weight and maximum fatigue cycles. The family of Pareto-frontiers was obtained for different rotating speeds by mean of descent-diffusion optimization approach.

3 - Multi-Objective Optimization for the Design of Fish and Meat Hot-Smoking Processes
Guilhem Raffray, Patrick Sebastian, Antoine Collignan

The purpose of this work is the food process design optimization for the production of African traditional hot-smoked products. Based on a methodology of interpretation and aggregation of multiple industrial constraints, a multi-objective decision tool is developed for improving the technological performances of productivity, energy efficiency and product quality. A genetic algorithm evaluates various design alternatives and converges to the most desirable solution. The optimized solution is then subjected to a sensitivity analysis to consider the lack of reliability of some field data.

4 - Multiple Criteria Simulation Optimization: Further Refinements
Esmeralda Niño Pérez, Mauricio Cabrera-Ríos

Pareto Efficiency conditions are used in an iterative framework based on experimental design, and pairwise comparison. In particular, this work improves upon the use of Data Envelopment Analysis to determine the efficient frontier, as well as, the use of a single-pass algorithm previously proposed by our research group. The results show a rapid convergence to a more precise characterization of the Pareto-efficient solutions. The revised algorithm is illustrated by a series of cases in manufacturing systems simulation.

■ FB-19

Friday, 10:30-12:00 - Room 128

New Methods for Multiobjective Optimization

Stream: Multiobjective Optimization - Theory, Methods and Applications
Invited session
Chair: *Alan Pearman*

1 - Complete Efficient Frontier of Bicriteria Nonlinear Separable Discrete Optimization Problems with Multiple Constraints
Yuji Nakagawa, Sakuo Kimura, Ross J. W. James, Chanaka Edirisinghe

We propose a technique for finding all efficient solutions of the bicriteria nonlinear separable discrete optimization (BINSDO) problem using a unique enumeration approach, termed the Target Method, which is based on a surrogate constraint method (Management Science, March 1914). As the Target Method does not use DP dominance, it can be applied to instances with multiple constraints. The Target Method is also superior to existing algorithms for 0-1 separable discrete problem with a single constraint in both speed and accuracy, whilst improving the number of efficient solutions.

2 - A new Algorithm for Optimizing a Linear Fractional Function over an Integer Efficient Set of a Multiple Objective Linear Problem
Younsi Née Abbaci Leila, Mustapha Moulai

In many situations, a decision maker faces a large number of different efficient solutions and the selection of her preferred solutions becomes a very hard task. A way of assessing some preferred solution is by optimizing a function over the efficient set. In this work, a new algorithm is developed that optimizes an arbitrary linear fractional function over an integer efficient set of a Multiple Objective Integer Linear Programming problem (MOILP). The proposed method is based on a simple selection technique that improves the principal objective value at each iteration.

3 - An Enumerative Cutting Plane Approach to Integer Linear Vector Optimization Problems
Walter Habenicht

The approach presented in this paper is a hybrid approach, using cutting planes and enumeration. In the interactive part of the procedure the decision maker controls the searching process by defining regions in outcome space. Cutting planes are used to install a stopping rule that guarantees under customary conditions the optimality of the solution.

4 - Identifying a Maximally Representative Sample: A Linear Binary Goal Programming Formulation
Alan Pearman

An analyst must select a sample of size s from a population, size n. Each member of the population has a number of characteristics - for example big/small; old/young/middle-aged; male/female; etc.. The chosen sample must contain at least a certain number in each of these categories. If s is small relative to n, it may be impossible to select a sample meeting all constraints and the constraints will need to be prioritised. The paper presents a linear binary goal programming model to search for an acceptable sample with an application to the evaluation of EU Framework 7 research projects.

■ FB-20

Friday, 10:30-12:00 - Room 129

Stochastic Unit Commitment with Renewables

Stream: Stochastic Optimization in Energy
Invited session
Chair: *Warren Powell*

1 - A Dynamic Programming Approach to the Ramp Constrained Intra-Hour Stochastic Single-Unit Commitment Problem
Ditte Heide-Jørgensen, Trine Krogh Boomsma, Pierre Pinson

We consider the problem of single-unit commitment (1UC) in a power system with renewable energy. To account for the intermittency of renewable generation and the resulting additional system flexibility requirements, we assume a fine time resolution of the scheduling horizon and consider ramping. We extend existing deterministic dynamic programming formulations of the 1UC problem to include stochastic wind power generation. In doing so, we consider how and when to account for updates of information, and put special efforts into modeling uncertainty in wind power forecasts as a Markov chain.

2 - SMART-ISO: An Informationally Correct Model of the PJM Energy Markets and Power Grid
Warren Powell

SMART-ISO is a detailed simulator of the PJM energy markets and power grid. It accurately captures the day-ahead unit commitment, intermediate term scheduling (every 30 minutes) and real-time economic dispatch (every 5 minutes). Generator scheduling reflects limits on notification times, which provides a precise model of uncertainty in each decision. We report on studies of high penetrations of renewables, and we describe the design of robust policies which eliminate outages while maximizing energy utilization from renewables, exploiting the properties of AC power flow networks.

3 - A Dynamic Stochastic Unit Commitment Formulation to Accommodate Wind Uncertainty
Canan Uckun, Audun Botterud, John Birge

There is a rapid increase in renewable energy generation in many parts of the world. New methods and approaches in electricity market operations are needed to efficiently manage the continuing increase in variability and uncertainty caused by expanding renewable resources. This paper proposes an improved stochastic programming approach for accommodating wind power uncertainty in electricity markets. The proposed formulation improves the standard two-stage stochastic unit commitment problem by incorporating a more dynamic representation of the scheduling decisions.

4 - Stochastic Market Clearing in Electricity Markets with High Penetration of Wind Energy: Air emissions Reductions and Economic Savings
Ali Daraeepour, Dalia Patino-Echeverri

This study measures the impacts of employing stochastic market clearing in a market-based power system. The benefits are in terms of reduced costs of the integration of variable energy resources (VERs) relative to deterministic market clearing models including, reduction in costs and air emissions from ancillary services required to manage the variability of these resources, and reduction in costs and air emissions from reduced wind-power curtailment. In order to increase the efficiency of the stochastic model, scenario generation and reduction techniques have been also employed.

■ FB-21

Friday, 10:30-12:00 - Room 006

Cutting and Packing 6

Stream: Cutting and Packing
Invited session
Chair: *Guntram Scheithauer*

1 - Minimal Proper Non-IRUP Instances of the One-Dimensional Cutting Stock Problem
Guntram Scheithauer, Vadim Kartak, Artem Ripatti

We consider the well-known one-dimensional cutting stock problem (1CSP). It is shown that all possible instances of the 1CSP can be divided into a finite number of equivalence classes when the number of items is fixed. A method for enumerating all these classes is investigated. This method is improved for searching proper non-IRUP instances with minimal number of items. We found that the minimal number of items is 10 when a proper non-IRUP instance exists. We also found 365 equivalence classes that consist of such instances.

2 - New Inequalities for 1D Relaxations of the 2D Strip Packing Problem
Isabel Friedow, Guntram Scheithauer

We investigate a heuristic for the 2-dimensional rectangular strip packing problem (2DSPP) that constructs a feasible packing by placing 1-dimensional cutting patterns obtained by solving the horizontal 1D bar relaxation (1DHBR). To represent a solution of 2DSPP, a 1DHBR solution has to satisfy, among others, the vertical contiguous condition. To strengthen the 1DHBR with respect to that vertical contiguity new inequalities were formulated and numerically analyzed.

3 - Branch-and-Price Methods for the 1D Contiguous Bin Packing Problem
Marat Mesyagutov, Guntram Scheithauer, Gleb Belov

We consider the 1D contiguous bin packing problem (CBPP-1). Being a relaxation of the 2D strip packing problem, CBPP-1 is also relevant for different areas, e.g., for scheduling. To tackle CBPP-1, we use a Gilmore-Gomory model, which is a Dantzig-Wolfe decomposition of the position-indexed formulation. In order to obtain a contiguous structure for the optimal solution, its basis matrix must have a consecutive 1's property. For construction of such matrices, we develop new branch-and-price algorithms which are distinguished by various strategies for the enumeration of partial solutions.

4 - A Two-Objective Two-Dimensional Cutting Stock and Assortment Problem
Banu İçmen, Refail Kasimbeyli

In this work we study two-dimensional cutting stock (2DCSP) and assortment problem where stock of different sizes is available and a set of rectangular items has to be obtained through guillotine cuts. We propose a two-objective mixed-integer programming model for the 2DCSP. The objective functions are formulated in the form of minimizing the global area of the used stock materials that is the total trim loss, and the number of used stock types. Different scalarization methods are used to solve the developed two-objective mixed-integer programming model and obtained solutions are compared.

■ FB-22

Friday, 10:30-12:00 - Room 007

Advances in Service Process Analysis

Stream: Game Theory and Service Management
Invited session
Chair: *Jan Van Mieghem*

1 - Optimal Design of Co-Productive Services: Interaction and Work Allocation
Guillaume Roels

In this paper, we develop an analytical model of joint production between a service provider and a customer and characterize how a service firm should design its co-productive system. We show that, as a task becomes more standard, it is desirable to decrease the degree of interaction between the provider and the customer by making their efforts more substitutable and to allocate most of the work to whoever is the most efficient. Our analysis gives rise to a service-process framework with three archetypes of co-productive services: collaborative services, service factories, and self-services.

2 - Collaboration and Resource Sharing in Networks
Jan Van Mieghem

We study collaboration and resource sharing in processing networks. We start by describing the challenges that collaboration and resource sharing brings to network capacity (maximal throughput). We present conditions on the network's collaboration architecture that guarantee that simple bottleneck analysis truly captures the capacity of the process. We then proceed to study control of synchronization under non-preemption. We find that synchronization of collaborating resource under non-preemptions introduces fundamental and non-trivial trade-offs between throughput and controllability.

3 - Staffing Service Systems When Capacity Has a Mind of its Own
Martin Lariviere

We examine a service provider that has contracted to process a flow of transactions but which allows its workers to design their own schedules. Hence, the firm must make sure it has enough staff over the horizon but cannot directly assign agents to time intervals. We show that if the firm offers constant compensation terms over periods with varying demands, low demand periods will be overstaffed. Adjusting the per-transaction compensation or by limiting the number of agents that can sign up in each period corrects this.

■ FB-23

Friday, 10:30-12:00 - Room 008

VNS and ILS

Stream: Metaheuristics
Contributed session
Chair: *Jose Brandao*

1 - A Variable Neighbourhood Metaheuristic for the Clustered Vehicle Routing Problem
Christof Defryn, Kenneth Sörensen

A vehicle routing problem in which clients are partitioned into clusters is called a clustered vehicle routing problem (CluVRP). Clients belonging to the same cluster should be visited by the same vehicle sequentially in the same path. We divide the problem in two underlying combinatorial problems: the bin packing problem - at the level of the clusters - and the travelling salesman problem - at individual client level. Different local search operators at each level, embedded in a variable neighbourhood metaheuristic framework, are combined to obtain high quality solutions.

2 - Iterated Local Search Algorithm for the Open Vehicle Routing Problem with Time Windows
Jose Brandao

The problem studied here is the open vehicle routing problem with time windows (OVRPTW). This problem is identical to the vehicle routing problem with time windows, except that the vehicles do not return to the distribution depot after delivering the goods to the customers. The OVRPTW has been solved with an iterated local search algorithm, taking as first objective to minimize the number of routes of the solution and as second objective minimizing the total distance travelled. The performance of the algorithm is tested using a large set of benchmark problems.

3 - A Parallel Iterated Local Search Algorithm on GPUs for Quadratic Assignment Problems
Erdener Ozcetin, Gurkan Ozturk

It is getting widespread to develop meta-heuristics on GPUs, with the motivation of decreasing solution time of combinatorial optimization problems. Up to 50x speed-ups are gained in recent studies. In this study, a parallel iterated local search algorithm has been proposed to solve the QAP on GPUs. This parallel algorithm and the sequential one on central processing units are tested and compared for test problems in literature. Indeed, it is observed that the parallel algorithm works averagely 6.31x for Skorin problems and 11.93x for Taillard problems faster than sequentially one.

■ FB-24

Friday, 10:30-12:00 - Room 212

Tools and Applications in Actuarial Sciences

Stream: Actuarial Sciences and Stochastic Calculus
Invited session
Chair: *Anna Castañer-Garriga*

1 - On Log Convex and Log Concave Discrete Random Variables Associated with Counting Processes
Carmen Sangüesa, Francisco Germán Badia

Counting processes are important in insurance as they can describe the arrivals of claims in an insurance company. In the present talk we consider a counting processes stopped at a random time T, independent of the process. Provided that T is log concave (log convex), we give sufficient conditions on the arrival times so that the number of events occurring before T preserves this property. We study both log concavity and log convexity preservation, under the assumption that the process has independent interarrival times. We also apply the log concavity results in inventory models.

2 - Sustainability of Public Pension
Tadashi Uratani

The financial sustainability of public pension requires that the reserve should be positive to pay the benefit in the demographic and economical environment change subject to the certain level of the income replacement ratio. Assuming the market asset and the income for pension follows an Ito processes and we maximize the net present value of pension for the cohort, to guarantee the pension fund sustainability, we apply the martingale method of the optimal consumption and investment theory. We use the age-structured model to the pension population change.

3 - Order Statistics and Insurance Risk Models
Claude Lefèvre

This paper points out and exploits a close connection between the joint distribution of order statistics and the finite-time ruin probability in a class of insurance risk models. An extension to insurance risk models with two classes of insurance business is then investigated. The key mathematical tool is a special family of Appell polynomials with one or two variables.

4 - Optimal Stop-Loss Reinsurance: A Dependence Analysis
Anna Castañer-Garriga, M. Mercè Claramunt

The stop-loss reinsurance stands out among reinsurance contracts in the insurance market. It presents an interesting property: it is optimal if the criterion of minimizing the variance of the cost of the insurer is used. We analyse this contract in one period from the point of view of the insurer and the reinsurer. Firstly, the influence of the parameters of the reinsurance on the correlation coefficient between the cost of the insurer and the reinsurer is studied. Secondly, the optimal stop-loss contract is obtained if the criterion used is the maximization of the joint survival probability.

■ FB-25

Friday, 10:30-12:00 - Room 009

Applications of Metaheuristics

Stream: Applications of Heuristics
Contributed session
Chair: *Hiroyuki Ebara*

1 - A new Heuristic Approach to the Set-Partition Problem
Goranka Nogo, Ivo Ivanisevic

We propose a new heuristic algorithm for solving the set-partition problem. Our algorithm is based on a combination of the best features of a greedy approach and Karmakar-Karp differencing algorithm. The computational results show that our approach has good performance. In some cases, we achieve significantly better results than both greedy approach and Karmakar-Karp algorithm.

2 - A Dual Search Method for Routing Problems
Mona Hamid, Jamal Ouenniche

Routing problems have been at the origin of the design of many optimal and heuristic solution frameworks such as branch-and-bound algorithms, branch-and-cut algorithms, local search methods and metaheuristics. In this research, we design a new dual local search for routing problems and test its performance on the TSPLIB instances. Computational results suggest that the proposed dual search framework is a promising design.

3 - Parallel Consultant-Guided Search for the Traveling Salesperson Problem
Koki Nakayama, Hiroyuki Ebara

Metaheuristic algorithms have been studied as a method for solving combinatorial optimization problems. Recently, the Consultant-Guided Search (CGS) for solving the Traveling Salesperson Problem (TSP) has been proposed. In this paper, we propose a parallel method which assigns consultants and clients of the CGS to processes of computers and calculates an approximation solution for the TSP. We execute a computer experiment with the benchmark instances (TSPLIB) by 10 quad-core computers. Our algorithm provides a solution with less than 6% error rate for problem instances of 3038 cities.

4 - Scheduling Container Trains at Port Botany
Daniel Harabor, Daniel Guimarans, Pascal Van Hentenryck

In a recent work we showed that there exists significant unrealised rail capacity at Sydney's Port Botany. Unlocking this capacity depends on better management of rail resources, including improved staging and scheduling practices. We study the impact of several such changes: (i) we replace fixed servicing windows with anytime servicing; (ii) we apply constraints to train length and rake utilisation; (iii) we schedule and stage trains holistically, between the port and intermodal terminals in the Sydney area. We aim to consolidate trains and move the same container volume with fewer trips.

■ FB-26

Friday, 10:30-12:00 - Room 010

Multiobjective Bi-Level Optimization (contributed)

Stream: Nonsmooth Optimization and Variational Analysis
Invited session
Chair: *Susanne Franke*

1 - Convexification in Multiobjective Semi-Infinite Programming
Francisco Guerra-Vázquez, Jan-J Ruckmann

We deal with multiobjective semi-infinite nonconvex optimization problems which are defined by finitely many objective functions and infinitely many inequality constraints in a finite-dimensional space. Under the reduction approach it is shown that, locally around a proper efficient solution, this problem can be transformed equivalently in such a way that the Lagrangian of the associated weighted sum optimization problem corresponding to the transformed problem is locally convex around the proper efficient solution.

2 - A Proximal Point Method with Generalized Distances for a Class of Bilevel Equilibrium Problems
João Xavier da Cruz Neto, Glaydston Bento, Jurandir Oliveira, Pedro Soares Junior, Antoine Soubeyran

We consider a bilevel problem involving two pseudomonotone equilibrium bifunctions and show that this problem can be solved by an interior proximal point method with generalized distances. We propose a framework for the convergence analysis of the sequences generated by the algorithm. This class is very interesting because it covers mathematical programs and optimization problems over equilibrium constraints.

3 - Bilevel Road Pricing: A Solution Algorithm
Susanne Franke

We consider a road pricing problem which is modeled as a bilevel programming problem: The leader represents the owner of the network who wants to influence the traffic flow by determining tolls, and the follower represents the user of the system. In order to solve this problem, we use the optimal value reformulation of the bilevel programming problem and propose an algorithm. We investigate the structure of the problem and formulate optimality conditions. We show that it is possible to find optimal solutions of the problem with the help of an outer approximation of its feasible set.

■ FB-27

Friday, 10:30-12:00 - Room 213

Infrastructure Development and Environment 2

Stream: Infrastructure Development and Environment
Invited session
Chair:
Chair: *Elise del Rosario*
Chair: *Erik Kropat*

1 - Planning Luanda's Electricity Distribution Network Expansion using a MILP approach
A. Miguel Gomes, António José Moreira, M. Teresa Costa

This work regards the electrical distribution network of Luanda, analysis and planning of what is considered to be urgent about its expansion, selection of locations where it is feasible to locate new substations, appropriate modeling of the real problem and a proposal for an optimal solution to expand the existing network. After analyzing different mathematical models applied to the distribution expansion problem, an MILP approach has been considered adequate. The model was solved by CPLEX. As a means of validation, the solution has been implemented in the Simulator PowerWorld 8.0 OPF.

2 - Optimizing a Supply Chain Network Design under Network Disruptions
Juan Esteban Muriel Villegas, Juan G. Villegas, Carmen Patino Rodriguez

This work studies a strategic supply chain (SC) management problem: How to design a Colombian SC network in the presence of transportation network disruptions caused by the national rain season. We present an optimization model that integrates a multiproduct, multi-echelon SC with economies of scale, and a road network prone to failures with site dependent probabilities. Using a stochastic optimization approach we are able to find a more resilient Colombian SC design that adapts better to different disruptive scenarios while minimizing the total costs of the SC.

3 - Selection of Governments Arrangements for Freight Transport in Mexico City: A Multilevel System
Zaida Estefanía Alarcón-Bernal

With the goal of optimizing the implementation of public politics for freight transportation into the urban area in Mexico City, this paper submits a multilevel program model in which the main problem aims to minimize maintenance costs of the principal roads, taking into account the companies involved in freight transportation within the city, who seek to minimize their operative costs; on a third level, it is considered the reaction of the population, who aims to minimize the impacts such as travel time and pollution. The model suggested can be resolved using a multiparametric approach.

4 - The Challenges in the Waterfront Regeneration by the Participatory Planning
Tomás Hanáček

The Eastern Europe city planning is becoming more flexible, the cities are able to absorb the changes in the different time intervals. The multidisciplinary planning process is based on the communication of all components of the participatory planning (city government, residents, communities, academia, experts). The unexploited brownfield and bluefield areas inside the cities appropriate the public attention. They have the potential to restart social and economic city development. The regeneration process increases the rate of collective knowledge and creates the specific solutions.

■ FB-28

Friday, 10:30-12:00 - Room 130

Advances in MINLP

Stream: Mixed-Integer Nonlinear Programming
Invited session
Chair: *Eva Lee*
Chair: *Ingmar Vierhaus*

1 - Nonlinear Mixed Integer Programming Approach for Cervical Cancer Treatment
Eva Lee

Cervical cancer is slow-growing and in early stages may not have any symptoms. Successful treatment remains challenging and the mortality rate in the U.S. is high at about 35%. We describe novel biological treatment planning designs that incorporate functional PET information for targeted escalated dose delivery. Our study reveals improvement both in local tumor control and organs-at-risk toxicity, two competing and desirable goals that were previously thought to be unachievable simultaneously.

2 - The Convex Hull of Graphs of Polynomial Functions
Wei Huang, Raymond Hemmecke

The convex hull of the graph of a polynomial function over a polytope is the intersection of all closed half-spaces containing the graph. We give a description of these half-spaces using semi-algebraic sets. This gives a finite algorithm to compute the convex hull. For polynomials in low dimension and degree (related to real applications), a polyhedral relaxation can be computed quickly by an algorithm which can be extended to a spatial branch-and-bound algorithm for MINLPs.

3 - Embedding Structural Information in Simulation-Based MINLP Optimization
Vidar Gunnerud

In this presentation, we present a method designed to find optimal settings, both discrete and continues, for a petroleum production network. Emphasis is put on the system being divisible into components, as this underlying assumption motivates the algorithm in its entirety in that rather simple relations between the system components are modeled as explicit structural constraints. The significantly more complex relations within each component are based on simulations, or approximations thereof. This results in a simulation based MINLP formulation with structural algebraic constraints.

■ FB-29

Friday, 10:30-12:00 - Room 011

Societal Complexity and Healthcare

Stream: Methodology of Societal Complexity
Invited session
Chair: *Eizo Kinoshita*
Chair: *Cathal Brugha*

1 - Efficiency of Orthopedic Wards in Acute Hopitals
Zilla Sinuany-Stern, Simona Cohen Kadosh, Lea Friedman

We study the effect of the socio-economic status of patients on the efficiency of orthopedic wards in all acute hospitals in Israel (20 hospitals), from the view point of the regulator — the ministry of Health. At the first stage, Data Envelopment Analysis is used with two inputs, and 3 outputs. As a second stage, regression analysis is utilized to test the effect of the socio-economic status of patients on the efficiency. Our hypothesis is that there is a negative effect of the socio-economic status of patients on the efficiency of orthopedic wards.

2 - Handbook Handling Societal Complexity
Dorien DeTombe

The Handbook 'Handling Societal Complexity: A Study of the Theory of the Methodology of Societal Complexity and the COMPRAM Methodology with Examples of Applications on Global Safety', by Dorien DeTombe, is published. The book describes the theoretical development of the theory and the Compram Methodology, a methodology for policy making for scientists, practitioners, politicians, master and PhD students in the field of Methodology, Social Sciences, Operational Research, Management and Political Sciences. Examples on Healthcare, Economics, Climate Change, Terrorism and Floods.

■ FB-31

Friday, 10:30-12:00 - Room 013

P2P, Social Networks and E-commerce

Stream: Telecommunications and Networks
Contributed session
Chair: *Yuliya Gaidamaka*

1 - Applying Multi-criteria Group Decision Approaches to Explore Online Group Buying Purchase Intention
Yang-Chieh Chin

Online group buying refers to a certain number users who join via Internet to buy a certain product at a discounted price. It is a multi-criteria group decision problem. Thus, this study uses a dominance-based rough set approach (DRSA) to determine the collective decision rules of the initiators and users, representing a generalized description of the decision makers' preference information. The second phase of the study uses the collective decision rules to classify all decision objects. Practical and research implications are also offered.

2 - Pancake Graph based Solution for Improving Dynamicity in P2P Networking
Amad Mourad, Djamil Aïssani, Mordji Zouweyna

P2P networking has been largely developed in recent time. However, high dynamicity is already a serious problem in most developed applications. Particular graphs have been proposed as underlying architecture such as De Bruijn and Pancake graphs. In this paper, we propose an optimized scheme for lookup acceleration in peer to peer network based on Pancake graph. The proposed model is pragmatic and easy to implement. Performance evaluations show that the results are globally satisfactory, especially in term of cost lookup with high churn rate.

3 - Construction and Analysis of a Mathematical Model for Data Buffering in Peer-to-Peer Based Streaming Networks
Yuliya Gaidamaka, Andrey Samuylov, Konstantin Samouylov, Sergey Shorgin

The detailed mechanism of data exchange between peers in streaming P2P-network is investigated, the network performance measures and quality of service (QoS) parameters are determined. A mathematical model for buffering streaming data in P2P-network is built as a Markov chain. The model takes into account buffer sizes, peers churn, playback lags, up- and download rates, collisions, and downloading strategy. The main network performance parameters are latency, startup delay, playback continuity, and universal streaming. The results of calculation of main QoS parameters are given.

■ FB-32
Friday, 10:30-12:00 - Room 014

Forecasting Methods

Stream: Forecasting Methods
Contributed session
Chair: *Chris Tofallis*

1 - A Complexity Improvement Strategy for the Mycielski Binary Forecasting Algorithm for Fast and Efficient Prediction
Omer Nezih Gerek, Mehmet Fidan

Mycielski algorithm is a strong binary forecasting method that depends on infinite-past observations. It traces the whole series for the longest suffix word that appears at the tail of the sequence. The repeated past search makes the algorithm complexity non-polynomial. By slightly increasing memory demands, we propose an improvement of the search using a dictionary-based approach. Eventually, the process speeds up to a polynomial order. Due to the similarity of the improvement to the famous LZ-78 method over the non-polynomial LZ-77, we call the new method the Mycielski-78 method.

2 - On a Time Series Forcasting Method based on Walsh Transform
Erik Bajalinov, Szabolcs Duleba

Many real-world time series exhibit strong seasonal behavior and may be successfully forecasted using Holt-Winters exponential smoothing methods. Our recent research connected with the Walsh functions shows that sometimes when analyzing time series the so called Walsh transform can lead to very accurate predictions. In our talk we discuss this unique approach, demonstrate some real-world numerical examples with highly accurate results and compare obtained results.

3 - Why MAPE Should not be used to Compare Forecasting Methods
Chris Tofallis

Surveys show the mean absolute percentage error is the most widely used measure of forecast accuracy in businesses. Yet it systematically favours methods which under-forecast. We explain this effect. We investigate an alternative relative error metric, based on the forecast/actual ratio, which overcomes this problem. We illustrate its use in estimating the prediction model and show that this has a multiplicative error. It predicts the geometric mean and so is less affected by outliers, and possesses a suitable form of unbiasedness for relative accuracy. This measure seems preferable to MAPE.

4 - A Forecasting Method for Non-Stationary Spare Parts Demand
Laura Turrini, Joern Meissner

Contextual events can strongly influence demand for spare parts: a very hot summer, for example, may increase the demand of delicate parts, while cancellation of a maintenance contract will reduce it drastically. Depending on so many contextual factors, demand fluctuates in size, and misses out the stationarity assumed in classic models. We develop a forecasting method that deals with non-stationarity of demand: it uses Hidden Markov Chains to model the demand generation process and estimates its parameters through history. We apply our method to distinct datasets to prove its practical use.

■ FB-34
Friday, 10:30-12:00 - Room 016

Knowledge Work and Workers

Stream: Knowledge in Organizations
Invited session
Chair: *A. D. Amar*

1 - A Knowledge and Capability Based View on Performance-Based Contracting in Defence Acquisition
Thomas Ekstrom, Kostas Selviaridis

The Swedish Defence Procurement Agency (DPA) is in the process of changing from procurement of equipment to acquisition of performance, and from procurement through competition to acquisition through, e.g., partnering. In addition, the Swedish Armed Forces and the DPA are transferring resources, roles and responsibilities, between them, in order to enhance overall effectiveness and efficiency. Based on a knowledge and capability based view, this paper reports on research that has been initiated in order to investigate how knowledge and capability is developed and maintained in this context.

2 - Innovation vs. Efficiency in the Supply Chain
Ajay Das

One source of competitive advantage is innovation. Another is process efficiencies. But process efficiency focuses on variance reduction and even flows. Innovation needs variance and experimentation. Is the pursuit of process efficiency then incompatible with the pursuit of innovation? And, specifically, considering the increasing size of external value-partitioning, does this incompatibility extend to supply chains as well? We theorize and examine the issue.

■ FB-35
Friday, 10:30-12:00 - Room 131

Stochastic Modeling and Simulation with Applications

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Contributed session
Chair: *Gennadiy Burlak*

1 - Utilizing a Trend-Renewal Framework for Estimating Repair Effects in Failing Systems
Ernie Love, Qingyu Yang

A failing system experiences multiple failure modes each of which causes system shutdown with subsequent repair and restart. A trend-renewal framework is utilized to capture the repair effects for each mode of failures/repair. Data was collected on a cement kiln incurring 150 failures and 5 shutdowns for overhaul. Causes of failure were identified as operational, mechanical or electrical. A trend-renewal framework is seen to usefully capture the (expected) improved failure rate by virtue of the repairs. Comparisons with Kijima virtual age frameworks are made.

2 - A Stochastic Optimization for Chemical Separation Problems
Fattaneh Cauley

This research presents a non-convex mathematical programming model of chemical separation problems. The model is based on algebraic relationships of the Standing Wave Design (SWD) equations, where by solving these equations the desired product purity and yield for many systems is guaranteed. The model can easily be modified for simultaneous optimization of a large number of variables. Pairing the model with two stochastic optimization algorithms, Simulated Annealing, and Genetic Algorithm, produces efficient tools for solving multi-objective optimization problems of SMB systems.

3 - Object-Oriented Approach at Optimization of Interacting Quasi-Similar Objects in Optical Simulations
Gennadiy Burlak

Study the properties of a complex system with interaction of many subsystems is interpreted as interaction of collection of quasi-similar objects. We apply this approach to study behavior of the photon spectrum in microspheres with many quasiperiodic layers. We considered a layer as a separate object having internal complex structure with fields, methods reflecting the specific behaviour. Our simulations have detected that the quasiperiodicity parameter of such objects can exceed the golden mean value. Then in such structure the extremely narrow resonances with complete transmittance arise.

■ FB-36

Friday, 10:30-12:00 - Room 132

Healthcare Management

Stream: Healthcare Management
Invited session
Chair: *Subhash Datta*
Chair: *Gerhard-Wilhelm Weber*

1 - HIV Diagnostic Service Delivery in South Africa: Scenario Analysis using a Multi-Objective Version of the Uncapacitated Fixed-Charge Location Model
Louzanne Oosthuizen, Johannes Gerhardus Benade, James Bekker

The commercial availability of a new, point-of-care device for HIV diagnostic testing has prompted a need to re-evaluate the delivery of diagnostic services in the South African public healthcare sector. The basic structure of the uncapacitated fixed-charge location model is expanded in this work to a multi-objective model and adapted to take location costs, operating costs, transport distances, service delivery levels and health impact into consideration in order to evaluate alternative scenarios for incorporating this testing device into the South African laboratory and hospital network.

2 - Models for Preventing and Treating Malaria in Resource-Constrained Regions
Susan Martonosi

Malaria is endemic throughout Africa and other regions of the world. While interventions exist to prevent malaria or reduce its consequences, resources for distributing these interventions in developing areas are limited. I will present an optimization framework for choosing cost-effective allocations of interventions across several geographic regions and multiple time periods subject to budget constraints.

3 - Optimal Appointment Schedules in a Hospital Radiology Department
Engin Bayturk, Sila Halulu, Fadime Üney-Yüksektepe

There have been growing health problems in recent years. Magnetic Resonance Imaging (MRI) results are expected for almost each patient to decide their treatment modalities. Therefore, demands of appointments for MRI machines are increasing rapidly. Since MRI machines of the hospitals are limited, they cannot meet the appointments. For this reason, the patients have to wait for about 6 months. In our study, we made an optimal schedule of the appointments for one of the biggest state hospital in Turkey. The results are compared with a current schedule and the improvements are discussed.

■ FB-37

Friday, 10:30-12:00 - Room 017

Managing Transshipments

Stream: Recovery Inventory Management Policies
Invited session
Chair: *Jianjun Xu*

1 - Decision Models for Purchasing and Reselling of Unused Spaces in Less-than-truckload Trips
Manop Reodecha, Naragain Phumchusri, Wissanu Sammaung

This extended multi-period newsboy decision model is to maximize the expected profit of a low-cost third-party logistics service provider (LSP) who purchases unused spaces in truck trips from other LSPs to service its customers. It helps to find an optimal target space to purchase for each route in a specific period and helps to decide to accept or reject each customer's service request. Trip offers and requests come gradually in periods prior to the actual trips with known probability distributions in each period. A truck trip allows multiple delivery and pick-up points and transshipments.

2 - Production and Transshipment Management of Two Manufacturing Facilities: Dynamics, Efficient Optimal Policy and Characteristics
Jianjun Xu, Youyi Feng

We study the optimal inventory and transshipment policy of a finite horizon, periodic review inventory system of two manufacturing facilities that replenishes the same product to fulfill stochastic demands. In each period the system plans to produce at both facilities and the production will be completed at the end of the period. After demands are realized, the leftover inventory of any facility can be transferred into the other facility. We show that the dynamics of optimal production and transshipment decisions in both facilities are specified by monotone switching curves.

3 - Multi-Refinery Product Transportation Optimization
Eren Cicek, Metin Turkay

Petroleum refining is a low-margin and very competitive industry. Thus for the multiple refinery operating companies, inter-refinery transportation of semi-products are vital for maximum utilization. The paper discusses the reciprocal transportation network between two refineries in Turkey, small one near the drilling site and complex one for meeting required product specifications. Transportation modes are railroad tankers, road haulage and blending the products into crude oil pipeline. The challenge is to minimize the overall transportation cost under fluctuating costs and demands.

4 - Approximate Dynamic Programming for Lateral Transshipment Problems in Multi-Location Inventory Systems
Olga Rusyaeva, Joern Meissner

To fix the mismatch between actual customer demand and the available stock in multiple locations under the inability to replenish from a central warehouse, companies often turn to lateral transshipments. We propose a proactive transshipment policy that answers the question from which source to which destination how many units should be transshipped in advance to maximize the revenue of the network. For high-dimensional instances, we develop a heuristic that constructs a concave piecewise-linear approximation and updates it using stochastic sample gradients.

■ FB-38

Friday, 10:30-12:00 - Room 214

Assessing Systemic Risk

Stream: Operational Research and Quantitative Models in Banking
Invited session
Chair: *Raffaella Calabrese*

1 - Modelling the Probability of Government Measures and Failures During the 2008-2012 through the GEV Model
Marta Degl'Innocenti, Raffaella Calabrese

After the autumn of 2008, the Euro-system and USA adopted a series of extensive measures to ensure financial and economic stability. Focusing on the US and EU banking industry, we employ the generalized extreme value regression (GEV) model proposed by Calabrese and Osmetti (2013) to estimate the probability of receiving ad hoc government interventions, namely recapitalization, debt guarantees and asset relief over the period 2008-2012. These estimates are then compared with the probability of bank failures.

2 - Carrying the (Paper) Burden: A Portfolio View of Systemic Risk and Optimal Bank Size
Jaap Bos, Martien Lamers, Victoria Purice

We examine the relationship between bank size and financial stability by viewing the supervisor of a banking system as an 'investor' holding a portfolio of banks. Based on this view, we investigate the role of large banks in determining the systemic risk in this portfolio. Using data on US banks and bank holding companies, our results indicate that the largest banks in the current portfolio are consistently overrepresented compared to the minimum variance portfolio, and that the riskiness of the portfolio can be reduced without sacrificing returns by limiting concentration.

3 - Modelling Cross-Border Bank Contagion using Marshall-Olkin Copula
Raffaella Calabrese, Silvia Osmetti

In this paper, we propose a new copula based methodology for modelling cross-border bank contagion. In this work we use copulae to model the dependence structure of times to defaults for banks located in two different countries. We suggest to apply the Marshall-Olkin(MO) copula for modelling bank contagion. The second innovative aspect of this work is to consider a Type I censored sampling. The sample information of non-defaulted banks can be so used to estimate the bank contagion. Finally, we apply the proposed approach to analyse the contagion between the Italian and British banking systems.

■ FB-39
Friday, 10:30-12:00 - Room 018

Discrete Optimization III

Stream: Discrete and Global Optimization
Contributed session
Chair: *Tonguc Ünlüyurt*

1 - Multi-Start Local Search Heuristic for the Cell Formation Problem
Mikhail Batsyn, Ilya Bychkov, Panos Pardalos, Pavel Sukhov

In this talk we present a local search heuristic for the cell formation problem. This problem consists in clustering of machines and parts into production cells such that the inter-cell movement of parts is minimized and the intra-cell movement is maximized. The local search procedure is repeated many times for randomly generated cell configurations. We improve a random solution moving one machine or part from one cell to another until the objective increases. Our experiments are performed for popular instances from the literature. Better solutions unknown before are found for several of them.

2 - Sequential Testing with Fixed Costs in Batches
Tonguc Ünlüyurt, Baris Selcuk, Ozgur Ozluk

Sequential Testing problem requires the identification of the correct state of a system when learning the states of the individual components of the system is costly. The goal is to minimize expected cost when probability of the state of each component is known. In this work, we consider an extension of the problem where multiple tests can be executed simulataneously. In this case the advantage would be to incur the fixed cost only once. In this work, we consider a series system where a given set of subsets of tests can be performed together. We report some initial computational results.

3 - Adaptivity in the Stochastic Blackjack Knapsack Problem
Aleksander Vainer, Asaf Levin

We bound the improvement of a policy due to adaptivity in a variant of the stochastic knapsack where the values are deterministic and the sizes have independent random distributions. In our problem items are chosen sequentially. The act of choosing an item instantiates its size. If the final subset is feasible, its value equals the sum of values of its items. Otherwise its value is zero. The goal is to find a policy maximizing its expected value. We study the adaptivity gap for this problem and other variants (or special cases).

4 - Canonical Duality Method for the Design of FIR Filters with Signed-Powers-of-Two Coefficients
Ning Ruan

We consider the optimal design of finite impulse response filters (FIR) with sums of signed-powers-of-two coefficients, which is based on the weighed integral square error criterion. This problem is formulated as a constrained integer programming problem. We construct the corresponding canonical dual problem through canonical duality theory. Then the analytic solution is obtained by criticality condition. It is noted that the dual problem over a positive definite space is a concave maximization problem over a convex set, and hence can be solved efficiently by existing optimization techniques.

■ FB-40
Friday, 10:30-12:00 - Room 019

Quantitative Models for Performance and Dependability II

Stream: Quantitative Models for Performance and Dependability
Invited session
Chair: *Sabri Erdem*

1 - Local-Scale Maximum Daily Ozone Prediction by using Artificial Intelligence Techniques
Bing Gong, Joaquin Ordieres-Mere

Ozone (O3) is one of the worst harmful pollutants nowadays which affects public health, damage the crop growing then lead to serious economic loss. In this study, some state-of-art artificial intelligence (AI) techniques such as Neural Network, Support Vector Machine, Random Forest and Ensemble methods will be used for predicting ozone level locally at different stations in the Valley Metropolitan Area of Mexico area which is considered as one of the biggest cities worldwide. Besides, integrate local-scale prediction models at different stations into a regional-scale model will be considered.

2 - A Bagging-Based Undersampling Strategy for Classification: A Customer Churn Prediction Application
Kristof Coussement, Geert Verstraeten

Several researchers have investigated how to overcome rare events in classification settings through undersampling. This research study uses real-life churn datasets to deliver insights into the merits and drawbacks of undersampling. This setting is an ideal test bed given that customer churn is often considered a rare event in multiple industries, while the classification context could largely benefit from undersampling given the large datasets. The authors propose a new bagging-based undersampling strategy that delivers promising performance results against existing methods.

3 - Assessing Entrepreneurial Potential of Individuals using Principal Component Analysis
Sabri Erdem, Nilay Bıçakcıoğlu, Mehmet Çağlıyangil

Entrepreneurship has taken considerable attention since it plays a vital role in contributing to the economy of a country. This paper studies entrepreneurship by collecting all the characteristics reviewed from the literature and develops an entrepreneurial scale to measure whether people have an entrepreneurial spirit. Our methodology is followed by expert opinions, questionnaire design and principal component analysis (PCA). The results show that PCA can be applied to measure entrepreneurship ability and guide following studies by providing a comparison tool for entrepreneurship ability.

■ FB-41

Friday, 10:30-12:00 - Room 216

Network Congestion Models

Stream: Traffic Equilibrium
Invited session
Chair: *Patrice Marcotte*
Chair: *Niccolo' Bulgarini*

1 - Novel Formulations for Stackelberg Security Games
Carlos Casorrán-Amilburu, Martine Labbé, Bernard Fortz, Fernando Ordonez

We present new tight formulations for the Single-type-of-Follower Stackelberg Game and for the Single-type-of-Attacker Stackelberg Security Game, improving the current formulations present in the literature. We show that both formulations provide a complete linear description of the convex hull of the sets of feasible solutions of the corresponding problems and show that one formulation is the projection of the other on the appropriate space. The formulations presented for the Bayesian case improve the continuous relaxations of existing formulations. Computational experiments are carried out.

2 - Derivative-Free Algorithms for the Estimation of Dynamic Demand Structure using Traffic Counts
Bojan Kostic, Daniele Tiddi, Guido Gentile

As travel demand is an essential input to the Dynamic Traffic Assignment (DTA) model, it is crucial to have correct Origin-Destination (O-D) matrices. In this paper we compare different derivative-free algorithms for the demand estimation, focusing on the structure of the matrices instead on the single entries. This is a non-linear bi-level problem as it involves congestion dynamics and user equilibrium. Three algorithms (SPSA, Nelder-Mead, CMA-ES) will be applied in different traffic regimes to investigate their ability of converging to a known solution, after perturbing the initial demand.

3 - A Convergent and Efficient Decomposition Method for the Symmetric Traffic Assignment Problem
Marco Sciandrone, David Di Lorenzo

We consider the symmetric network equilibrium problem, formulated as a convex minimization problem whose variables represent the path flows. In order to take into account the difficulties related to the large dimension of real network problems we adopt a decomposition-based approach, suitably combined with a column generation strategy. We present an inexact block-coordinate descent method with proven global convergence. Computational experiments performed on medium-large dimensional problems show that the proposed algorithm is competitive with state of the art methods.

4 - Decomposition Methods for One-Level Formulations of the Origin-Destination Estimation Problem
Niccolo' Bulgarini, David Di Lorenzo, Fabio Schoen, Marco Sciandrone

The most general formulation of the Origin-Destination (OD) estimation problem is a bilevel programming model based on observations from a link subset and on historical OD information. We consider one-level convex optimization problems, as relaxed OD estimation formulations, and propose convergent decomposition algorithms for large-scale problems. The proposed algorithms take into account that one-level formulations can be viewed as static traffic assignment problems with elastic demand, where negative cycles may be present in the network. Computational results are presented and discussed.

■ FB-42

Friday, 10:30-12:00 - Room 215

Qualitative Multiple-Criteria Decision Making II

Stream: Qualitative Multiple Criteria Decision Making
Invited session
Chair: *Marko Bohanec*
Chair:

1 - Numerical Relational Multi-Attribute Models in Qualitative Multi-Attribute Method DEX
Nejc Trdin, Marko Bohanec

DEX is a qualitative decision support method aimed at evaluation and analysis of decision alternatives. Many real decision problems are based on relational properties between at least two types of entities, and require a combination of numeric and symbolic attributes. For example, evaluation of bank's reputational risk has relations between banks, bank's counterparts and clients, and financial products. In this work we address the task of extending DEX to facilitate evaluation of relationally connected decision alternatives, described with a combination of numeric and symbolic attributes.

2 - Multi-Attribute Model for Assessment of SMEs Adoption of High Performance Computing Cloud Services
Mirjana Kljajic Borstnar, Tomi Ilijas, Andreja Pucihar

High Performance Computing offered as a cloud service is regarded as one of the key competitiveness boosters for SMEs, particularly manufacturing. However, business models are not yet explored, and technology adoptance is in its early stages. In order to explore and support new business ideas there is need for assessment of the SMEs readiness and market viability. Based on theory and practice we are proposing a qualitative multi-attribute model for SMEs' cloud HPC adoption assessment. The model will be verified on a set of experiments conducted within several EU projects in I4MS initiative.

3 - Business Intelligence System Complexity, and Approaches to Understand the User Segments in Business Intelligence Systems and Adapt Data Cubes to User Needs
Violeta Mirchevska, Igor Korelič, Matjaz Gams, Franc Škedelj, Mirjana Kljajic Borstnar, Vladislav Rajkovic

Business intelligence (BI) systems offer wide variety of functionalities for data retrieval, analysis and visualization, improving the quality of business decision-making. Still, the usage analyses reveal rather low BI adoption. In this contribution, we discuss the complexity of BI systems and approaches to make them user- and context-specific. We analyse results of a case study for determining different types of BI users from system-user interaction traces using clustering, and adaptation of data cubes to user needs by using multiple criteria decision analysis.

4 - Information Gathering for Multiple-Attribute Selection Decisions
Dennis Leber, Jeffrey Herrmann

Multiple-attribute selection decisions require gathering information using observations that can provide data about only one of the attributes at a time. When resources are scarce, the decision-maker must choose which attributes to observe (sample) in a way that maximizes the likelihood that the correct alternative will be selected. This talk will describe sample allocation policies for multiple-attribute selection decisions with attribute values estimated through pass-fail testing (Bernoulli trials) and those estimated by techniques that are subject to normally distributed measurement error.

■ FB-43

Friday, 10:30-12:00 - Room 217

Risk Management and Performance Analysis

Stream: Operational Research and Quantitative Models in Banking
Contributed session
Chair:
Chair:
Chair: *Jake Ansell*

1 - GAM Models Explore Non-Parametric Feature of UK SMEs Performance During Financial Crisis
Jake Ansell, Meng Ma, Galina Andreeva

This paper extends our understanding of SMEs performance during the past crisis from standard models into semi parametric methods. Employing Generalized Additive Models (GAM) to investigate both linear and nonparametric features of UK SMEs provides useful insight. We find nonparametric effects are significant for both start-up SMEs and non-start-ups. GAM models improve our understanding of comprehensive SMEs performance during the switch in the economy. Several measures have been used for comparison with standard models.

2 - Lending Decisions with Limits on Capital Available
Lyn Thomas, Mee Chi So

In order to stimulate or subdue the economy, banking regulators have sought to impose caps or floors on individual bank's lending to certain types of borrowers. This work shows that the resultant decision problem for a bank of which potential borrower to accept is a variant of the marriage/secretary problem where one can accept several applicants. This work solves the decision problem using dynamic programming. By solving numerical examples we show the potential loss of profit and the inconsistency in the lending decision that are caused by introducing floors and caps on lending.

3 - Feasible Algorithms for Lattice and Directed Subspaces
Piotr Wojciechowski, Vladik Kreinovich, Jennifer Del Valle

In some practical situations it is important to check whether a given linear subspace of a vector-lattice is a lattice. In financial applications, it was proven by Abramovich et al. (J. of Economic Dynamics & Control 2000) that the existence of appropriate minimum-cost insured portfolios is equivalent to the fact that the linear space generated by the corresponding financial instruments is lattice-ordered. In the talk we present feasible, polynomial-time, algorithms for solving the problem. Some generalizations and future applications will be discussed.

Friday, 12:15-13:45

■ FC-50

Friday, 12:15-13:45 - Plenaries room

Plenary Session K. Smith-Miles

Stream: Plenary Sessions
Keynote session
Chair: *Stefan Nickel*

1 - Understanding Strengths and Weaknesses of Optimization Algorithms with new Visualization Tools and Methodologies
Kate Smith-Miles

Objective assessment of optimization algorithm performance is notoriously difficult, with conclusions often inadvertently biased towards the chosen test instances. Rather than reporting average performance of algorithms across a set of chosen instances, we discuss a new methodology to enable the strengths and weaknesses of different optimization algorithms to be compared across a broader instance space. Results will be presented on TSP, timetabling and graph coloring to demonstrate: (i) how pockets of the instance space can be found where algorithm performance varies significantly from the average performance of an algorithm; (ii) how the properties of the instances can be used to predict algorithm performance on previously unseen instances with high accuracy; (iii) how the relative strengths and weaknesses of each algorithm can be visualized and measured objectively; and (iv) how new test instances can be generated to fill the instance space and provide desired insights into algorithmic power.

Friday, 14:00-15:30

■ FD-50

Friday, 14:00-15:30 - Plenaries room

Closing Ceremony

Stream: Plenary Sessions
Invited session

STREAMS

Actuarial Sciences and Stochastic Calculus

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Track(s): 24

AHP (Analytic Hierarchy Process) /ANP (Analytical Network Process)

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Track(s): 37

Algorithmic Game Theory

Ron Lavi
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Track(s): 22

Algorithms and Computational Optimization

Basak Akteke-Ozturk
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Track(s): 43

Allocation Problems in Game Theory

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Track(s): 30

Analytics Application and Practice

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Track(s): 23

Applications of Dynamical Models

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Track(s): 30

Applications of Heuristics

Geir Hasle
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Track(s): 25

Auctions

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Track(s): 41

Aviation

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Track(s): 3

Behavioural Operational Research

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Track(s): 23

Big Data Analytics

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Track(s): 42

Biomass-Based Supply Chains

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Track(s): 38

Business Analytics Optimization and Big Data

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Diego Klabjan
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Track(s): 45

Challenge ROADEF/EURO

Eric Bourreau
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Track(s): 28

City Logistics and Freight Demand Modeling

Jose Holguin-Veras
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Track(s): 6

Combinatorial Optimization

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Track(s): 2 11

Computational Statistics

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Track(s): 43

Continuous and Discontinuous Dynamical Systems

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Track(s): 12

Convex Optimization Methods and Applications

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Marc Teboulle
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Track(s): 38

Copositive and Polynomial Optimization

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Daniel Plaumann
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Track(s): 16

Cutting and Packing

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José Fernando Oliveira
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Track(s): 21

Data Mining

Dolores Romero Morales
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Track(s): 25

Data Mining in Finance and Commodities

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Dejan Stokic
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Track(s): 34

Data Mining, Knowledge Discovery and Artificial Intelligence

Karla Hoffman
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Track(s): 32

DEA Applications

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Meryem Duygun Fethi
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Track(s): 14

Decision Analysis, Decision Support Systems

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Track(s): 27

Decision Making Modeling and Risk Assessment in the Financial Sector

Cristinca Fulga
Gheorghe Mihoc-Caius Iacob Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy
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Track(s): 34

Decision Processes

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Track(s): 31

Decision Support Systems

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Track(s): 42

Defence and Security Applications

Ana Isabel Barros
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Track(s): 33

Demand and Supply Planning in Consumer Goods and Retailing

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Track(s): 19

Discrete and Global Optimization

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Dynamic and Repeated Games

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Dynamic Programming

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Track(s): 8

Dynamical Models in Sustainable Development

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Track(s): 7

Dynamical Systems and Mathematical Modelling in OR

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Energy Economics, Environmental Management and Multicriteria Decision Making

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Equilibrium Problems in Energy

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Track(s): 7

Experimental Perspectives and Challenges in Management Accounting and Management Control

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Financial Mathematics and OR

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Financial Optimization

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Forecasting Methods

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Fuzzy Decision Support Systems, Soft Computing, Neural Network

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Fuzzy Optimization - Systems, Networks and Applications

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Game Theory

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Game Theory and Operations Management

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Geometric Clustering

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Global Optimization

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Graphs and Networks

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Green and Humanitarian Logistics

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Health Care Applications

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Health Care Data Analytics

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Healthcare Management

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Humanitarian Operations Research

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Hybrid Heuristics

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Infrastructure Development and Environment

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Intelligent Optimization in Machine Learning and Data Analysis

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Interior Point Methods and Conic Optimization

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Track(s): 17

International Aspects of OR: Cooperation — Coordination — Communication

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Knowledge in Organizations

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Logistics in Health Care

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Lot-Sizing and Related Topics

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Managing Risk in Supply Chains

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Maritime Transportation

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Mathematical Economics

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Track(s): 25

Matheuristics

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Meta-Analytics: A Marriage of Metaheuristics and Analytics

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Metaheuristics

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Methodology of Societal Complexity

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Mixed-Integer Nonlinear Programming

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Multiobjective Linear, Integer, and Combinatorial Optimisation

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Multiobjective Optimization

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Multiobjective Optimization - Theory, Methods and Applications

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Multiple-Criteria Decision Making and Optimization

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Nonlinear Programming

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Nonsmooth Optimization and Variational Analysis

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Operational Research and Quantitative Models in Banking

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Operational Research in Financial and Management Accounting

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Operations Finance Interface

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Operations/Marketing Interface

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Optimization Models and Algorithms in Energy Industry

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OR in Agriculture, Forestry and Fisheries

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OR in Water Management

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Petroleum Logistics

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Preference Learning

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Production and the Link with Supply Chain

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Production Management & Supply Chain Management

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Project Management and Scheduling

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Qualitative Multiple Criteria Decision Making

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Quality and Performance Measurement in Humanitarian Relief Chains

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Quantitative Models for Performance and Dependability

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Railway and Metro Transportation

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Realistic Production Scheduling

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Recovery Inventory Management Policies

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Revenue Management I

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Scheduling

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Scheduling under Resource Constraints

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Simulation in Management Accounting and Management Control

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Simulation Methods in Finance

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Simulation-Optimization in Logistics & Production

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Stochastic Modeling and Simulation in Engineering, Management and Science

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Stochastic Models for Service Operations

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Stochastic Optimization in Energy

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Stochastic Programming

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Strategy and Analytics

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Theoretical Developments in DEA

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Traffic Equilibrium

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Traffic Flow Theory and Traffic Control

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Vehicle Routing

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