Technical Sessions – Monday July 11

Track	Meeting Rooms	Plenary 09:00 - 11:00	MA 11:30 - 13:00	MB 14:00 - 15:30	MC 16:00 - 17:30
1	Plenary Hall 3	Opening Ceremony Opening Plenary: Sir James A. Mirrlees, Optimum Choice Sets: How Tightly Should we Regulate? Plenary Hall 3	**Development Prize**	**Development Prize**	**Development Prize**
			Development Prize Presentations I	Development Prize Presentations II	Development Prize Presentations III
2	Meeting Room 101		**Game Theory**	**Game Theory**	**Game Theory**
			Game Theory Applications in Marketing	Game Theory Applications in Operations Management I	Game Theory Applications in Operations Management II
3	Meeting Room 102		**Meta-heuristics**	**Meta-heuristics**	**Meta-heuristics**
			Math-Heuristics	Hybrid Metaheuristics	Innovative Algorithms for Container Management
4	Meeting Room 103		**Operations Management**	**Operations Management**	**Operations Management**
			Current Issues in Inventory Management	Spare Parts Inventory Systems	Production Line Design
5	Meeting Room 104		**Service Science and Sustainability**	**Service Science and Sustainability**	**Service Science and Sustainability**
			New Mathematical Paradigms for Service Science	Service Operation Management	Sustainability and Service Provision
6	Meeting Room 105		**Non-linear Optimisation**	**Transportation**	**Transportation**
			Sparse Optimization and Applications	Aviation Optimization	Routing and planning
7	Meeting Room 106		**Cutting and Packing**	**Cutting and Packing**	**OR software**
			Cutting and Packing 1	Cutting and Packing 2	OR software
8	Meeting Room 107		**Bioinformatics**	**Bioinformatics**	**Bioinformatics**
			Tutorial	Algorithms for Nucleic Acid Analysis	Computational Methods in Biomolecular and Phylogenetic Analyses
9	Meeting Room 108		**Vehicle Routing**	**Vehicle Routing**	**Vehicle Routing**
			Stochastic Demand & Dynamic Travel Time	Rich Vehicle Routing	Pick-up and Delivery
10	Meeting Room 111		**Time Definite Logistics**	**Time Definite Logistics**	**Time Definite Logistics**
			Freight Transport Practice	Strategic Network Design for Time-sensitive Networks	Metaheuristics for Time-Definite Logistics
11	Meeting Room 112		**Submodular Structures and Optimization**	**Submodular Structures and Optimization**	**Submodular Structures and Optimization**
			Discrete Convexity in Operations Research	Queueing Models and Analyses I	Queueing Models and Analyses II
12	Meeting Room 205		**Contributed Talks**	**Contributed Talks**	**Travel Behaviour**
			Trade and Development	Services Management	Travel behaviour 1
13	Meeting Room 206		**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**
			Power, Control and Optimization	Data Mining and Continuous Optimization	Optimal Control
14	Meeting Room 207		**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**
			Variational Analysis	Nonsmooth Optimization I	Stability in Optimal Control and Optimal Control Applications in Economics
15	Meeting Room 208		**Military, Defense and Security Applications**	**Military, Defense and Security Applications**	**Military, Defense and Security Applications**
			Special Issues in Military Modeling	Analyses for Air and Space Operations	Military Soft Operations Research
16	Meeting Room 209		**Scheduling**	**Scheduling**	**Scheduling**
			Scheduling with Breakdowns	Scheduling Service and Manufacturing Systems	Task Scheduling with Learning Effects
17	Meeting Room 214		**Multicriteria Decision Analysis and Multiobjective Optimisation**	**Multicriteria Decision Analysis and Multiobjective Optimisation**	**Multicriteria Decision Analysis and Multiobjective Optimisation**
			Robust Multi Criteria Decision Analysis	Artificial Intelligence for MCDA	Multi-Objective Combinatorial Optimization
18	Meeting Room 215		**Data Envelopment Analysis**	**Data Envelopment Analysis**	**Data Envelopment Analysis**
			Applications of DEA in Firms and Industries	DEA Theortical development - 1	Applications of DEA in Agriculture and Farm Efficiency
19	Meeting Room 216		**Education and Operations Research**	**Education and Operations Research**	**Education and Operations Research**
			Making OR More Interesting For Students	Projects & Cases - Getting Students Involved	Games and OR Education
20	Meeting Room 217		**Soft OR and Problem Structuring**	**Soft OR and Problem Structuring**	**Soft OR and Problem Structuring**
			Soft OR I	Soft OR II	Soft OR III
21	Meeting Room 218		**OR in Agriculture**	**Forestry Applications**	**Forestry Applications**
			OR in Agriculture	OR in Forestry	OR in Forestry II

Technical Sessions – Tuesday July 12

Track	Meeting Rooms	TA 09:00 - 10:30	TB 11:00 - 12:30	Plenary 13:30 - 14:30	TC 15:00 - 16:30	TD 17:00 - 18:30
1	Plenary Hall 3	**OR Practice** IFORS SURVEY on OR PRACTICE 1	**OR Practice** IFORS SURVEY on OR PRACTICE 2	Plenary: Dr.Brenda Dietrich, Operations Research for a Smarter Planet Plenary Hall 3	**OR Practice** OR Consultancy and Case Studies	**OR Practice** OR Consultancy and Case Studies 2
2	Meeting Room 101	**Game Theory** Game Theory Applications in Operations Management III	**Game Theory** Game Theory Applications in Economics I		**Game Theory** Game Theory Applications in Economics II	**Game Theory** Issues in Game Theory
3	Meeting Room 102	**Meta-heuristics** Simulation at Container Terminals	**Meta-heuristics** Modern Heuristics in Transportation		**Meta-heuristics** Metaheuristics	**Meta-heuristics** Metaheuristics Applications to Production Planning with Deterioration & Perishability
4	Meeting Room 103	**Operations Management** Issues in Supply Chain Procurement	**Operations Management** New Directions in Operations Management		**Revenue Management and Dynamic Pricing** Revenue Management 2	**Revenue Management and Dynamic Pricing** Revenue Management 1
5	Meeting Room 104	**OR and Marketing** Marketing/Operations Interfaces I	**OR and Marketing** Marketing/Operations II		**OR and Marketing** Marketing/Operations III	**OR and Marketing** Marketing/Operations IV
6	Meeting Room 105	**Transportation** Workforce Management in Vehicle Routing	**Transportation** Routing Problems: Innovative Applications & Solution Techniques		**Transportation** Models and Methods for City Logistics	**Transportation** City Logistics
7	Meeting Room 106	**Discrete Optimization** Flow Problems - Easy, Hard, and (almost) Impossible	**Discrete Optimization** Discrete Optimization		**Combinatorial Optimization** Topics in Combinatorial Optimization I	**Combinatorial Optimization** Topics in Combinatorial Optimization II
8	Meeting Room 107	**Service & Health Care Operations** Health Care Operations I	**Service & Health Care Operations** Health Care Operations III		**Dynamic Programming** Bandit Processes and Resource Allocation	**Dynamic Programming** Supply Chain Management & Logistics
9	Meeting Room 108	**Vehicle Routing** Arc Routing & Node Routing	**Vehicle Routing** Meta-heuristic Approaches to Vehicle Routing		**Vehicle Routing** VRP I	**Vehicle Routing** VRP II
10	Meeting Room 111	**Public Transit** Robust Planning and Rescheduling	**Public Transit** Railway Applications I		**Public Transit** Railway Applications II	**Public Transit** Planning Railway Rapid Transit
11	Meeting Room 112	**Simulation - Sponsored by I-SIM** Simulation Optimization	**Simulation - Sponsored by I-SIM** Modeling of Military Systems		**Simulation - Sponsored by I-SIM** Simulation for Operations Management	**Simulation - Sponsored by I-SIM** Simulation for Supply Chain Management
12	Meeting Room 205	**Contributed Talks** Production Systems	**Contributed Talks** Supply Chains and Auctions		**Contributed Talks** Graph problems	**Contributed Talks** Networks
13	Meeting Room 206	**Continuous and Non-smooth Optimisation** Perturbations, Graphs and Games	**Continuous and Non-smooth Optimisation** Mathematical Programming VII		**Continuous and Non-smooth Optimisation** Optimization, Forecasting, Renewable Energy & Electricity Grid I	**Continuous and Non-smooth Optimisation** Optimization, Forecasting, Renewable Energy & Electricity Grid II
14	Meeting Room 207	**Continuous and Non-smooth Optimisation** Global Optimization	**Continuous and Non-smooth Optimisation** Memorial Session in Honour of Professor Alexander Rubinov		**Continuous and Non-smooth Optimisation** Continuous Optimization in Life and Human Sciences I	**Continuous and Non-smooth Optimisation** Optimization Methods and Stochastic Calculus in the Financial Sector I
15	Meeting Room 208	**Military, Defense and Security Applications** Weapon Systems Analysis	**Military, Defense and Security Applications** Mathematics of Defence Decision Support		**Military, Defense and Security Applications** Mathematical Modeling,OR, and Decision making in Military and Defense Analysis	**Military, Defense and Security Applications** Holistic Approaches to Military and Security Modeling
16	Meeting Room 209	**Scheduling** Metaheuristics for Scheduling in Manufacturing	**Health Care Applications** OR for Health Policy Decisions I		**Health Care Applications** Simulation Modelling for Healthcare	**Health Care Applications** System Dynamics Modelling for Health Care
17	Meeting Room 214	**Multicriteria Decision Analysis and Multiobjective** Fundamentals of Multicriteria Decision Analysis	**Network Optimisation and Telecommunications** Network design and routing		**Network Optimisation and Telecommunications** Network Optimisation	**Finance** OR in Finance 1
18	Meeting Room 215	**Data Envelopment Analysis** Applications of DEA in Education sector	**Data Envelopment Analysis** DEA- Keynote & Tutorial		**Data Envelopment Analysis** Applications of DEA	**Data Envelopment Analysis** Applications of DEA
19	Meeting Room 216	**Education and Operations Research** Attracting and Retaining Students in OR Programs	**Education and Operations Research** Using Cases in OR Courses		**Education and Operations Research** The Changing Skills Graduates Need to be Successful in Applying Analytics	**Education and Operations Research** Issues in OR Education in Developing Nations
20	Meeting Room 217	**Soft OR and Problem Structuring** Soft OR IV	**Analytic Hierarchy/Network Process** AHP I		**Analytic Hierarchy/Network Process** AHP II	**Analytic Hierarchy/Network Process** AHP III
21	Meeting Room 218	**Airline Applications** Airline Scheduling	**Airline Applications** Ground Operations		**Airline Applications** Robustness and Recovery in Airline Operations	**Airline Applications** Location, Simulation, Cargo

Technical Sessions – Thursday July 14

Track	Meeting Rooms	HA 09:00 - 10:30	HB 11:00 - 12:30	HC 13:30 - 15:00	HD 15:30 - 17:00
1	Plenary Hall 3	**OR Applications in Energy**	**OR Applications in Energy**	**OR Applications in Energy**	**OR Applications in Energy**
		OR Applications in the Design and Operation of Electricity Markets	OR Applications in Electricity Transmission & Distribution	OR Applications in Renewable Energy Generation - I	OR Applications in Renewable Energy Generation - II
2	Meeting Room 101	**Game Theory**	**Scheduling**	**Scheduling**	**Scheduling**
		Innovative Applications in Game Theory	Project Scheduling	Shipping and Transportation Scheduling	Production Scheduling
3	Meeting Room 102	**Intelligent Optimisation**	**Contributed Talks**	**Travel Behaviour**	**Travel Behaviour**
		Intelligent Optimisation	Green Supply Chain Management	Travel Behaviour 2	Travel Behaviour 3
4	Meeting Room 103	**Supply Chain Management**	**Supply Chain Management**	**Supply Chain Management**	**Supply Chain Management**
		SCM - Topics Of General Interest	Advances in Inventory Theory	Supply Chain Inventory and Scheduling	Carbon Emissions and Supply Chains
5	Meeting Room 104	**Marketing and OM Interface**	**Marketing and OM Interface**	**Marketing and OM Interface**	**Marketing and OM Interface**
		Consumer-Driven OM Models	Interface between OM and Marketing	Retail competition, Insurance and Energy Markets	Consumer Credit Risk and Supply Chain Risk
6	Meeting Room 105	**Transportation**	**Transportation**	**Transportation**	**Transportation**
		Industrial Applications of Scheduling and Routing I	Industrial Applications of Scheduling and Routing II	Intelligent Transport Systems	Intelligent Traffic Management and Control
7	Meeting Room 106	**Combinatorial Optimisation**	**Combinatorial Optimisation**	**Combinatorial Optimisation**	**Constraint Programming (CP-AI)**
		Integer Programming and Combinatorial Optimization	Topics in Combinatorial Optimization III	Topics in Combinatorial Optimization IV	CP-MIP Hybridisation
8	Meeting Room 107	**Dynamic Programming**	**Dynamic Programming**	**Dynamic Programming**	**Dynamic Programming**
		Dynamic Programming Applications I	Dynamic Programming Applications II	Multi-criteria Dynamic Models	Deterministic, Stochastic & Nondeterministic Dynamic Programming
9	Meeting Room 108	**Emergency Evacuation and Response**	**Emergency Evacuation and Response**	**Emergency Evacuation and Response**	**Emergency Evacuation and Response**
		Network Behavior under Disruption	Humanitarian Logistics	Rescue and Response in Disasters	Disaster Planning and Preparedness
10	Meeting Room 111	**Public Transit**	**Public Transit**	**Stochastic Programming**	**Stochastic Programming**
		Public Transport planning	(Re)scheduling of Vehicles and Crew	Computational Developments in Stochastic Programming	Stochastic Dynamic Optimisation and Bayesian Methods
11	Meeting Room 112	**Integer Programming**	**Integer Programming**	**Integer Programming**	**Integer Programming**
		ILP and Clustering Algorithms	Algorithms for Integer Programming	Knapsack, Assignment Problems	Industry Applications - Airlines, Fishery
12	Meeting Room 205	**Contributed Talks**	**Contributed Talks**	**Contributed Talks**	**Contributed Talks**
		Traffic Flows and ITS	Public Transport and Navigation	Maritime Transport	Location and Bulk Port Operations
13	Meeting Room 206	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**
		Continuous Optimization in Life and Human Sciences II	Continuous Optimization, Modelling and Dynamics in Biology and Medicine III	Mathematical Programming II	New Approaches to Multi-objective Optimization Problems II
14	Meeting Room 207	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**	**Continuous and Non-smooth Optimisation**
		Continuous Optimization, Modelling and Dynamics in Biology and Medicine I	Mathematical Programming I	New Approaches to Multi-objective Optimization Problems I	Computational Statistics with Optimization I
15	Meeting Room 208	**Military, Defense and Security Applications**	**Military, Defense and Security Applications**	**Military, Defense and Security Applications**	**Fuzzy Logic**
		OR for Irregular Warfare	OR and Land Warfare Analyses	OR Practice: Practical Aids for the Military	Linguistic Uncertainty in the Design of Decision Aid Systems
16	Meeting Room 209	**Health Care Applications**	**Health Care Applications**	**Health Care Applications**	**Health Care Applications**
		OR for Ambulance Services and Emergency Departments	OR for Hospital and Regional Health Services I	OR for Hospital and Regional Health Services II	OR for Health Contingency Operations
17	Meeting Room 214	**Finance**	**Finance**	**Finance**	**Finance**
		OR in Finance 2	OR in Finance 3	OR in Finance 4	OR in Finance 5
18	Meeting Room 215	**Data Envelopment Analysis**	**Data Envelopment Analysis**	**Data Envelopment Analysis**	**Data Envelopment Analysis**
		Applications of DEA in Banking and Financial Institutions	DEA Theortical development - 2	Applications of DEA in Banking and Financial Institutions	Applications of DEA in Health Sector
19	Meeting Room 216	**Education and Operations Research**	**Education and Operations Research**	**Discrete and Global Optimization**	**Discrete and Global Optimization**
		Innovation in OR Education	Good Practices - In OR and Education	Discrete and Global Optimization with Applications	Integer and Combinatorial Optimization
20	Meeting Room 217	**Knowledge and Knowledge Organizations**	**Knowledge Management**	**OR and Strategy**	**OR and Strategy**
		Managing Knowledge and Innovation	Knowledge Management	Building bridges between OR and Strategy	Strategy
21	Meeting Room 218	**Maritime Transportation and Logistics**	**Maritime Transportation and Logistics**	**OR and Real Implementation**	**OR and Real Implementation**
		Maritime Inventory Routing Problems in the Asia-Pacific Region	Ship Design, Terminal and Fleet Operations	Sustainable Logistics	OR in Science-Based Applications

Technical Sessions – Friday July 15

Track	Meeting Rooms	FA 09:00 - 10:30	Plenary 11:00 - 12:15	FB 13:15 - 14:45	FC 15:15 - 16:45	FD 17:00 - 18:30
1	Plenary Hall 3	**OR Applications in Energy** OR Applications in Energy Policy and Planning	Closing Plenary: Prof. Daniel Ralph, Risk Modelling, Stochastic Programming and Investment in Power Plants Closing Ceremony Plenary Hall 3	**OR Applications in Energy** Design and Operation of Competitive and Environmentally Friendly Transportation Systems	**OR Applications in Energy** OR, Energy, and Africa	**OR Applications in Energy** OR Applications on Increasing Energy Efficiency in Complex Systems
2	Meeting Room 101	**Scheduling** Scheduling: Algorithms and Complexity		**Scheduling** Scheduling for Services	**Scheduling** Scheduling	No Session
3	Meeting Room 102	**Contributed Talks** Decision Support and Software		**Contributed Talks** Metaheuristics	**Contributed Talks** AI and Game Theory	No Session
4	Meeting Room 103	**Supply Chain Management** Information and Incentives in the Supply Chain		**Supply Chain Management** Optimization in Bulk Goods Supply Chains	No Session	No Session
5	Meeting Room 104	**Marketing and OM Interface** Consumer Behavior and Inventory Model		**OR and Sports** OR and Sports 1	**Contributed Talks** Queuing and Simulation	No Session
6	Meeting Room 105	**Transportation** Maritime Routing		**Transportation** Logistics	**Contributed Talks** Location and Facility Planning	No Session
7	Meeting Room 106	**Applied Probability** Queueing Theory		**Applied Probability** Healthcare Systems and Queues	**Contributed Talks** Quality	No Session
8	Meeting Room 107	**Dynamic Programming** Markov Decision Processes		**Dynamic Programming** Natural Resource Management	No Session	No Session
9	Meeting Room 108	**Contributed Talks** Public Sector Problems		**Contributed Talks** Data Mining	No Session	No Session
10	Meeting Room 111	**Stochastic Programming** Stochastic Programming Models and Methods		**Contributed Talks** Stochastic Optimisation	No Session	No Session
11	Meeting Room 112	**Integer Programming** Partitioning Problems		**Integer Programming** Network Design	**Integer Programming** Integer Programming Models in Production, Inventory	No Session
12	Meeting Room 205	**Continuous and Non-smooth Optimisation** Stochastic Routing and Network Problems		**Continuous and Non-smooth Optimisation** Robust Optimization, Planning and Control	**Continuous and Non-smooth Optimisation** Computational Statistics with Optimization II	**Continuous and Non-smooth Optimisation** Optimization Methods.&.Stochastic Calculus in the Financial Sector II
13	Meeting Room 206	**Continuous and Non-smooth Optimisation** Mathematical Programming III		**Continuous and Non-smooth Optimisation** Mathematical Programming IV	**Continuous and Non-smooth Optimisation** Mathematical Programming V	No Session
14	Meeting Room 207	**Continuous and Non-smooth Optimisation** Optimization Modeling and Equilibrium Problems I		**Continuous and Non-smooth Optimisation** Optimization Modeling and Equilibrium Problems II	**Continuous and Non-smooth Optimisation** Nonsmooth Optimization II	**Continuous and Non-smooth Optimisation** Nonsmooth Optimization III
15	Meeting Room 208	**Fuzzy Logic** Fuzzy Optimization		**Fuzzy Logic** Fuzzy Sets	**Contributed Talks** Fuzzy Decision Making	**Contributed Talks** Fuzzy Logic
16	Meeting Room 213	**Health Care Applications** OR for Health Policy Decisions II		No Session	No Session	No Session
17	Meeting Room 214	**Finance** Investment Strategies and Valuation I		**Finance** Emerging Aspects in Finance, Supply Chains and Environment	**Finance** Investment Strategies and Valuation II	No Session
18	Meeting Room 215	**Data Envelopment Analysis** Applications of DEA in Health Sector		**Data Envelopment Analysis** DEA Theortical development - 3	**Data Envelopment Analysis** Applications of DEA	**Data Envelopment Analysis** Applications of DEA
19	Meeting Room 216	**Network Optimisation and Telecommunications** Multiobjective flows and paths problems		**Network Optimisation and Telecommunications** Telecommunications	**Network Optimisation and Telecommunications** Telecommunications II	No Session
20	Meeting Room 217	**Contributed Talks** Decision Theory		**Contributed Talks** Multi-criteria Decision Analysis	**Contributed Talks** Multi-criteria Decision Making	No Session
21	Meeting Room 218	**Mining Applications** Deterministic Open Pit Mine Planning		**Mining Applications** Stochastic Open Pit Mine Planning and Supply Chains	**Mining Applications** Underground Mine Planning, I	**Mining Applications** Underground Mine Planning, II

Monday, 9:00-11:00

■ PA-01

Monday, 9:00-11:00
Plenary Hall 3

Opening Plenary: Sir James A. Mirrlees, Optimum Choice Sets: How Tightly Should We Regulate?

Stream: Plenaries
Plenary session

Tuesday, 13:30-14:30

■ PB-01

Tuesday, 13:30-14:30
Plenary Hall 3

Plenary: Dr Brenda Dietrich, Operations Research for a Smarter Planet

Stream: Plenaries
Plenary session

Friday, 11:00-12:15

■ PC-01

Friday, 11:00-12:15
Plenary Hall 3

Closing Plenary: Prof. Daniel Ralph, Risk Trading and Capacity Expansion in Energy Markets

Stream: Plenaries
Plenary session

Monday, 11:30-13:00

■ MA-01

Monday, 11:30-13:00
Plenary Hall 3

Development Prize Presentations I

Stream: OR Development Prize
Invited session
Chair: *Subhash Datta*, NIILM CMS, 53 Knowledge Park V, 201310, Greater Noida, UP, India, subhash.datta@gmail.com

1 - Cost Efficient Equitable Water Distribution in Algeria: A Bi-criteria Fair Division Problem with Network Constraints

Javier Cano, Rey Juan Carlos University, Spain, javier.cano@urjc.es, *Angel Udias*, *David Rios-Insua*, *Hocine Fellag*

We describe a complex water distribution problem as a bi-criteria fair division problem over time with network constraints: we aim at distributing water fairly in a reliable and cost-efficient manner. The problem involves both the optimization of the pump operational schedules, as well as strategic planning. Complex rules establish energy fares depending on the daytime and the contractual issues of the pump facility. The problem is illustrated for the region of Kabylia, Algeria. We discuss the relevance and implementation of different solution concepts in this context, showing various alternatives which improve upon current management procedures..

2 - High Precision Coverage Optimization Models and Algorithms for GSM and TD-SCDMA Networks

Tiande Guo, School of Mathematical Sciences,Graduate University of Chinese Academy of Sciences,, Chinese Academy of Science, No. 19A Yuquan Road,Shijingshan District, 100049, Beijing, Shijingshan District, China, tdguo@gucas.ac.cn

The existing network resources of GSM and TD-SCDMA have been in short supply with the increasing number of the cell-phone users in China. In this paper, optimization models of GSM and TD-SCDMA networks are proposed to enhance resource utilization and improve the QoS. First, a new adaptive propagation model and a traffic matching model are proposed to obtain a high-precision coverage and a high-precision traffic map respectively. Based on the above work, we present a multi-objective optimization model for advancing the QoS of the communication network by adjusting the parameters of the antennas. In addition, we establish another optimization model for the addition of new base stations (BSs). Finally, a Single Instruction Multiple Threads Pattern Search Algorithm (SIMT-PS) based on the Graphic Processing Unit (GPU) is presented to solve the models. The applications in Beijing and Guangzhou have achieved great improvements of QoS and reduced the cost of communication system operation.

3 - CORE: A Decision Support System for Competitiveness Analysis of Mexican Regions

Jorge Navarro, Investigación y Desarrollo, Centro de Ciencias de Sinaloa, Av. Américas #2771 Nte., Col. Villa Universidad, 80010, Culiacán, Sinaloa, Mexico, navarro@computo.ccs.net.mx

If regional competitiveness is equated to the capacity to attract and preserve investments, then the perception investors have of the region's characteristic is fundamental. This perception is a result of a complex integration of multiple criteria. This paper approaches the analysis of regional competitiveness by techniques of multi-criteria sorting. An ELECTRE-inspired preference model is used in the framework of the new THESEUS multi-criteria evaluation method for making competitiveness assignments. The model's parameters are inferred from a set of assignment examples. This model is implemented in the CORE decision support system, which satisfies a requirement of Sinaloa State Government in Mexico. CORE performs very well analyzing the competitiveness of Mexican regional entities. This will allow governments to better define their policies by placing financial resources more efficiently. The model and the system are conceived to easily emigrate towards other regional contexts

■ MA-02

Monday, 11:30-13:00
Meeting Room 101

Game Theory Applications in Marketing

Stream: Game Theory
Invited session
Chair: *Gary Erickson*, University of Washington, United States, erick@uw.edu

1 - Shelf Space Competition Between Store and National Brands

Chia-Wei Kuo, National Taiwan University, Taiwan, cwkuo@ntu.edu.tw

Shelf space allocation is one of the retailer's most challenging operational decisions. We propose a game-theoretic model in which one retailer, acting as a leader by deciding the total shelf space available and selling both national and store brands, maximizes her category profit, and one national-brand manufacturer, acting as a follower, maximizes his own profit. Our analysis suggests that the allocation of the shelf space depends on two thresholds of total shelf space for both brands.

2 - Incentives and Supply Contracts for Sales Agents

Samar Mukhopadhyay, GSB, SungKyunKwan University, 53 Myungryun-dong 3-ga, Jongno gu, 110 745, Seoul, Korea, Republic Of, samar@skku.edu, *Ying Zhang*

We consider two competing supply chains each with one manufacturer and a selling agent. The manufacturers offer contract types from which the agents choose one. The chosen contracts can be different. The agents compete by exerting different selling efforts that improve own product demand and decrease demand for other product. Two market conditions observable only to the agents are considered. Two different contract types — A single linear contract and a menu of linear contracts — are studied in a non-cooperative game setting. Optimum strategies and managerial guidelines are developed.

3 - Transfer Pricing in a Dynamic Marketing-Operations Interface

Gary Erickson, University of Washington, United States, erick@uw.edu

A transfer price mechanism is proposed to coordinate the strategies of the marketing and operations functional areas with a firm. Marketing and operations are strategic decision-makers in a differential game, in which a transfer price is entered into the objective functionals. Feedback strategies are derived for price, advertising, and production, which allows a solution for the system involving goodwill and backlog, and the expression of total firm payoff as a function of the transfer price level, which is maximized to determine the optimal transfer price for the firm.

■ MA-03

Monday, 11:30-13:00
Meeting Room 102

Math-Heuristics

Stream: Meta-heuristics
Invited session
Chair: *Stefan Voss*, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de

1 - Branch-Cut-and-Price Heuristics for Routing Problems

Marcus Poggi de Aragão, Informatica, PUC - Rio, 22591-900, Rio de Janeiro, RJ, Brazil, poggi@inf.puc-rio.br, *Henrique Viana*, *Pedro Moura*

Neighborhood search over MIP formulations have its efficiency closely dependent on the integrality gap. For some routing problems, formulations derived from Dantzig-Wolfe decomposition can, along with classes of valid inequalities, produce small gaps. We exploit this characteristic of the resulting branch-cut-and-price approach on routing problems. Besides the k-opt neighborhood, we experiment with generalizations such as an ellipsoidal neighborhood where two or more elite solutions act as the search starting point. This approach is applied to the TOP and CVRP. New upper bounds were obtained.

2 - Math-heuristic Algorithms as a Tool for Optimization

Stefan Voss, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de, *Marco Caserta*, *Moshe Sniedovich*

Math-heuristics hybridize metaheuristics and mathematical programming techniques (MP). Using the notion of model-based metaheuristics we aim to solve optimization problems granting to MP the cross-problem robustness and constrained-CPU-time efficiency of metaheuristics. We present a simple mechanism to fine tune parameters of the corridor method as a math-heuristic. The algorithm uses MP and exploits ideas from the method to use a standard MIP solver over different portions of a solution space. Tests are run on some well known optimization problems from logistics and computational biology.

3 - A biased random-key genetic algorithm for the Steiner triple covering problem

Mauricio Resende, Algorithms & Optimization Research, AT&T Labs Research, 180 Park Avenue, Bldg. 103, Room C241, 07932, Florham Park, NJ, United States, mgcr@research.att.com, *Rodrigo Toso*, *José Fernando Gonçalves*, *Ricardo Silva*

We present a biased random-key genetic algorithm (BRKGA) for finding small covers of computationally difficult set covering problems that arise in computing the 1-width of incidence matrices of Steiner triple systems. Using a parallel implementation of the BRKGA, we compute improved covers for the two largest instances in a standard set of test problems used to evaluate solution procedures for this problem. The new covers for instances A405 and A729 have sizes 335 and 617, respectively. On all other smaller instances our algorithm consistently produces covers of optimal size.

■ MA-04

Monday, 11:30-13:00
Meeting Room 103

Current Issues in Inventory Management

Stream: Operations Management
Invited session
Chair: *Candace Yano*, University of California, Berkeley, United States, yano@ieor.berkeley.edu

1 - An Inventory Substitution Problem with Stock-Level-Dependent Demand

Yun Zhou, Department of Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, yzhou@se.cuhk.edu.hk, *Frank Y Chen*

Retail demand can be stimulated by larger display quantities of products and customers may switch to other products if their preferred product is stocked-out. We consider a scenario in which the retailer sells two substitutable products whose demands depend on stocking quantities. When one product runs out of stock while the other does not, part of demand for the former turns to the latter. We show how the retailer's profit varies with the stocking quantities. We also compare the basic model to the scenario in which the products are sold by two independent retailers.

2 - Optimal Inventory Policies with Non-stationary Supply Disruptions and Advance Supply Information

Bilge Atasoy, Transport and Mobility Laboratory, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, Switzerland, bilge.kucuk@epfl.ch, *Refik Gullu*, *Tarkan Tan*

We consider a periodic review, single-item, deterministic demand inventory model under non-stationary, all-or-nothing supply availability. Advance supply information is provided by the supplier. For a finite-horizon setting, we show the optimality of state dependent (s,S) policies. For the case with no fixed ordering cost we show the optimality of an order-up-to type policy and prove various properties of the optimal order-up-to levels. We provide a simple characterization of optimal order-up-to levels. We also propose a heuristic for the model with fixed cost.

3 - A Distribution Inventory Model with Transshipments from a Support Warehouse

Christian Howard, Industrial Management & Logistics, Lund University, Ole römers väg 1, Box 118, 22100, Lund, Sweden, christian.howard@iml.lth.se, *Sven Axsäter*, *Johan Marklund*

Motivated by collaboration with a global spare parts service provider, we consider an inventory system consisting of N retailers and a regional support warehouse. All stock points apply standard (R,Q) replenishment policies. In case of stock-outs, the retailers receive transshipments from the support warehouse at an extra cost. We present a model for cost evaluation and optimization of the reorder points in the system under fill rate constraints. The solution method is designed to handle large-scale systems and is fast enough to be directly implemented in practice.

■ MA-05

Monday, 11:30-13:00
Meeting Room 104

New Mathematical Paradigms for Service Science

Stream: Service Science and Sustainability

Invited session

Chair: *Eizo Kinoshita*, Urban Science Department, Meijo University, 4-3-3 Nijigaoka, 509-0261, Kani, Gifu, Japan, kinoshit@urban.meijo-u.ac.jp

1 - Why Bubble Economy Occurs and Crashes? –Service Science for Next Paradigm

Eizo Kinoshita, Urban Science Department, Meijo University, 4-3-3 Nijigaoka, 509-0261, Kani, Gifu, Japan, kinoshit@urban.meijo-u.ac.jp

This paper shows that there are two different phases in economics.These are the primal and dual problems.This paper defines the concept of Economic Growth,Bubble Economy and Destruction of Bubble Economy.And this paper describes that why bubble economy occurs and bubble economy crashes.In the process,this paper shows that Primal Economy exists before Bubble Economy and Dual Economy exists after Destruction of Bubble Economy.And,the authors proposes that new Primal Economy have new Paradigm which is "Service Science".

2 - Cloud Computing Service Value Measured Using the AHP

Norikumo Shunei, Osaka University of Commerce, General Management Department, 4-1-10, Mikuriyasakae-machi, 577-8505, Higashiosaka, Osaka, Japan, shunei.norikumo@gmail.com

This study, the cloud is an emerging technology IT investments value measurement of service delivery from the side of advantages and disadvantages of cloud. If the company operated in house corporate information assets, and if the commission cloud. Were analyzed by two layers of cloud are configured. The first is providing software to SaaS(Software as a Service), services and infrastructure development and operation of such a PaaS(Platform as a Service).

3 - Improvement of Productivity in Japanese Service Industry

Norihiko Saiga, Urban Science Dept., Meijo University, Nijigaoka, 4-3-3, 509-0261, Kani, Gihu, Japan, nsaiga@urban.meijo-u.ac.jp

It is said that the productivity of the service industry of Japan is low, and causes the global competitiveness decrease in Japan. Therefore, it is a pressing issue to improve the productivity of the service industry of Japan. I think that it is a big cause that the current Japanese Government makes efforts to the technology strengthening of manufacturing, and there were little assistance measures in the service industry.

■ MA-06

Monday, 11:30-13:00
Meeting Room 105

Sparse Optimization and Applications

Stream: Non-linear Optimisation

Invited session

Chair: *Wotao Yin*, Computational and Applied Mathematics Dept., Rice University, 6100 Main St, MS-134, 77005, Houston, TX, United States, wotao.yin@rice.edu

Chair: *Yin Zhang*, CAAM, Rice University, MS 134, 6100 Main, 77005, Houston, Texas, United States, yzhang@rice.edu

1 - S-Goodness and G-numbers of Linear Transformation in Low-rank Matrix Recovery

Naihua Xiu, Northern Jiaotong University, Applied Mathematics Dept., 100044, Beijing, China, naihua_xiu@126.com, *Lingchen Kong*, *Levent Tencel*

In this paper, we extend and characterize the concept of s-goodness for a sensing matrix in sparse signal recovery to a linear transformation in the low-rank matrix recovery (LMR). Using two G-numbers of a linear transformation, we not only show necessary and sufficient conditions for the linear transformation to be s-good, but also provide sufficient conditions for exact and stable LMR from the nuclear norm minimization. Moreover, we give computable upper bounds of G-number. Finally, we establish the connection between restricted isometry property and s-goodness, and give new bounds for restricted isometry constant in LMR.
The work was supported in part by the National Natural Science Foundation of China (10831006) and the National Basic Research Program of China (2010CB732501), and a Discovery Grant from NSERC.

2 - A Subspace Algorithm for L1 Minimization

Ya-Xiang Yuan, Institute of Computational Mathematics, Chinese Academy of Sciences, Academy of Mathematics and Systems Science, Zhong Guan Cun Donglu 55, 100190, Beijing, China, yyx@lsec.cc.ac.cn

In this talk, a subspace algorithm for L1 minimizaiton is presented. In each iteration of the algorithm, the new iterate point is found by minimizing a subproblem defined in a low dimensional subspace, therefore the subspace subproblem is significantly smaller than the original problem in scale, particularly for large scale problems. Convergence properties of the new algorithm is given and some numerical tests are also reported.

3 - Markov Decision Processes under Probability Constraints

Felisa Vazquez-Abad, Computer Science Dept., City University New York, 695 Park Ave, Room HN1000E, 10065, New York, United States, felisav@hunter.cuny.edu, *Owen Jones*, *Pierre Carpentier*

We study a controlled Markov process that must be stationary at periodic intervals, but the stationary failure probability must be small. For example, a battery controls storage and release of eolian energy every minute, trying to avoid surcharges; a dam is controlled each day to sell electricity, trying to keep the level high in Summer for recreational activities. On consecutive days (years) the battery (dam) state should start with the same distribution. Because the control and probability constraint act at different time scales, the problem cannot be solved using existing methods.

4 - Alternating Direction Methods Applied to Sparse Optimization Problems

Yin Zhang, Dept. of CAAM, Rice University, 6100 Main Street, Rice University, 77005, Houston, Texas, United States, yzhang@rice.edu

The classic augmented Lagrangian alternating direction methods (ALADM or AMD for short) have recently found utilities in solving many sparse optimization problems arising from signal and image processing including both convex and non-convex problems. We will introduce such recent applications, and then report some new convergence results.

■ MA-07

Monday, 11:30-13:00
Meeting Room 106

Cutting and Packing 1

Stream: Cutting and Packing
Invited session

Chair: *A. Miguel Gomes*, Faculty of Engineering / INESC Porto, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, agomes@fe.up.pt

1 - Modified KOMBI to Reduce the Different Patterns in Cutting Stock Problems

Horacio Yanasse, LAC, INPE, Av. dos Astronautas 1758, CP 515 - INPE/CTE, 12227-010, São José dos Campos, SP, Brazil, horacio@lac.inpe.br, *Kelly Poldi*

Reducing the number of cutting patterns in a cutting stock problem may be of interest in some productive systems. In this work we propose a simple variation of KOMBI, a pattern reduction method suggested previously in the literature. The improved performance of this variation, compared with the previous one, is illustrated with computational test results with one dimensional cutting stock instances. Extensions of the modified KOMBI that balance the reduction of cutting patterns with an increase in the number of objects cut are also presented.

2 - A Biased Random Key Genetic Algorithm for the Three-dimensional Bin Packing Problem

José Fernando Gonçalves, LIAAD, Faculdade de Economia, Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-464, Porto, Portugal, jfgoncal@fep.up.pt

In this paper we propose a biased random key genetic algorithm for the three-dimensional bin packing problem. For each GA chromosome we construct a solution based on a maximal-space heuristic which packs the boxes according to the order supplied by chromosome. Next an improvement procedure is applied to the solution. Computational tests are presented using available instances taken from the literature. The results validate quality of the solutions and the approach. Supported by Fundação para a Ciência e Tecnologia (FCT) project PTDC/GES/72244/2006.

3 - A Hierarchical Approach to the Circle Covering Problem

A. Miguel Gomes, Faculty of Engineering / INESC Porto, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, agomes@fe.up.pt, *Pedro Rocha*, *Jose Fernando Oliveira*

Covering problems aim to cover a certain complex region with a set of simpler geometric forms. The objective is to minimize the number of covering objects while making the best approximation to the initial complex region. A particular case of a problem of this kind is the circle covering problem (CCP), where the goal is to minimize the radius of circles that can fully cover a given region, with a fixed number of identical circles. The specific problem approached in this work is to cover a multi-connected region represented by a complex polygon (i.e., irregular polygons with holes). This work presents a hierarchical approach to enclosing a given irregular geometrical form, using non-uniform circular enclosures. Preliminary computational experiments with complex polygons taken from nesting datasets show promising results. (Partially supported by Fundação para a Ciência e Tecnologia (FCT) — Project PTDC/EME-GIN/105163/2008 — EaGLeNest).

4 - An Improved Problem Generator for the Two-dimensional Rectangular Cutting and Packing Problem

Jose Fernando Oliveira, Faculty of Engineering / INESC Porto, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, jfo@fe.up.pt, *A. Miguel Gomes*, *Gerhard Wäscher*

We present an improved problem generator for the two-dimensional rectangular cutting and packing problem. This problem generator addresses all basic types of the 2D rectangular problem, according to Waescher et al. typology, and the advantages in relation to the existent generators are discussed and highlighted. (Partially supported by FCT — Project PTDC/EIA-CCO/115878/2009 - CPackBenchFrame)

■ MA-08

Monday, 11:30-13:00
Meeting Room 107

Tutorial

Stream: Bioinformatics
Invited session

Chair: *Ming-Ying Leung*, The University of Texas at El Paso, TX 79968-0514, El Paso, United States, mleung@utep.edu

1 - Graph Approaches to Genome Reading

Jacek Blazewicz, Instytut Informatyki, Politechnika Poznanska, ul.Piotrowo 2, 60-965, Poznan, Poland, jblazewicz@cs.put.poznan.pl

In the talk we will present the operational research approaches to the DNA and RNA chain reading. First, the DNA sequencing problem will be analyzed. Based on it, the algorithms solving the DNA assembling problem, involving 454 sequencers, will be characterized. An impact of this approach on the graph theory itself will be also presented. Later, RNA Partial Degradation Problem will be described. We will give its mathematical formulation and present its complexity status as well as algorithms for its solution.

■ MA-09

Monday, 11:30-13:00
Meeting Room 108

Stochastic Demand & Dynamic Travel Time

Stream: Vehicle Routing
Invited session

Chair: *Richard Eglese*, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, R.Eglese@lancaster.ac.uk

1 - Solving the VRP with Stochastic Demands using Distributed and Parallel Computing

Javier Faulin, Department of Statistics and OR, Public University of Navarre, Los Magnolios Builing. First floor, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, javier.faulin@unavarra.es, *Angel A. Juan*, *Josep Jorba*, *Scott Grasman*

This work focuses on the VRP with Stochastic Demands (VRPSD) presenting an algorithm that combines parallel computing, heuristics and Monte Carlo simulation. Thus, for a given VRPSD instance, the algorithm considers different levels of the safety stocks or scenarios. Then, it solves each scenario concurrently by integrating Monte Carlo simulation with the Clarke & Wright heuristic. The resulting parallel solutions are compared and the one with the minimum total costs is selected. Finally, the paper also discuses some future work regarding the use of distributed computing approaches for VRP.

2 - The Vehicle Routing Problem with Stochastic Demand: A Sample Average Approximation Method for Assigning Time Windows

Remy Spliet, Econometric Institute, Erasmus University Rotterdam, Burgemeester Oudlaan 50, 3000DR, Rotterdam, Netherlands, Spliet@ese.eur.nl

In our research we consider a vehicle routing problem in which time windows have to be assigned for each location before demand is known. Next, demand is revealed and a routing schedule has to be constructed, adhering to the time windows. This problem is encountered frequently in retail chains. We solve this problem by using a sample average approximation approach. We find a solution to the resulting deterministic problem by using a column generation algorithm.

3 - A Solution Approach for Routing with Time-dependent Travel Times

Fabien Tricoire, Department of Business Administration, University of Vienna, Chair for Production and Operations Management, Brünner Straße 72, 1210, Vienna, Austria,

fabien.tricoire@univie.ac.at, *Stefanie Kritzinger*, *Karl Doerner*, *Richard Hartl*

In many real-life routing problems, travel times depend on the time of day. This is especially true in urban logistics and due in no small part to traffic and congestion issues. The problem difficulty increases further when considering a fixed fleet and time windows. We present a heuristic approach to solve such problems; special emphasis is brought to the interaction between the various constraints, as well as their impact on the objective of minimizing cost and lateness.

4 - Finding a Minimum Cost Path in a Time-varying Road Network

Richard Eglese, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, R.Eglese@lancaster.ac.uk

The cost of travelling between two points in a road network may be influenced by several factors which can vary with the time of travel. The speed at which the vehicle can travel at different times due to road congestion is one. A congestion charging scheme where the cost of travelling on a road or within a designated area may change by time is another. Heuristic methods are described to find minimum cost paths taking these factors into account and results are presented based both on artificial networks and real road networks with traffic information.

■ MA-10

Monday, 11:30-13:00
Meeting Room 111

Freight Transport Practice

Stream: Time-Definite Logistics

Invited session

Chair: *Alan Erera*, School of Industrial and Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, 30306, Atlanta, GA, United States, alerera@isye.gatech.edu

1 - Simulating Vulnerability in Victoria's Fruit and Vegetable Supply Chain

Leorey Marquez, Mathematical and Information Sciences, CSIRO, Gate 5, 71 Normanby Road, 3168, Clayton, Vic, Australia, leorey.marquez@csiro.au, *Andrew Higgins*, *Silvia Estrada-Flores*

Recent catastrophic flooding in Queensland and Victoria showed the huge impact that extreme weather events can produce on Australia's food supply chain. With this scenario in mind, the Victorian Eco-Innovation Lab initiated a study that developed the Supply Chain Database Tool (SCDT), a deterministic model mapping the transport components of Victoria's fruit and vegetable supply chain and evaluating scenarios featuring system vulnerabilities. This paper discusses the results of an SCDT investigation into three vulnerability scenarios, including one representing the Queensland floods.

2 - Shipping Data Generation for the Hunter Valley Coal Chain

Hamish Waterer, School of Mathematical and Physical Sciences, University of Newcastle, 2308, Callaghan, NSW, Australia, hamish.waterer@newcastle.edu.au, *Natashia Boland*, *Martin Savelsbergh*

Strategic capacity planning is a core activity for the Hunter Valley Coal Chain Coordinator as demand for coal is expected to double in the next decade. Optimization and simulation models are used to suggest and evaluate infrastructure expansions and operating policy changes. Creating arrival streams of ships at the port that accurately represent future demand scenarios, used as input to these models, has been a time-consuming and daunting challenge. We develop an integer programming-based framework that facilitates and enhances this process and has become an integral part of the work flow.

3 - Robust Empty Repositioning in Large-scale Freight-consolidation Networks

J. Antonio Carbajal, Industrial and Systems Engineering, Georgia Institute of Technology, United States, acarbajal@gatech.edu, *Alan Erera*, *Martin Savelsbergh*

Developing dynamic empty-repositioning plans remains a major challenge for trucking transportation providers with large-scale consolidation networks due to uncertainties in future trailer requirements. Prior research has proposed robust optimization models to address this issue, but the resulting integer programs are suitable only for small-scale networks because they require an exponential number of constraints. To bridge this gap, we develop solution techniques to construct robust, cost-effective and practically-deployable repositioning plans in large-scale freight transportation networks.

4 - Sugarcane Harvest Logistics in Brazil

Barrett Thomas, Management Sciences, University of Iowa, 108 John Pappajohn Building, 52242-1994, Iowa City, IA, United States, barrett-thomas@uiowa.edu

Sugar mills represent significant capital investments. To maintain appropriate returns on their investment, sugar companies seek to run the mills near or at capacity over the entire nine months of the sugarcane harvest season. Because the sugar content of cane degrades considerably once it is cut, sugar mills are unable to maintain inventories of raw cane to buffer against uncertainty in the cane supply process. Instead, variability must be mitigated via coordinated logistics. The goal is to coordinate the harvest and the transport of raw cane to ensure a steady arrival at the mill.

■ MA-11

Monday, 11:30-13:00
Meeting Room 112

Discrete Convexity in Operations Research

Stream: Submodular Structures and Optimization

Invited session

Chair: *Akiyoshi Shioura*, Graduate School of Information Sciences, Tohoku University, Aoba-ku, 9808579, Sendai, Japan, shioura@dais.is.tohoku.ac.jp

1 - Overview of Discrete Convex Analysis

Akiyoshi Shioura, Graduate School of Information Sciences, Tohoku University, Aoba-ku, 9808579, Sendai, Japan, shioura@dais.is.tohoku.ac.jp

Discrete Convex Analysis is a theory of discrete convex functions defined on integer lattice points, which parallels the ordinary convex analysis, covering discrete analogues of the fundamental concepts such as conjugacy and duality. Since its introduction in the late 90s, the theory has been used extensively in various fields of operations research such as discrete optimization, inventory systems, scheduling, combinatorial auction, game theory, etc. In this talk, we review basic concepts such as M-/L-convexity and fundamental results, and explain some applications in operations research.

2 - Appointment Scheduling with Discrete Random Durations and Applications

Mehmet Begen, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond St. N., N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca, *Maurice Queyranne*

We determine an optimal appointment schedule for a given sequence of jobs (surgeries, physician appointments) on a processor (operating room, physician) to minimize the expected total underage (idle-time of the processor) and overage costs (waiting time of jobs and overtime of the processor) when jobs have integer stochastic durations given by a joint discrete distribution. Simple conditions on the cost rates imply that the objective function is discretely convex. We find an integer optimum in polynomial time. We also consider several extensions and applications.

3 - Discrete Convexities in Some Economic and Game Models

Takuya Iimura, Tokyo Metropolitan University, 192-0397, Tokyo, Japan, t.iimura@tmu.ac.jp

Two discrete convexities that appear in some economic and game models are discussed. These are (1) the M-natural convex-valued demand correspondences in a gross substitute economy and (2) the L-natural convex-valued response correspondences in a strategic complements game. We show that these discrete convexities insure some nice properties for the price and strategy adjustment processes, respectively, enabling us to prove the existence of Walras and Nash equilibria in a unified manner.

4 - Submodular Optimization in Clustering Problems

Kiyohito Nagano, University of Tokyo, 1538505, Tokyo, Japan, nagano@sat.t.u-tokyo.ac.jp

A number of objective functions in clustering problems can be described with submodular functions. A submodular function is known to be a discrete analogue of a convex function, and the discrete convexity enables us to develop efficient algorithms. In this talk, I will discuss some clustering methods based on submodular optimization techniques.

■ MA-12

Monday, 11:30-13:00
Meeting Room 205

Trade and Development

Stream: Contributed Talks

Contributed session

Chair: *Tatjana Tambovceva*, Faculty of Engineering Economics and Management, Riga Technical University, Mezha Street 1/7- 213, LV-1048, Riga, Latvia, tatjana.tambovceva@rtu.lv

1 - The Co-existence of Diverse Medical Systems

Andrew Stranieri, School of Information Technology and Mathematical Sciences, University of Ballarat, University Drive, Mt. Helen, 3350, Ballarat, Victoria, Australia, a.stranieri@ballarat.edu.au

The trend toward co-existence of medical systems including Western Medicine and Traditional Chinese Medicine presents challenges that include the need for models that facilitate the juxtaposition of reasoning from diverse systems, support for patients in making informed choices, informatics initiatives including the development of standards that accommodate all traditions, and regulatory regimes that are not restricted to one tradition. In this article requisites for the co-existence of diverse medical systems are described and implementations that exemplify requisites are advanced.

2 - Peculiarities of the Property Tax Administration in Latvia

Sanda Geipele, Riga Technical University, Mezha Street 1/7, 212 room, LV-1048, Riga, Afghanistan, sanda_geipele@inbox.lv

Property Tax is one of the most important tools of each state economics. Immovable property tax is imposed upon land, buildings and building spaces utilized for economic activity, except conditions stipulated by the law, as well as starting with 2010 the tax was imposed upon dwelling houses and engineering structures. The aim of the paper is to display peculiarities of the Property Tax administration in Latvia. Author analyzes the importance of the present tax in the state budget, problems of calculation of the tax and elaborates solutions how to improve the Property Tax administration.

3 - Sustainable Construction in Latvia: Development and Future Challenges

Tatjana Tambovceva, Faculty of Engineering Economics and Management, Riga Technical University, Mezha Street 1/7- 213, LV-1048, Riga, Latvia, tatjana.tambovceva@rtu.lv, *Ineta Geipele*, *Sanda Geipele*

Sustainable construction has become very popular throughout the world. To promote sustainable construction green building assessment tools have been used. The purpose of study is to explore and analyze present status of sustainable construction and green building assessment in Latvia and to indicate the strategies of it development. The analysis shows that the effective way is to choose an international tool as a basement and then make a custom-build tool according to Latvian situation. And that the process of sustainable construction in Latvia is in a progressive stage of introduction.

■ MA-13

Monday, 11:30-13:00
Meeting Room 206

Power, Control and Optimization

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Nader Barsoum*, Electrical Dept., Curtin University, Curtin Campus, 98009, Miri, Sarawak, Malaysia, pcoglobal@gmail.com

Chair: *Pandian Vasant*, Electrical & Electronic Engineering Dept., University Technology Petronas, 31750 Tronoh, BSI, Perak, DR, Malaysia, vasantglobal@gmail.com

Chair: *Jeffrey Webb*, School of Engineering and Science, Swinburne University of Technology, Jalan Simpang Tiga, 93576, Kuching, Sarawak, Malaysia, mailjeffwebb@yahoo.com

1 - Dynamic Programming for Optimal Allocation of Maintenance Resources on Power Distribution Networks

Eduardo Tadeu Bacalhau, Densis, Unicamp, Campinas, Sao Paulo, Brazil, dudubaca@yahoo.com.br, *Fábio Usberti*, *Christiano Lyra*

Power distribution companies, in order to sustain predefined reliability indexes, must have their network equipments go through a periodic maintenance. These companies maintenance policies reflect the decision of which equipments will undergo maintenance on a given planning horizon. This work uses a dynamic programming based algorithm to minimize maintenance costs, subject to a maximum System Average Interruption Frequency Index (SAIFI). The proposed mathematical model considers a failure rate model, which predicts the equipments failure rate depending on the maintenance schedule.

2 - A Multi-objective Model for the Planning and Optimisation of Multinational Supply Chains

Behnam Fahimnia, School of Management, University of South Australia, 29B Baird Street, 5095, Mawson Lakes, South Australia, Australia, b_fahimnia@yahoo.com, *Mark Goh*, *Asef Nazari*, *Ali Eshragh Jahromi*

Scanty literature exists addressing the planning of multinational supply chains in which products are produced in local and foreign manufacturing/assembly plants and distributed to international markets in different counties. This study develops a unified optimisation model for the optimal planning of a complex multinational supply chain. The proposed model minimises the summation of production/assembly costs, distribution costs, tariff costs and exchange costs. The solution for the proposed integrated problem is sought comparing the performance of two different solution approaches.

3 - Future Energy and Desirable Automation for Global Optimal

Nader Barsoum, Electrical Dept., Curtin University, Curtin Campus, 98009, Miri, Sarawak, Malaysia, pcoglobal@gmail.com

Energy mix is now recognized to be developed in future as a replacement of fossil fuel or oil. This is a hybrid power between nuclear and renewable energy, including solar, wind and hydraulic. Design of solar tracker is now essential to develop for better energy efficiency. This includes controller for sensitive drives to have the optimum power at all times globally. Our session will show the recent and new research outcomes on the optimum energy and global automation including computational intelligent, smart drives, constraint programming and stochastic optimization.

■ MA-14

Monday, 11:30-13:00
Meeting Room 207

Variational Analysis

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Alexander Kruger*, Graduate School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

1 - Optimality Conditions via Exact Penalty Functions

Xiaoqi Yang, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, mayangxq@polyu.edu.hk, *Kaiwen Meng*

In this paper, we study KKT optimality conditions for constrained nonlinear programming problems and strong and Mordukhovich stationarities for mathematical programs with complementarity constraints using l_p penalty functions, with 0 <= p <=1. We introduce some optimality indication sets by using contingent derivatives of penalty function terms. We show that the KKT optimality condition holds at a feasible point if this point is a local minimizer of some l_p penalty function with p belonging to the optimality indication set.

2 - Optimality Conditions in Nonsmooth Analysis

Andrew Eberhard, Mathematical and Geospatial Sciences Dept., RMIT University, GPO Box 2476V, 3001, Melbourne, Victoria, Australia, andy.eb@rmit.edu.au

In this talk we consider some recent advances in the casting of optimality conditions in the context of nonsmooth optimization. Some examples will be discussed.

3 - Proximal Analysis in Reflexive Smooth Banach Spaces

Messaoud Bounkhel, Department of Mathematics, King Saud University, College of Science, PO Box: 2455, 11451, Riyadh, Saudi Arabia, bounkhel@ksu.edu.sa

In this paper, we study a new proximal normal cone in reflexive Banach spaces in terms of a generalized projection operator. Two variants of generalized proximal subdifferentials are introduced in reflexive smooth Banach spaces. The density theorem for both proximal subdifferentials has been proved in p-uniformly convex and q-uniformly smooth Banach spaces. Various important properties and applications of our concepts are also proved.

4 - Stability of Error Bounds for Convex Constrained Systems

Alexander Kruger, Graduate School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

In this talk, I am going to show that certain known sufficient conditions for local and global error bounds in Banach spaces actually ensure error bounds for a family of convex functions being in a sense small perturbations of the given one. Subdifferential slopes are used for formulating error bound criteria.

■ MA-15

Monday, 11:30-13:00
Meeting Room 208

Special Issues in Military Modeling

Stream: Military, Defense and Security Applications

Invited session

Chair: *Amnon Gonen*, Management of Technology, Holon Institute of Technology - HIT, 52,Golomb St., 58102, Holon, Israel, agonen1@gmail.com

1 - Practical Approaches to the Frequency Assignment Problem in Land Military Communication Networks

David Raz, Management of Technology, Holon Institute of Technology, Holon, Israel, davidra@hit.ac.il

In this work we demonstrate practical approaches to the problem of assigning frequencies to groups of nodes in land military communication networks. The objective is to select a frequency assignment which minimizes the number of frequencies used, while maintaining acceptable reception levels and acceptable cochannel, adjacent-channel and harmonic interferences. We focus on land units, and deal specifically with the location disparity inherent in the military environment and with the issue of transmission power selection.

2 - Approximating the Military Reality

Amnon Gonen, Management of Technology, Holon Institute of Technology - HIT, 52,Golomb St., 58102, Holon, Israel, agonen1@gmail.com

Some of the military models are so complicated that users can hardly estimate the magnitude of results. This paper presents some approximations to military modeling that enables users in estimating the results. The paper discusses hit and kill probably, detection and surveillance, reliability and logistics. In some cases the physical model of human behavior is approximated by an "inverse engineering" approach. The model starts from the results toward their cause and formulate the calculation process that fits these final results.

3 - A Network Flow Approach to Terrorist Network Disruption

Susan Martonosi, Mathematics Dept., Harvey Mudd College, 301 Platt Blvd., 91711, Claremont, CA, United States, martonosi@math.hmc.edu

We present a new network disruption technique that tries to make otherwise secretive members of a terrorist group more visible. Through vertex deletion, this technique forces the secretive members to increase their participation in network communication. This talk will illustrate our disruption metric based on network flows, address graph-theoretic characteristics of promising vertices to target and discuss some computational challenges.

■ MA-16

Monday, 11:30-13:00
Meeting Room 209

Scheduling with Breakdowns

Stream: Scheduling

Invited session

Chair: *Xiao-qiang Cai*, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Shatin, NT, Hong Kong, xqcai@se.cuhk.edu.hk

Chair: *Xian Zhou*, Actuarial Studies, Macquarie University, Sydney, New South Wales, Australia, 2109, Sydney, New South Wales, Australia, xian.zhou@mq.edu.au

1 - Stochastic Scheduling Subject to Multiple-type Machine Breakdowns

Xiao-qiang Cai, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Shatin, NT, Hong Kong, xqcai@se.cuhk.edu.hk, *Xianyi Wu*, *Xian Zhou*

This work develops a general stochastic scheduling model with a single machine subject to multiple types of stochastic breakdowns. The aim is to maximize the expected weighted discounted rewards, which cover a variety of performance measures in the literature. The probabilistic features of the processing process are investigated in terms of semi-Markovian decision process. The optimal policy is tackled by using the multi-armed bandit process in terms of Gittins indices. The optimal policies of some extensively studied models are derived as the applications of the theory developed.

2 - Production Planning and Inventory Allocation of an Assemble-to-order System Subject to Machines Breakdowns

Houcai Shen, Management Science and Engineering, Nanjing University, Hankou Road No. 22, 210093, Nanjing, China, hcshen@nju.edu.cn

We consider the production and inventory allocation of an assemble-to-order system with multiple demand classes and lost sales. Each component is replenished by a dedicated unreliable machine. We find that the machine state not only influences the production and allocation decisions on its own component but also influences the decisions on the other components. We show through computational experiments that the heuristic policies do not perform well all the time, which reveals that taking machine failures into consideration is meaningful and important.

3 - Online Scheduling to Minimize Total Weighted Completion Time on Uniform Machines

Lianmin Zhang, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Hong Kong, lmzhang@se.cuhk.edu.hk, *Xiao-qiang Cai*

We study the online version of the classic uniform machine scheduling problem to minimize total weighted completion time with nonpreemptive setting. Using the linear programming based scheduling technique, we present a deterministic online scheduling policy for that model, and derive performance guarantees that is related to the number of machines and the ratio between the largest machine's speed and the total machine's speed. Our algorithm naturally extends several approaches to uniform machine scheduling. To the best of our knowledge, it is the first competitive ratio for this problem.

4 - An Equilibrium Model of Distribution Supply Chain Network with Inventory Transshipment

Jing Zhou, Management Science and Engineering, Nanjing University, 210093, Nanjing, Jiangsu, China, houcaishen@gmail.com

In this paper, an equilibrium model of distribution supply chain network with inventory transshipment was developed based on capacity constraints equilibrium model of supply chain network. The model was calculated by a simple case with two wholesalers, two retailers and two consumers. It confirmed that inventory transshipment would cause an increase in total cost of distribution supply chain. However, the total cost would decrease when increasing the cost of inventory transshipment. To restrain abnormal behaviors, some strategies were suggested to increase the cost of inventory transshipment.

■ MA-17

Monday, 11:30-13:00
Meeting Room 214

Robust Multi Criteria Decision Analysis

Stream: Multicriteria Decision Analysis and Multiobjective Optimisation

Invited session

Chair: *Jutta Geldermann*, Professur für Produktion und Logistik, Universität Göttingen, Platz der Göttinger Sieben 3, D-37073, Göttingen, Germany, geldermann@wiwi.uni-goettingen.de

1 - Evaluation based Resource Allocation to Improve Security in Container Line Supply Chain

Dawei Tang, Manchester Business School, M13 9UR, Manchester, United Kingdom, dawei.tang.wh@googlemail.com, *Dong-Ling Xu*, *Shan-Lin Yang*, *Jian-Bo Yang*

Container Line Supply Chain (CLSC) is a dominant yet high vulnerable way to transport cargo globally, whilst resources to improve its security are always limited. To improve CLSC security efficiently, a model is developed to allocate resources optimally for CLSC. Different from other Resource Allocation (RA) models, the model proposed has 2 major features: 1) resources are allocated based on security evaluation, thus areas with lower security have higher priority to get resources; 2) the proposed model can handle imprecise, uncertain and semi-structured information involved in RA processes.

2 - Stochastic and Robust Multicriteria Decision Support for Supply Planning of Renewable Resources

Susanne Wiedenmann, Professur für Produktion und Logistik, Universität Göttingen, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, susanne.wiedenmann@wiwi.uni-goettingen.de, *Sven Krumke*, *Jutta Geldermann*

Supply planning for the industrial use of renewable resources confronts the decision maker with specific challenges. We study models and policies for coping with incomplete and uncertain information and discuss various ways to cope with the uncertainty. Since this involves a couple of conflicting goals which cannot be scalarized in a straightforward way, this naturally leads to a multicriteria optimization problem. We analyze this problem from the viewpoints of robust, stochastic and online optimization and provide computational results.

3 - Application of Non-Linear Optimization for the Determination of Optimal Plant Setups for Biofuel Production

Lars-Peter Lauven, Chair of Production and Logistics, Georg-August-Universitaet Goettingen, Platz der Goettinger Sieben 3, 37073, Goettingen, Germany, llauven@gwdg.de, *Jutta Geldermann*

Second Generation biofuels are often based on complex synthesis reactions with numerous products. Superlinearly rising specific transportation costs for large biofuel plants using biomass as input material counteract the desirable effects of sublinearly rising economies of scale. Modeling these two drivers of biofuel production costs is necessary to determine an optimal choice of plant size and product upgrading setup. The resulting non-linear optimization problem is solved using the CONOPT solver, which is based on the Generalized Reduced Gradient algorithm.

■ MA-18

Monday, 11:30-13:00
Meeting Room 215

Applications of DEA in Firms and Industries

Stream: Data Envelopment Analysis

Invited session

Chair: *Antonio Perrelli*, Finance and Economics Dept., ELETROBRAS Chesf, R. Carlos Pereira Falcão 743 ap 103, 51021350, Recife, PE, Brazil, antonioperrelli@hotmail.com

1 - Forecasting Electric Energy Consumption and Benchmarking Performance of Selected Buildings in the University of Santo Tomas

Oliver Gagarin, Facilities Management Office, University of Santo Tomas, Espana, 1008, Manila, Philippines, orgagarin@mnl.ust.edu.ph, *Nancy Eleria*

The electric energy consumption (EEC) is significant in the building past and future performances. Regression analysis and ANN are used to determine the effects of physical and climatic variables in EEC. The building performances are determined by Multi-Stage DEA. It has identified that the building size, number of enrolled students, building age, and peak-load time are the physical factors affecting EEC. The study concluded that some buildings are technically inefficient because they are having EEC more than what their age and peak-load time would require in a monthly operation.

2 - The Application of Improved DEA Model in Evaluation of China's Production Comprehensive Efficiency

Yuquan Cui, School of Mathematics, Shandong University, Shan Da Nan Lu Number 27, 250100, Jinan, Shandong, China, cuiyq@sdu.edu.cn

In this paper, we improved DEA model. According to the function of output data and input data, we determine the form and number of input variables. If input variables are too many, we can use principal component analysis to reduce the dimensions, and then we use the improved DEA model to calculate. We use the improved DEA model to evaluate and analyze the efficiency of the production environment in China in recent years. Actual evaluation results are excellent agreement with the actual situation.

3 - The Determinants of Firms' Efficiency in the International Textile and Clothing Industry

Magdalena Kapelko, Department of Business Administration, Universidad Carlos III de Madrid, Calle Madrid 126, Office 7.0.56, 28903, Getafe (Madrid), Spain, magdalena.kapelko@gmail.com

This study examines the factors that can explain efficiency of international textile and clothing industry. We rely on the original database of 5477 observations for the firms that operated in different world regions from 1995 to 2004. We use truncated regression with bootstrap to infer on the relationship of DEA efficiency to some factors that based on the theory are related to efficiency. Our evidence shows that efficiency is positively associated with intangibles, size, textile sector and economic development. Other variables such as leverage and economic integration contribute negatively.

4 - The Use of Data Envelopment Analysis as a Regulation Tool for the Energy Transmission Sector in Brazil

Antonio Perrelli, Finance and Economics Dept., ELETROBRAS Chesf, R. Carlos Pereira Falcão 743 ap 103, 51021350, Recife, PE, Brazil, antonioperrelli@hotmail.com

The Second Periodic Tariff Revision (PTR) Cycle for the Energy Transmission Sector in Brazil defined new annual permitted revenue (APR) for the concessionaires. This process used the NDRS model of DEA to create scores that would work as parameters for the revenue calculation. At the end of the process, the concessionaires had huges revenue losses in comparison with the First PTR in the year of 2005. This paper aims to expose the energy market impacts created by the methodology used, the regulators errors while applying the analysis and projections to a possible III PTR.

■ MA-19

Monday, 11:30-13:00
Meeting Room 216

Making OR More Interesting For Students

Stream: Education and Operations Research
Invited session

Chair: *Khehla Moloi*, University of Limpopo, Polokwane, South Africa, KHEHLA.MOLOI@ul.ac.za

1 - Helping Students Understand Basic Probability through a Method for Calculating Probabilities in Ball Games According to Scores During the Matches Using a Spread Sheet

Nobuyoshi Hirotsu, School of Health and Sports Science, Juntendo University, 1-1 Hiragagakuendai, 270-1695, Inzai, Chiba, Japan, nhirotsu@hotmail.com

We teach basic probability to athletes (students), but we come across the problem how we can help them understand it. They are taught how to use a spread sheet in a course of computer literacy. So, using a spread sheet we try to teach them how to calculate probabilities in ball games which they are familiar with. In practice, we introduce a method for calculating probabilities in ball games such as tennis and soccer according to scores during the matches. We discuss the student reaction based on anecdotal evidence we have observed.

2 - Games and Interactive Activities in OR Classroom

Mariana Funes, Facultad de Ciencias Económicas - Universidad Nacional de Córdoba, Avda. Valparíso s/n Ciudad Universitaria, 5000, Córdoba, Argentina, mfunes@eco.unc.edu.ar

Student motivation and engagement with their learning are a constant challenge for teachers. Considering that games get students involved and promote learning opportunities, games were implemented that significantly contributed to make students feel uninhibited and to increase their participation in solving analytical and reflective activities designed to strengthen their knowledge. The presentation deals with the games and activities developed and the obtained results.

3 - Creating Excitement in Operations Research Classroom: A Case of the University of Limpopo

Khehla Moloi, University of Limpopo, Polokwane, South Africa, KHEHLA.MOLOI@ul.ac.za

In this paper the author will demonstrate how active learning can engage students in such high-order thinking tasks such as analysis, synthetic and evaluation. The paper argues that student's throughput and quality improves drastically when active learning technique is employed as opposed to passive learning. The author will also address challenges/ obstacles associated with active learning such as mega-class, lack of needed material, time or resources, non-participation of students. Most of these challenges/ obstacles can be overcome through careful, thoughtfully planning.

■ MA-20

Monday, 11:30-13:00
Meeting Room 217

Soft OR I

Stream: Soft OR and Problem Structuring
Invited session

Chair: *Vicky Mabin*, Victoria Management School, Victoria University of Wellington, PO Box 600, 6140, Wellington, New Zealand, vicky.mabin@vuw.ac.nz

1 - Shaping Sustainable Communities: A Case of Urban Water Management

Robyn Moore, Victoria Management School, Victoria University of Wellington, 16 Kotipu Place, Pukerua Bay, 5026, Porirua, Wellington, New Zealand, robyn@j.co.nz, *Vicky Mabin*

While water is relatively abundant in New Zealand, the quality of freshwater is a concern, given the value New Zealanders place on their 'clean green' reputation and outdoor lifestyle. This Community OR project examines the challenges and possibilities facing Kapiti community's aim of sustainable urban water management. This case study examines how Theory of Constraints, Stakeholder Typology and Causal Loop Diagrams were used to capture and examine stakeholder perspectives, inform decision-making and improve urban water management outcomes.

2 - Offshore IT Outsourcing between India and New Zealand: A Systemic Analysis

Arun Elias, Victoria University of Wellington, FC, Wellington, New Zealand, arun.elias@vuw.ac.nz, *Saji Mathew*

Although both India and New Zealand recognise trade between the two countries as important, trade in information technology between the two nations has been very low. This research seeks to structure this problem situation systemically to understand the complexities underlying this uneven profile of India's outsourcing. This study takes a service provider perspective. A causal loop model is developed to explain the counterintuitive problem situation. Finally, strategies to improve the problem situation are explained using an analysis of the feedback loops captured in the model.

■ MA-21

Monday, 11:30-13:00
Meeting Room 218

OR in Agriculture

Stream: OR in Agriculture
Invited session

Chair: *Marcela Gonzalez*, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl

1 - A Periodic Tabular Policy for Scheduling of a Single Stage Production-Inventory System for Agricultural Products

Krishna Sundar Diatha, Productions and Operations Management, Indian Institute of Management, Bannerghatta Road, 560076, Bangalore, Karnataka, India, diatha@iimb.ernet.in, *Shashank Garg*

In a production system that handles perishable raw materials, scheduling of the production facility plays a vital role. In this paper, we consider scheduling of a single stage production-inventory system in the presence of uncertainty regarding demand patterns, production times and switchover times. We derive approximations for the first two moments of demand over lead time using residual service analysis of vacation queue models and determine optimal production frequencies for individual types. The numerical study demonstrates the effectiveness of the proposed policy against cyclic policies.

2 - An Integer Linear Model for Scheduling the Cutting Process in Swine Industry

Marcela Gonzalez, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl, *Rodrigo Sanchez*

An integer linear model is developed for supporting decisions about pork cutting process in a plant, considering demands, production lots sizes, inventory level of each product, capacity constraints, warehouse restrictions, production periods, products shelf life, aiming to maximize the company profits. The model is applied for scheduling the cutting process in a Chilean swine company.

Monday, 14:00-15:30

■ MB-01

Monday, 14:00-15:30
Plenary Hall 3

Development Prize Presentations II

Stream: OR Development Prize
Invited session
Chair: *Subhash Datta*, NIILM CMS, 53 Knowledge Park V, 201310, Greater Noida, UP, India, subhash.datta@gmail.com

1 - Optimising Location and Size of Rural Schools in Chile

Fernando Araya, Universidad de Chile, CH, Santiago, Chile, fearaya@gmail.com

The Chilean Ministry of Education oversees preschool, primary, and secondary education in both urban and rural areas. Many parts of Chile are sparsely populated and there are currently over 4,000 rural schools (almost 38% of all schools in Chile) educating 9.5% of the students in the country. Many of the rural schools are small with only one teacher responsible for instruction of all local students (multi-grade schools). The geographical distribution of the rural schools has not been coordinated and this has resulted in unequal utilization of existing schools and some unreasonably long student travel times. Good management of the rural schools is fundamental to meeting Chile's goal of providing quality education to its citizens. Seeking to improve the situation, the Ministry of Education ordered a study of the optimal location and size of rural schools with the general goals of reducing the number of lesser quality multigrade schools and reducing student travel times while maintaining reasonable costs. This paper presents results of this study obtained using an integer linear program that has been imbedded in a geographical information system. We present computational results for the entire country. Recommendations include where to open new rural schools as well as where to expand, reduce, close or leave unchanged existing schools. We show how recommendations are sensitive to key parameters such as the cost of transportation.

2 - Using System Dynamics to address dental workforce issues in Sri Lanka: a practical approach in a developing country

Dileep de Silva, Ministry of Health, SO17 1BJ, Southampton, United Kingdom, dileepdenta@yahoo.com

Sri Lanka is a developing South Asian country where education and health are free for all its citizens. Country's Dental Health policies had failed to achieve their intended result because of the complexity of Oral health, dental health services and the dental health policy-making process; leading to "unemployment' of dental surgeons amidst the need for more dental health professionals for country's health development. In this article, we review a novel method of collecting information from dental surgeons and the benefits of using system dynamics (SD) model to address Dental Health workforce issues. The illustrations show how SD modelling and simulation yield realistic, practical and insightful lessons for policy making stemming from the endogenous and aggregate perspectives. The Government of Sri Lanka having accepted the results of this study has increased the employment opportunities for dental surgeons to optimize the dental human resource utilization to match the country' s development.

3 - Dealing with Uncertainties in the Bio Diesel Supply Chain Based on Small Farmers : A Robust Approach

Raphael Leao, PETROBRAS, SP, Sao Paolo, Brazil, raphaelleao@yahoo.com.br

The strategy adopted by the Brazilian Biodiesel Program is to base its fuel production on grains acquired from small, family-owned farms in the poorest regions of the country, thereby fostering social inclusion and transfer of income. The success of the program depends on the development of a robust supply chain logistic structure, appropriate distribution of crop production, and investments in new grain crushing units. This article presents the development of mathematical models for optimizing the production arrangements for the supply of a biodiesel plant sourced from family farms, taking into account agricultural, logistic and industrial aspects, and the uncertainties inherent to the process. Three different approaches are proposed in order to deal with the problem stochasticity and cope with the investor's risk tolerance profile. The models were successfully applied to a case study for the production chain for biodiesel fuel from castor oil in the semi-arid region of Brazil.

■ MB-02

Monday, 14:00-15:30
Meeting Room 101

Game Theory Applications in Operations Management I

Stream: Game Theory
Invited session
Chair: *Bowon Kim*, Graduate School of Management, KAIST, 207-43 Cheongryangri Dongdaemoon-Ku, 130-722, Seoul, Korea, Republic Of, bowonkim@kgsm.kaist.ac.kr

1 - Non-Cooperative Game in Overbooking Problem

Kannapha Amaruchkul, School of Applied Statistics, National Institute of Development Administration, Bangkok, Thailand, kamaruchkul@gmail.com

We present a game theoretic analysis in a competitive overbooking model. Each firm with constrained resource chooses a limit to maximize its expected profit, given the other firm's optimal limit. Sufficient conditions for existence and uniqueness of Nash equilibrium are derived. Our comparative statics analysis reveals that the equilibrium increases as a revenue-to-oversale ratio increases or a show-up rate decreases. Nevertheless, the equilibrium is not affected by a distribution of requests. Moreover, the limits in the competitive model are identical to those in the non-competitive model.

2 - Competitive Stackelberg Hub Location

James Campbell, College of Business Administration, University of Missouri-St. Louis, 63124, St. Louis, MO, United States, campbell@umsl.edu, *Mihiro Sasaki*

We address the design of revenue maximizing transportation hub networks for airlines in a competitive environment. We model two air carriers that transport passengers or freight in a Stackelberg framework, where the leader firm designs its optimal network, given that the follower firm will subsequently design its own optimal network. We use a hub arc location model with discounted transport costs between hubs, along with costs for connecting at hubs and different cost structures for the two firms. The results provide insights into how the leader and follower design networks under competition.

3 - Analysis of Competition under Demand Substitution

Genco Fas, Mathematics and Computer Sciences, Bahcesehir University, Ciragan Caddesi, Besiktas, 34353 , Istanbul, Turkey, gencofas@gmail.com, *Taner Bilgic*

We analyze the competition in a dynamic duopoly under demand substitution. The common random demand in each period is allocated randomly to retailers after replenishment. A proportion of unsatisfied customers substitute from the other retailer if appropriate. For the case where the total quantity ordered is less than the market demand the substitution is significant. We formulate the single period and extend it to a finite horizon dynamic game. The existence and uniqueness of a feedback Nash equilibrium (fNE) is shown and a state dependent order-up-to policy turns out to be a fNE of this game.

4 - Production Capacity and Pricing Equilibrium Policies in a Supply Chain

Bowon Kim, Graduate School of Management, KAIST, 207-43 Cheongryangri Dongdaemoon-Ku, 130-722, Seoul, Korea, Republic Of, bowonkim@kgsm.kaist.ac.kr, *Fouad El Ouardighi*

We develop a differential game model to analyze how the members of a decentralized two-level supply chain should determine their production capacities and pricing policies to maximize their cumulative profits over an infinite planning horizon. We first characterize the equilibrium strategies for the centralized suply chain, and then look into the open-loop Nash equilibrium of the decentralized chain.

■ MB-03

Monday, 14:00-15:30
Meeting Room 102

Hybrid Metaheuristics

Stream: Meta-heuristics
Invited session

Chair: *Celso Ribeiro*, Department of Computer Science, Universidade Federal Fluminense, Rua Bogari 70, 22471-340, Rio de Janeiro, RJ, Brazil, celso@inf.puc-rio.br

Chair: *Stefan Voss*, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de

1 - The Myopic Dynamic Programming Approach for the Knapsack Problem with Time-window

Misato Okada, National Defense Academy, Computer Science Dept., Hasirimizu, Yokosuka, Kanagawa, Japan, em49034@nda.ac.jp, *Seiji Kataoka*

The knapsack problem called KPTW is as follows: each item has the consecutive periods (time-window) in which we can take it, and the total amount of weights in each period has to be within the capacity. We propose the myopic dynamic programming that sees only expected states. It uses memory of limited size, but can reach an almost optimal solution. It also gives non-decreasing lower bounds anytime in the process. With effective upper bounds on them, a considerable number of variables can be pegged. Besides, by deleting redundant constraints, we succeed in diminishing KPTW to solvable size.

2 - Iterated Hybrid Metaheuristics for Solving Single-Machine Total Weighted Tardiness Problems with Sequence-Dependent Setup Times

Chun-Lung Chen, Department of Accounting Information, Takming University of Science and Technology, Taiwan, charleschen@takming.edu.tw

An iterated hybrid metaheuristic is proposed to solve the single-machine scheduling problems with sequence-dependent setup times. The algorithm first integrates the principles of the Variable Neighborhood Search and Tabu Search to achieve a local optimal solution, and then a shaking procedure is developed to perturb the best solution to obtain a new initial solution attempt to escape the local optimal solution. To verify the proposed algorithm, computational experiments were conducted on benchmark problem sets and the results show the proposed algorithm outperforms several meta-heuristics.

3 - Restart Strategies for GRASP with Path-relinking Heuristics

Celso Ribeiro, Department of Computer Science, Universidade Federal Fluminense, Rua Bogari 70, 22471-340, Rio de Janeiro, RJ, Brazil, celso@inf.puc-rio.br, *Mauricio Resende*

GRASP with path-relinking is a hybrid metaheuristic for combinatorial problems. A restart strategy in GRASP with path-relinking is a set of iterations on which the heuristic is restarted from scratch using a new seed for the random number generator. Restart strategies have been shown to speed up stochastic local search algorithms. We propose a restart strategy for GRASP with path-relinking. We illustrate the speedup obtained with this restart strategy on heuristics for the maximum cut problem, the maximum weighted satisfiability problem, and the private virtual circuit routing problem.

■ MB-04

Monday, 14:00-15:30
Meeting Room 103

Spare Parts Inventory Systems

Stream: Operations Management
Invited session

Chair: *Scott Webster*, Syracuse University, 13244, Syracuse, NY, United States, stwebste@syr.edu

1 - A Spare Parts Provisioning Problem

Baris Balcioglu, Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, M5S 3G8, Toronto, ON, Canada, baris@mie.utoronto.ca, *Pedram Sahba*, *Dragan Banjevic*

We analyze a system of different fleets of machines where machines can fail due to a single type of critical component. A certain number of critical components are kept in a centralized inventory as spare parts with a shared inventory serving all fleets and reserved inventories for each fleet. Failed components are repaired in a single repair shop and the destination fleet can be chosen either on an FCFS basis or by considering static or dynamic priority rules among the fleets. Our numerical examples indicate that the best policy is a system operating under the inventory rationing policy.

2 - A Finite Horizon Spare Parts Inventory Problem

Nesim Erkip, Industrial Engineering, Bilkent University, 06800, Ankara, Turkey, nesim@bilkent.edu.tr

While considering the life-cycle of a spare part inventory problem, one usually assumes that there are two main phases, followed by the final phase. The first main phase is when the part is steadily used for assembly, and the second main phase represents the periods when the part is no longer used as an input for manufacturing, but has a stochastic demand as a spare part. The final phase, on the other hand is usually represent by a single procurement. In this study, we propose a heuristic that will consider the joint problem that reflects the second main phase, with the final phase.

3 - Final Purchase and End-of-Life Acquisition Decisions in Response to a Component Phase-Out Announcement

Scott Webster, Syracuse University, 13244, Syracuse, NY, United States, stwebste@syr.edu, *Dwayne Cole*, *Burak Kazaz*

We consider a problem faced by a durable-goods manufacturer of a product that is no longer manufactured but still under warranty. A supplier announces that a component of the product will be phased out and specifies a deadline for the final order. The manufacturer faces a two-stage decision problem: (1) the size of the final order and, in the event that the final order is less than actual requirements, (2) the design of a trade-in program for component harvesting. We investigate how a firm's trade-in policy, decisions, and profits are influenced by industry and market characteristics.

■ MB-05

Monday, 14:00-15:30
Meeting Room 104

Service Operation Management

Stream: Service Science and Sustainability
Invited session

Chair: *Ming Chun Tsai*, Chung Hua University, 30012, Hsinchu, Taiwan, mctsai@chu.edu.tw

Chair: *Shu-Ping Lin*, Technology Management, Chung Hua University, 707, Sec.2, WuFu Rd., 30012, Hsinchu, Taiwan, splin@chu.edu.tw

1 - A Study of Inertia Type and Inertia Relational Model

Ming Chun Tsai, Chung Hua University, 30012, Hsinchu, Taiwan, mctsai@chu.edu.tw, *Ching-Chan Cheng*

Inertia is characteristic of human nature. Service providers can then take advantage of the inertia to keep up good relationships with their customers. Accordingly, this study are, first, to explore the core variables of the inertias by analyzing the dependencies among them through DEMATEL; second, to study the main factors affecting the inertias so as to establish an inertia relationship model. Finally, as a case in point, SEM will be utilized to empirically examine the customer inertia relationship model of the fashion business to identify the leading factors affecting its customer inertias.

2 - Adopting Quality Functional Deployment to Enhance the Service Recovery Implementation

Yahui Chan, Technology Management Dept., Chung Hua University, Hsinchu, Taiwan, silvia_219@yahoo.com.tw, *Shu-Ping Lin*

Delivering superior service to retain customers is critical to a firm's sustainability. As it is difficult for firms to avoid all service failures (SFs), the service recovery (SR) implementation has then become an important issue. In view of QFD is useful for ensuring customer's voice being deployed throughout all the planning/designing stages, the aim of this study is to develop a SR model by adopting QFD as the basis. The proposed SR model is illustrated using data collected from Taiwan's Mobile-Telecom industry. Results show that QFD is useful for identifying the core resource for SR.

3 - A Study on Constructing Green Consumption Behavior System by DEMATEL Method

Shu-Ping Lin, Technology Management, Chung Hua University, 707, Sec.2, WuFu Rd., 30012, Hsinchu, Taiwan, splin@chu.edu.tw, *Yahui Chan*, *Chen Ping-Hsien*

As the green demands have continuously increased, to understand the antecedents of consumer's acceptance intention towards green products will be helpful for green marketing. In view of the relevant studies discussing green consumption behavior (GCB) are lack, the aim of this study is to build a GCB system by DEMTEL method in order to clarify the interrelationship between the antecedents from different theories. Solar industry in Taiwan is chosen and seven experts were interviewed. All the results will be expected to give as the reference for green marketing.

4 - Bridge the Gaps: Examining Restaurant Service Quality from the Perspectives of Customers, Management and Employees

Chien-Lin Lin, Department of Technology Management, Chung Hua University, Department of Tourism Management, Hsing Wu College, N0. 707 Sec. 2 Wufu Rd., 30012, Hsinchu, ROC, Taiwan, 082001@mail.hwc.edu.tw, *Ming Chun Tsai*

From the services triangle perspective, the interlinked groups, meaning customers, management and providers, are integral for quality service delivery. Few studies have investigated on the gaps between the three. In this study an international tourist hotel in Taiwan was chosen to empirically examine the gaps between customers' service expectations and service received, and the gaps between customers' service expectations and the perceptions of these expectations by the management and employees. A revised importance-performance analysis was then used to construct a service evaluation matrix to identify areas for improvement in the hope of giving some insight for the hospitality industry.

■ MB-06

Monday, 14:00-15:30
Meeting Room 105

Aviation Optimization

Stream: Transportation

Invited session

Chair: *Vikrant Vaze*, Civil and Environmental Engineering, MIT, 77, Massachusetts Avenue, 02139, Cambridge, MA, United States, vikrantv@MIT.EDU

1 - Multi-agent Models of Airline Competition for Congestion Mitigation in the National Air Transportation System

Vikrant Vaze, Civil and Environmental Engineering, MIT, 77, Massachusetts Avenue, 02139, Cambridge, MA, United States, vikrantv@MIT.EDU, *Cynthia Barnhart*

Delays to flights and passengers cost billions of dollars annually. Airline competition is closely related to and partially responsible for exacerbating the congestion situation. First, we develop bounds on the degree of inefficiency introduced by airline competition. Next, we present models of airline competition and efficient algorithms for Nash equilibrium computation. Finally, we evaluate the performance of simple demand management strategies in a competitive environment. Results establish the connection between competition and congestion, and show that significant improvements in flight and passenger delays and in airline profits can be achieved through simple slot reduction strategies.

2 - Stochastic Integer Programming Models for Air Traffic Flow Management Problems

Michael Ball, R H Smith School of Business, University of Maryland, 20742, College Park, MD, United States, mball@rhsmith.umd.edu

In this paper we address a stochastic air traffic flow management problem that arises when airspace congestion is predicted, so that the number of flights passing through a volume of airspace must be reduced. We formulate a stochastic integer program that assigns to each flight either a delayed departure time or the decision to use a secondary route. These decisions take into account a distribution of possible weather scenarios. We conduct experiments that both demonstrate the computational efficiency of our approach and draw conclusions regarding appropriate flow management strategies.

3 - Improving Schedule Robustness with Flight Re-timing and Aircraft Swapping

Sophie Dickson, Department of Mathematics and Statistics, The University of Melbourne, 3010, Parkville, VIC, Australia, sophiedickson@gmail.com, *Natashia Boland*

All plans go astray, especially airline schedules. Flight delays have knock-on effects that frustrate passengers and cost airlines money. Most schedules include slack time to reduce knock-on delays. We present new models that re-time and swap flights between aircraft in a schedule, redistributing slack to minimise knock-on effects. We extend previous research by combining flight retiming and aircraft routing in one model. Our models optimise the delay distribution, rather than average or total delay measures. We cover the model, how parameters are set from real data, and experimental results.

4 - An Optimisation-based Approach to Airline Disruption Recovery

David Ryan, Engineering Science, The University of Auckland, Private Bag 92019, 1, Auckland, New Zealand, d.ryan@auckland.ac.nz

A disruption event in airline operations affects planned schedules for aircraft, crew and passenger resources. In this talk I will describe a solution framework which attempts to minimize the extent of disruption to the original planned schedules. The solution framework involves a restricted disruption neighbourhood of disrupted resources. Within the neighbourhood a set partitioning model is formulated to reschedule affected resources while ensuring continuous boundary conditions exist for all resources within the neighbourhood to their undisturbed schedules outside the neighbourhood.

■ MB-07

Monday, 14:00-15:30
Meeting Room 106

Cutting and Packing 2

Stream: Cutting and Packing

Invited session

Chair: *Karen Daniels*, Department of Computer Science, University of Massachusetts Lowell, One University Avenue, Olsen Hall, Room 216, MA 01854, Lowell, United States, kdaniels@cs.uml.edu

1 - A Genetic Algorithm No-Fit Polygon Placement Technique for Improving Build Volume Utilization of Layer Manufacturing Machines'

Vassilis Dedoussis, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou str., 185 34, Piraeus, Greece, vdedo@unipi.gr, *Vassilis Canellidis*, *John Giannatsis*

Rapid Manufacturing (RM) is an emerging set of technologies aiming at manufacturing end-use products using Layer Manufacturing (LM) technologies. The present work examines the application of a Genetic Algorithm in conjunction with an effective placement rule based on the notion of No Fit Polygon, as a mean of optimizing RM processes, i.e. the build volume of LM technologies, that due to technical or quality reasons prohibit the fabrication of a part on top of another. The performance of the proposed technique is demonstrated via a case study concerning representative "real world' parts.

2 - Regarding an Alternative Method for Translational Single-Item Containment

Jason M'Sadoques, University of Massachusetts Lowell, 01854, Lowell, United States, jlyonm@gmail.com, *Karen Daniels*

The placement of a (possibly nonconvex) shape into a container, via translation, is a fundamental operation useful in containment, packing and layout problems. Using the Minkowski sum here requires a complement operator with unbounded sets that can be handled by various limited methods. We discuss an alternative formulation that eliminates unbounded sets. This is motivated by work on packing 3D suitcases into a car trunk. We prove that this yields the same result as the standard translational single-item containment algorithm, with some restrictions, and that it works in arbitrary dimensions.

3 - A Priority-considering Approach for the Three-dimensional Bin Packing Problem

Jidong Ren, Graduate School of Engineering, Kyoto University, Yoshida Honmachi, Sakyo-ku, 6068501, Kyoto, Japan, renjd111@hotmail.com, *Yajie Tian*, *Tetsuo Sawaragi*

A heuristic approach is proposed to solve the three-dimensional bin packing problem in which a given set of three-dimensional rectangular items should be packed into the minimum number of identical finite containers. The core idea of this approach is that some items with large volume are preferentially assigned into the containers. Within the approach a single container algorithm is used which is generalized from the algorithm proposed in Ren et al. (2011). The proposed approach achieves excellent results for the test cases suggested by Ivancic et al. (1989) with reasonable computing time.

4 - Multi-sphere Scheme with a General Nonlinear Programming Solver

Takashi Imamichi, IBM Research - Tokyo, 1623-14, Shimotsuruma, 242-8502, Yamato, Kanagawa, Japan, imamichi@jp.ibm.com, *Ernesto G. Birgin*

The multi-sphere scheme is a general framework for finding a layout of given shapes into a container. It first approximates each shape by a set of circles or spheres and then find a layout of the sets of circles or spheres. The author applied the quasi-Newton method, which is for unconstrained nonlinear programming problems, to finding a layout in the previous work. In this talk, we apply a general nonlinear programming solver 'ALGENCAN' instead, construct an algorithm for the two-dimensional strip packing problem with free-rotations, and report the results of experiments.

■ MB-08

Monday, 14:00-15:30

Meeting Room 107

Algorithms for Nucleic Acid Analysis

Stream: Bioinformatics

Invited session

Chair: *Marta Szachniuk*, Institute of Bioorganic Chemistry, PAS, Noskowskiego 12/14, 61-704, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

1 - RNA Structure Prediction from OR Perspective

Marta Szachniuk, Institute of Bioorganic Chemistry, PAS, Noskowskiego 12/14, 61-704, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

RNA molecules serve diverse structural, catalytic and regulatory function in living cells. The knowledge of their 3D folds is essential to understand the increasing number of their biological functions. The talk will present a problem of RNA structure modeling from the OR perspective. A new approach to the RNA comparative modeling based on fragment matching and assembly will be highlighted. We will focus on solutions applied on the different levels of structure composition process, like graph theory based approach to secondary structure fragmentation, module alignment and merging.

2 - Match-searching Algorithms for Gene Silencing Assessment

Mark Horn, Mathematics, Informatics & Statistics, CSIRO, Locked Bag 17, 1670, North Ryde, NSW, Australia, Mark.Horn@csiro.au

Gene silencing applications involve the use of synthetic RNA silencer molecules with sequences designed to suppress specific genes. Reliable assessment of silencer impacts requires the rapid identification of matching sites in messenger RNA. The paper presents algorithms and data structures for this task, based on a compact numerical encoding of sequence data. The main algorithm involves a search for a Boolean dominance relation, which is related to a database task called skyline search. Computational tests show that the algorithm is significantly faster than conventional alternatives.

3 - Inversion Distributions in RNA and Their Roles in Secondary Structure Prediction

Ming-Ying Leung, The University of Texas at El Paso, TX 79968-0514, El Paso, United States, mleung@utep.edu, *Sameera Viswakula*, *Michela Taufer*, *Kyle Johnson*

RNA secondary structures (SS) provide information for understanding replication mechanisms of viruses with critical influence on agricultural resource sustainability. As sequence lengths of viral genomic RNA often exceed limits allowed by SS prediction software, we develop strategies to cut long RNA sequences into shorter chunks to be predicted separately. Individual predictions are then assembled to form an overall SS. Statistical distribution properties of inversions, which are essential for all SS, can help establish criteria in the segmentation process to maximize prediction accuracy.

■ MB-09

Monday, 14:00-15:30

Meeting Room 108

Rich Vehicle Routing

Stream: Vehicle Routing

Invited session

Chair: *Marc Sevaux*, Lab-STICC - CNRS UMR 3192, Université de Bretagne Sud - UEB, Centre de Recherche - BP 92116, 2 rue de Saint Maude, 56321, Lorient, France, marc.sevaux@univ-ubs.fr

Chair: *Kenneth Sörensen*, Faculteit Toegepaste Economische Wetenschappen, Universiteit Antwerpen, Prinsstraat 13, 2000, Antwerpen, Belgium, kenneth.sorensen@ua.ac.be

Chair: *Richard Hartl*, Dept of Management, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, richard.hartl@univie.ac.at

1 - Fuel Efficient Haul Truck Routing on Mines

Kevin Duffy, Institute of Systems Science, Durban University of Technology, Berea Rd, 4000, Durban, Kzn, South Africa, kevind@dut.ac.za

This research investigates computational methods for estimating fuel efficient path calculations for a mine road network based on fuel consumed by large haul trucks. Algorithms using both shortest path and fuel efficient path computations are compared. Depending on road condition the fuel efficient path can save more fuel. The results are discussed with reference to extreme and general situations. By scaling the results up to realistic mine proportions it is shown how significant saving in production costs should be possible where a fuel efficient haul road utilization system is implemented.

2 - A Tabu Search Method for the Open Vehicle Routing Problem with Time Windows

Leon Li, Department of Logistics & Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, lgtleon@polyu.edu.hk, *Zhuo Fu*, *Richard Eglese*

In this paper, a tabu search heuristic with an intensive search mechanism for the open vehicle routing problem with soft time windows (OVRPSTW) is proposed, by which the problem with hard time windows (OVRPHTW) can also be solved by simply setting appropriate parameters in the penalty function. Computational results on the benchmark problems are provided and compared with results in the literature, which show that it can produce good solutions. Comparisons of the features of two different soft time window constraint types are also carried out.

3 - A New Solution Approach for the Rollon-rolloff Vehicle Routing Problem

Juyoung Wy, Industrial and Management Engineering, Pohang University of Science & Technology, 790-784, Pohang, Korea, Republic Of, hwiriric@postech.ac.kr, *Byung-In Kim*

The rollon-rolloff vehicle routing problem, in which large garbage collection containers are at customer locations such as construction sites and shopping centers, is handled. Tractors transport a container at a time between locations. We propose an integrated heuristic algorithm which can construct initial solutions and improve the solutions iteratively. The construction algorithm is based on the Sweep Nearest Algorithm and the improvement algorithm includes perturbation, inter- and intra-route algorithms. New best solutions for the benchmark problems were found using the proposed approach.

4 - Adaptive Large Neighborhood Search for Service Technician Routing and Scheduling Problems

Richard Hartl, Dept of Management, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, richard.hartl@univie.ac.at, *Attila Kovacs*, *Sophie Parragh*, *Karl Doerner*

We define the service technician routing and scheduling problem with and without team building. Technicians must complete a set of service tasks with time windows. Each technician has different skills at different levels and each task demands technicians with the required skills. Sometimes technicians have to be grouped into teams for completing complex tasks. The objective is to minimize total routing and outsourcing costs. Using an adaptive large neighborhood search algorithm, high quality solutions are obtained within short computation times for both, artificial and real world instances.

■ MB-10

Monday, 14:00-15:30
Meeting Room 111

Strategic Network Design for Time-sensitive Networks

Stream: Time-Definite Logistics

Invited session

Chair: *Anne Lange*, Operations Planning Acc. & Control, Technische Universiteit Eindhoven, Faculteit Industrial Engineering & Innovation Sciences, Postbus 513, 5600 MB, Eindhoven, Netherlands, a.lange@tue.nl

1 - A New Method for a Cost-oriented Robust Supply Chain Design

Thomas Makuschewitz, BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen, Hochschulring 20, 28359, Bremen, Germany, mak@biba.uni-bremen.de, *Bernd Scholz-Reiter*

A robust supply chain design is given by the capability of the network to cope with expected and unexpected changes of key parameters. In this talk we measure the robustness with the stability radius that reflects the smallest perturbation of parameters that destabilizes the network. Based on a fluid approximation of a multiclass queueing network and findings concerning the stability radius we present a method for a robust network design. This method allows finding the number of production locations, the allocation of production steps and capacities that maximizes robustness for given costs.

2 - Integrated Bio-refinery and Forest Products Supply Chain Network Design

Sophie Damours, Mechanical Engineering Dept, Université Laval, 1065 Avenue de la Medecine, Pavillon Pouliot, G1V 0A6, Quebec, Canada, Sophie.damours@forac.ulaval.ca, *Yan Feng*, *Luc LeBel*, *Mustapha Nourelfath*

We present a mixed integer programming model to support the design of the integrated bio-refinery and forest product supply chain. A general market-driven supply chain network structure is proposed allowing the optimal investment decisions to be made in choosing the right facilities, technologies, capacities, and their locations, that strategically maximize the supply chain value. In the model development, the biomass and energy supply decisions are also considered as decision variables. The model is validated using an experimental case. It is used to analyse the need for timely policy making.

3 - Integrated Scheduling of Production and Distribution Operations for Rapidly Perishable Products

Tsung-Sheng Chang, Graduate Institute of Logistics Management, National Dong Hwa University, 1, Sec.2, Da-Hsueh Rd., Shou-Feng, 974, Hualien, Taiwan, ts@mail.ndhu.edu.tw, *Ya-Ching Lin*

The major challenge faced by perishable-product logistics managers is how to control the quality of perishable products since they continuously and often rapidly decay throughout the supply chain. This research thus seeks to deal with the time-sensitive issue of managing perishable-product logistics by effectively integrating the scheduling of production and distribution operations. The integrated problem is NP-hard, and involves combining various logistics activities. Therefore, this research develops decomposition-based approaches to solve the problem.

4 - Frequency Driven Strategic Design for Less-than-truckload Networks

Anne Lange, Operations Planning Acc. & Control, Technische Universiteit Eindhoven, Faculteit Industrial Engineering & Innovation Sciences, Postbus 513, 5600 MB, Eindhoven, Netherlands, a.lange@tue.nl

Less-than-truckload transportation benefits from frequent terminal departures. Network optimization models integrating frequencies exist, but strongly rely on data and assumptions that are error-prone for strategic planning. This paper suggests as an alternative approach a heuristic algorithm generating networks while ensuring frequencies. Simulating transportation on the networks allows gaining high-level insights on their behavior. Results show that the mere existence of minimal frequencies rather than the exact frequency-setting is of relevance for various aspects of network performance.

■ MB-11

Monday, 14:00-15:30
Meeting Room 112

Queueing Models and Analyses I

Stream: Submodular Structures and Optimization

Invited session

Chair: *Yutaka Takahashi*, Graduate School of Informatics, Kyoto University, Sakyo-ku, 606-8501, Kyoto, Japan, takahashi@i.kyoto-u.ac.jp

1 - Conditional Sojourn Times of Processor-Sharing Queues

Chia-Li Wang, Applied Mathematics Dept, National Dong Hwa University, Shoufeng, 974, Hualien, Taiwan, cwang@mail.ndhu.edu.tw

Queues operated by a processor-sharing mode have important applications in many modern systems. However, performance measures of the sojourn time are difficult to derive, even with given initial condition. In addition, when the system limit is finite, the sojourn time is more complicated. In this paper, we take an algebraic approach to derive the moments of the sojourn time. We obtain an iterative formula and use it to investigate properties of the conditional sojourn time. The approach is simple and intuitive, and can be applied to queues with multiple-class customers as well.

2 - An Efficient Numerical Method for Multi-server Retrial Queues with Abandonments

Tuan Phung-Duc, Dept. of Systems Science, Graduate School of Informatics, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto City, 606-8501, Kyoto, Japan, tuan@sys.i.kyoto-u.ac.jp, *Yutaka Takahashi*

We consider an M/M/c/c retrial queue where those customers that find all the servers being fully occupied either leave the queue forever or join an orbit to retry later. After some exponentially distributed time in the orbit, a retrial customer either retries to occupy an idle server or abandons receiving service. Using a matrix continued fraction approach, we develop an efficient algorithm to compute the joint stationary distribution of the number of busy servers and the number of customers in the orbit. Numerical examples are presented to show the influence of retrials and abandonments.

3 - A Simple Backlog Evaluation Formula based on the Stochastic Network Calculus with Many Flows

Kazutomo Kobayashi, Faculty of Engineering, Nagasaki University, 1-14, Bunkyo-machi, 852-8521, Nagasaki, Japan, kobayashi@cis.nagasaki-u.ac.jp, *Yukio Takahashi*, *Yukihiro Takada*

In a previous paper, the authors proposed a new stochastic network calculus for many flows from an approach like large deviations techniques, and obtained asymptotic end-to-end evaluation formulas for output burstiness and backlog. In this paper, we apply this stochastic network calculus to a heterogeneous tandem network with many forwarding flows and cross traffic flows, and obtain a simple evaluation formula for the end-to-end backlog.

4 - Light-Tailed Asymptotics of the Joint Queue Length Distribution of a Multiclass M/G/1 Queue with the FCFS Service Discipline

Kenzo Hara, Dept. of Systems Science, Graduate School of Informatics, Kyoto University, 606-8501, Kyoto, Japan, ken3@sys.i.kyoto-u.ac.jp, *Hiroyuki Masuyama*, *Yutaka Takahashi*

This talk is concerned with a multiclass M/G/1 queue with the FCFS service discipline, which is fed by independent Poisson arrival processes with different service time distributions. For the multiclass M/G/1 queue, it is, in general, difficult to obtain an explicit expression of the stationary joint queue length distribution. We derive a light-tailed asymptotic formula for the stationary joint queue length distribution, assuming that the service time distributions are all light-tailed. The asymptotic formula is useful to understand the tail behavior and expected to serve as an approximation.

■ MB-12

Monday, 14:00-15:30
Meeting Room 205

Services Management

Stream: Contributed Talks

Contributed session

Chair: *Ronsen Purba*, Information Technology, STMIK Mikroskil, Jalan Thamrin No.124/140 Medan, Jalan Sembada XI No. 9, 20212, Medan, North Sumatera, Indonesia, ronsen@mikroskil.ac.id

1 - A Case Study of Design and Implement of a Service Business on a Heavy Machinery Manufacturing Firm

Nobuhiko Nishimura, Faculty of Economics, Nagasaki University, 4-2-1, Katafuchi, 850-8506, Nagasaki, Japan, nishimra@nagasaki-u.ac.jp

Three major perspectives relating to service business are reviewed, followed by an in-depth case study on a new e-service business design and implementation initiative at a heavy machinery manufacturing firm. It is confirmed that profitable services business can be designed based on strategic fitting to capability and position already built by the firm in its conventional business, with repeat prototyping to elicit potential customers' requirements. The resulting system makes the service offering complementary to and dependent upon products to raise the entry barrier against competitors.

2 - Verification of e-customer Purchasing Behavior Pattern Model by Cohort Analysis

Hisaya Sunada, Web Business Technology, The Kyoto College of Graduate Studies for Informatics, Japan, hisaya.sunada@gmail.com, *Tong Wu*, *Wang Chao*, *Maotao Chen*, *Hongxue Wang*, *Hong Seung Ko*

In the e-business environment, the visualization of e-customer purchasing behavior is absolutely necessary to select the most valuable e-customer who must be retained. In this paper, we perform the cohort analysis to the segmentation factor, that is purchasing frequency ,profitable sales and 7 Steps of e-customer purchasing behavior process in the e-customer purchasing behavior pattern model which is proposed by Ko et al. Consequently, we check up the validity of the e-customer purchasing behavior pattern model by the characteristics on the e-customer purchasing behavior pattern as a result.

3 - A use of Bootstrapped Malmquist Indices to Assess Productivity Changes of the Iranian Banks

Amir Arjomandi, Economics, University of Wollongong, 5/20, Smith Street, 2522, Wollongong, NSW, Australia, amira@uow.edu.au, *Abbas Valadkhani*

This study employs various bootstrapped Malmquist indices and efficiency scores to investigate the effects of government regulation on the performance of the Iranian banking industry over the period 2003-2008. An alternative decomposition of the Malmquist index, introduced by Simar and Wilson (1998a), is also applied to decompose technical changes further into pure technical change and changes in scale efficiency. A combination of these approaches facilitates a robust and comprehensive analysis of Iranian banking industry performance. While this approach is more appropriate than the traditional Malmquist approach, for the case of banking efficiency studies, it has not previously been conducted for any developing country's banking system. The results obtained show that although, in general, the regulatory changes had different effects on individual banks, the efficiency and productivity of the overall industry declined after regulation. We also find that productivity had positive growth before regulation mainly due to improvements in pure technology, and that government ownership had an adverse impact on the efficiency level of state-owned banks. The bootstrap approach demonstrates that the majority of estimates obtained in this study are statistically significant.

4 - On Deciding Sustainable Distribution Centre of a Supply Chain

Ronsen Purba, Mathematics Dept., STMIK Mikroskil Medan/Graduate School of Mathematics, University of Sumatera Utara, Jalan Thamrin No. 140 Medan North Sumatera, Medan, Indonesia, purbaronsen17@yahoo.com

A supply chain is a network that performs the procurement of raw material, the transportation of raw material to intermediate and end products, and the distribution of end products to retailers or customers. In this paper we address a new approach for solving a supply chain optimization model to decide distribution centres based on environmental consideration.

■ MB-13

Monday, 14:00-15:30
Meeting Room 206

Data Mining and Continuous Optimization

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - Necessary Conditions for the Confidence Level of the Randomized Cluster Stability Algorithm

Oleg Granichin, Mathematics & Mechanics, Sankt-Petersburg State University, 28 Universitetskii prospect, Petergof, 198504, St. Petersburg, Russian Federation, Oleg_granichin@mail.ru, *Renata Avros*, *Zeev (Vladimir) Volkovich*, *Mikhail Morozkov*

The well known machine learning problem is an estimation of clusters amount in a given dataset. We offer the approach in the framework of the common "elbow" methodology such that the true number of clusters is recognized as the discontinuity point of the differential risk function. We apply a randomized algorithm to allocate this position. The scenario approach is used to significantly reduction the computation complexity. We present necessary conditions to provide the chosen by user level of confidence. Numerical simulation example of an unknown huge amount of clusters illustrates the theory.

2 - Cluster Analysis of A Tobacco Control Data Set

Zari Dzalilov, School of Information Technology and Mathematical Sciences, University of Ballarat, 1, University Drive, 3353, Ballarat, VIC, Australia, z.dzalilov@ballarat.edu.au, *Adil Bagirov*

Development of theoretical and methodological frameworks in data analysis is fundamental for modeling complex tobacco control systems. Optimization methods can detect nonlinearity and be effective analysis tools of complex data. We evaluate the modified global k-means clustering algorithm for a massive set. Cluster analysis identified fixed and stable clusters in the studied data. Clusters correspond to smoker groups with similar behavior, identification of these clusters may allow modification of existing tobacco control systems and on design of future data acquisition surveys.

3 - Algorithm Learning Based Neural Network for Multivariate Classification

Hyunsoo Yoon, School of Industrial Management Engineering, Korea University, Anam 5-ga, Anam-dong, Sungbuk-gu,

136-701, Seoul, Korea, Republic Of, fineyouth@korea.ac.kr, *Cheong Sool Park*, *Jun Seok Kim*, *Sung-Shick Kim*, *Jun-Geol Baek*

We propose a new method to improve the accuracy for multivariate classification by integrating feature selection and classification. The method is self-sufficient by using the properties of various existing algorithms to learn NN(neural network) as training information. Each learned NN reflects those properties via connecting weights. The connected NN can be learned again for classification and to produce new features. We also study algorithm combinations to determine how to use the method suitably for data characteristics. The method can be applied to various areas requiring high accuracy.

4 - Cluster Validation Attitude via Information Distances

Zeev (Vladimir) Volkovich, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Stability of cluster solutions reveals the reliability of the clustering process. Partition' readiness is characterized by the its clusters homogeneity represented in our approach by the information distances between samples' occurrences in the clusters. In the framework of the Gaussian Mixture Model these distances lead to the known probability metrics such as the weighed T-square statistic. The appropriate cluster number can be deduced from the most concentrated at the origin, distance's empirical distribution, constructed for several possible quantities of clusters.

■ MB-14

Monday, 14:00-15:30
Meeting Room 207

Nonsmooth Optimization I

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Adil Bagirov*, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

1 - Epsilon-cleaning of Big Datasets

Andrew Yatsko, ITMS Dept., University of Ballarat, Mt. Helen campus, 3350, Mount Helen, VIC, Australia, andrewyatsko@students.ballarat.edu.au, *Adil Bagirov*

In applications of Cluster Analysis and Data Classification there is a performance issue arising from the sheer multitude of instances. An existing technique does clearing of the closely packed data, but what is discarded is arbitrary. We address the issue of bias and suggest a way of preserving the cropped data. A modified procedure of cleaning is proposed and tested on some known examples. It is run recursively on reduced sets, their integrity being verified. The staged out cleaning offers an update mode from simple to complex, able to dramatically improve performance of some algorithms.

2 - Lipschitzian Properties of the Dual Pair in Infinite-Dimensional Linear Optimization

Marco A. López-Cerdá, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es, *Andrea Beatriz Ridolfi*, *Virginia N. Vera de Serio*

We apply coderivatives and other tools from variational analysis to study the stability of the feasible sets of both, the primal and the dual problem in infinite-dimensional linear optimization with infinitely many explicit constraints and an additional conic constraint. After providing some specific duality results for our dual pair, we study the Lipschitz-like property of both mappings and also give bounds for the associated Lipschitz moduli.

3 - Novel Robust Regression Methods Based on Non-smooth and Derivative Free Optimization

Gleb Beliakov, School of Information Tecnology, Deakin University, Melbourne, Victoria, Australia, gleb@deakin.edu.au, *Andrei Kelarev*

Robust regression methods based on non-smooth optimization methods have many important applications. Our experiments compare the performance of several derivative free optimization algorithms computing robust multivariate estimators, where the objective is non-smooth, non-convex and expensive to calculate. It is shown that the existing algorithms often fail to deliver optimal solutions. We introduce two new methods using Powell's derivative free algorithm. Extensive experimental results demonstrate that our new proposed methods are reliable and can process very large data sets.

4 - Algorithms for Optimization of Electricity Distribution Systems when Upgraded by Renewable Energy

Sattar Seifollahi, School of Information Technology & Mathematical Sciences, University of Ballarat, Australia, s.seifollahi@ballarat.edu.au, *Adil Bagirov*

Distributed energy planning is a non-convex combinatorial problem, and in many cases, it may contain integer variables. In this talk, we present non-smooth optimization based algorithms for solving such problems. The algorithms can be applied to networks of large size and have advantages over the existing algorithms in that they guarantee a globally optimal solution. An overview on the use of some existing optimization algorithms in the distribution systems is also provided. The results of the proposed methods are compared with others, demonstrating the efficiency of the proposed algorithms.

■ MB-15

Monday, 14:00-15:30
Meeting Room 208

Analyses for Air and Space Operations

Stream: Military, Defense and Security Applications
Invited session

Chair: *Ariela Sofer*, George Mason University, MS4A6 4400 University Drive, 22030, Fairfax, VA, United States, asofer@gmu.edu

1 - Predicting the Required Naval Combat Helicopter Fleet Size

David Marlow, Air Operations Division, DSTO, 506 Lorimer St, 3207, Fishermans Bend, Vic, Australia, david.marlow@dsto.defence.gov.au, *Ana Novak*

A discrete event simulation has been developed that models a fleet of naval combat helicopters. The simulation includes detailed models of the ashore and embarked flying program, and represents unscheduled, phased and deep maintenance. The purpose of the model is to assist the Australian Government in determining the size of the new fleet of naval combat helicopters. The fleet must meet minimum requirements for the number of helicopters embarked on ships, while simultaneously providing a minimum number of annual flying hours ashore.

2 - Routing Optimisation for Air-to-Air Refuelling

Yue-Jin Wang, Joint Operations Division, Defence Science and Technology Organisation, DSTO-Fairbairn, Canberra, ACT, Australia, yue-jin.wang@dsto.defence.gov.au, *Ian Brunskill*

Air-to-Air refuelling (AAR) is the process of transferring fuel from one aircraft (tanker) to another (receiver) during flight. Optimal use of limited tanker resources is a major concern in military AAR planning. This paper formulates the tanker assignment problem as a multiple-vehicle routing problem with time windows (VRPTW). It aims at designing a set of minimum-cost routes for a tanker fleet tasked to refuel a number of receiver aircraft at predefined locations in the required time windows. A genetic algorithm-based technique is developed for solving this complicated VRPTW problem.

3 - Analysis Tools in Swedish Air Force Studies

Anders Tavemark, Division of Defence Analysis, Swedish Defence Research Agency, FOI, SE-172 90, Stockholm, Sweden, tavemark@foi.se

Swedish operational analysts support military studies at the Swedish Armed Forces. The studies range from system studies at the armed services level to long term planning studies at the armed forces level. Different study questions require different study approaches. One constant limitation is available resources. This presentation describes experiences from using different analysis tools in Swedish Air Force studies, ranging from spreadsheets to the Swedish Air Force Combat Simulation Centre.

4 - Scheduling Optimization for Multi-Satellite Constellations using Column Generation

Ariela Sofer, George Mason University, MS4A6 4400 University Drive, 22030, Fairfax, VA, United States, asofer@gmu.edu

Imagery satellites serve purposes from intelligence analysis to environmental analysis. Demand for imagery however far exceeds available satellites. The multi-satellite scheduling problem determines which targets should be imaged by which satellite and when. We propose a new cluster-route-schedule approach which first groups targets into smaller clusters, next uses column generation to determine which clusters each satellite should image and when, and then assigns individual targets within each cluster. The goal is to maximize the overall utility of the imagery subject to physical, orbit, and energy constraints. Computational results are presented and demonstrated on Google Earth.

■ MB-16

Monday, 14:00-15:30
Meeting Room 209

Scheduling Service and Manufacturing Systems

Stream: Scheduling
Invited session

Chair: *Chelliah Sriskandarajah*, School of Management, SM30, University of Texas at Dallas, 800 West Campbell Road, 75080, Richardson, Texas, United States, chelliah@utdallas.edu

1 - Minimization of Earliness, Tardiness and Due Date Penalties on Uniform Parallel Machines with Identical Jobs

Inna Drobouchevitch, Korea University Business School, Seoul, Korea, Republic Of, innadro@hotmail.com, *Jeffrey B. Sidney*

We consider a problem of scheduling n identical nonpreemptive jobs with a common due date on m uniform parallel machines. The objective is to determine an optimal value of the due date and an optimal allocation of jobs onto machines so as to minimize a total cost function, which is the function of earliness, tardiness and due date values. For the problem under study, we establish a set of properties of an optimal solution and develop a polynomial-time algorithm to solve the problem.

2 - Optimal Scheduling of Mobile Advertisements

Subodha Kumar, Mays Business School, Texas A&M University, Wehner 301F - 4217 TAMU, 77843, College Station, TX, United States, subodha@tamu.edu, *Bandyopadhyay Tridib*, *Milind Dawande*, *Vijay Mookerjee*

Mobile wireless devices are increasingly becoming powerful platform for advertising because they can be used to track physical location of its users. However, the ineffective advertisements not only increase the cost to the advertisers, but may also create a negative value for the item. Hence, the firms need to make the advertising decisions judiciously. We optimize the decisions for a large marketing firm which needs to maximize the effectiveness of advertisements in a given planning horizon.

3 - Batch Scheduling to Minimize Inventory Holding and Delivery Costs with Release Time Constraints

Esaignani Selvarajah, Odette School of Business, University of Windsor, 401 Sunset Avenue, N9B 3P4, Windsor, Ontario, Canada, selvare@uwindsor.ca, *Rui Zhang*

A manufacturer receives jobs from suppliers, and produces and delivers final products to customers in batches. The manufacturer is modeled as a single machine in the supply chain and the problem is modelled as minimizing the sum of weighted flow time and the batch delivery costs. Since the problem is strongly NP-hard, we first analyze some polynomially solvable special problems. Then we develop a heuristic algorithm to solve the general problem. The computational experiments show that the solutions of the heuristic algorithm are close to optimal solution.

4 - Fresh Product Sales Planning: As a Whole or As Parts?

Xiaolin Xu, Business Administration, Nanjing University, Anzhong Building, School of Business, 210093, Nanjing, Jiangsu, China, xuxl@nju.edu.cn

We consider a fresh produce supplier, who can sell his product either as a whole in the spot market or as two separate parts through a mixed channel. The two parts differs in demand, with one (say part 1) dominating the other (say part 2). If selling as parts, the supplier decides his wholesale price based on its effect on the procurement quantity to part 1 retailer, taking into account the spot demand uncertainty of part 2. We study under what situations which strategy should be adopted by the supplier.

■ MB-17

Monday, 14:00-15:30
Meeting Room 214

Artificial Intelligence for MCDA

Stream: Multicriteria Decision Analysis and Multiobjective Optimisation
Invited session

Chair: *Constantin Zopounidis*, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, kostas@dpem.tuc.gr

1 - Missing Item Scores Estimation in Incomplete Reciprocal Pairwise Comparison Matrix

Yi Peng, School of Management and Economics, University of Electronic Science and Technology of China, 610054, Chengdu, China, pengyicd@gmail.com, *Daji Ergu*, *Gang Kou*, *Yong Shi*

An intelligence processing technique is proposed to intelligently calculate and estimate the missing item scores of an incomplete reciprocal pairwise comparison matrix (IRPCM). A scale format is used to design the score items for a comparison matrix. Besides, an induced bias matrix model (IBMM) is proposed to estimate the missing item scores of the reciprocal pairwise comparison matrix. The theorems of the IBMM are developed, some different cases with different missing numbers in a general IRPCM of order four are analyzed, and some numerical examples are used to illustrate the proposed model.

2 - Theoretical Analysis on Cut-off Policy in Credit Scoring - Linear Programming Models with Changeable Right Hand Parameters

Jing He, School of Engineering and Science, Victoria University, PO Box 14428, Melbourne, VIC 8001, Australia, jing.he@vu.edu.au, *Yanchun Zhang*, *Yong Shi*, *Guangyan Huang*

Linear discriminant models consider two objectives: firstly, the minimal distances of observations from the critical value are maximized (MMD); the second minimizes the sum of the deviations (MSD) of the observations. Given a threshold, the best data separation can be selected from results determined by different b (cutoff or right-hand parameter) values. We utilize multiple criteria and multiple constraint levels linear programming model to explore LP models with changeable right hand parameters (b). We will study how to find best solutions in general and specific linear discriminant cases.

■ MB-18

Monday, 14:00-15:30
Meeting Room 215

DEA Theoretical Development - 1

Stream: Data Envelopment Analysis
Invited session

Chair: *Francisco Lopez*, School of Business, Macon State College, 100 College Station, 31206, Macon, GA, United States, francisco.lopez@maconstate.edu

1 - Incorporate Dual-role Factors in DEA

Wen-Chih Chen, Dept of Industrial Engineering and Management, National Chiao Tung University, 1001 Ta Hsueh Rd., 300, Hsinchu, Taiwan, wenchih@faculty.nctu.edu.tw

Typical DEA studies consider production processes of transforming many inputs to various outputs. In some cases, however, some factors may be considered as both inputs and outputs; these factors are referred to as dual-role factors. For example, research funding is an important output criterion while it is a resource to strengthen academic performance of a university. This study investigates dual-role factors in DEA. Rather than proposing an ad hoc model directly, an axiomatic approach is used. Therefore, our model is theoretically well-defined and intuitively obvious.

2 - Stability of Network DEA

Necmi Avkiran, UQ Business School, The University of Queensland, St Lucia Campus, 4072, Brisbane, Queensland, Australia, n.avkiran@uq.edu.au

Users of network DEA (NDEA) presume efficiency estimates to be robust. Findings indicate (a) removing a relevant input improves discrimination (b) introducing an extraneous input leads to a moderate loss of discrimination (c) simultaneously adjusting data shows a mostly stable NDEA (d) swapping divisional weights produces a substantial drop in discrimination (e) stacking perturbations has the greatest impact on efficiency estimates with substantial loss of discrimination, and (f) layering suggests that the core inefficient cohort is resilient against omission of benchmark branches.

3 - A Computational Analysis of the Impact of Correlation in DEA

Francisco Lopez, School of Business, Macon State College, 100 College Station, 31206, Macon, GA, United States, francisco.lopez@maconstate.edu, *Johnny Ho*, *Alex Ruiz-Torres*

Two recent articles discuss especial types of linear relations (perfect correlation) among DEA attributes and how they may affect the DEA scores. These perfect correlations may have a very different impact on the DEA scores. In the case of one of these linear relations, removing one of the DEA attributes does not change the efficiency score of any DMU. The presence of another type of linear relation makes all the DMUs efficient. This research project aims at conducting an extensive computational analysis to understand the effect on the DEA efficiency scores of correlation among attributes.

4 - A DEA Approach in Supplier Selection Taking into Account Transportation and Inventory costs

Stella Sofianopoulou, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou street, 18534, Piraeus, Greece, sofianop@unipi.gr

Most studies related to the supplier selection problem consider several selection criteria but little attention is given to transportation and inventory costs. In this paper, a two-phase approach for the supplier selection problem is proposed. First, the sum of transportation and inventory costs for each supplier is determined by employing genetic algorithms. Second, a DEA approach is adopted to evaluate performance of suppliers based on multiple criteria including transportation and inventory costs and at the same time suggest negotiation strategies for inefficient suppliers.

■ MB-19

Monday, 14:00-15:30
Meeting Room 216

Projects & Cases - Getting Students Involved

Stream: Education and Operations Research
Invited session

Chair: *Susan Martonosi*, Mathematics Dept., Harvey Mudd College, 301 Platt Blvd., 91711, Claremont, CA, United States, martonosi@math.hmc.edu

1 - A Case-Based Approach for Teaching Management Science and Project Management

Bert De Reyck, Management Science & Operations, London Business School, Regent's Park, NW1 4SA, London, United Kingdom, bdereyck@london.edu

I will give an overview of how cases are used in my Project Management and Management Science courses at London Business School and University College London. In my opinion, the use of cases is essential for making a course interesting and relevant, but cases can be of different types, and used in different ways. I will describe how I develop and use cases in the classroom with MBA and MSc students, and contrast it with other approaches.

2 - Experiences on Cooperative Learning in OR courses

Marcela Gonzalez, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl

The experience acquired in the last three years on cooperative learning in OR courses is presented. Some cooperative learning methods applied for helping students to work in groups and to solve OR problems are shown.

3 - Senior Capstone Projects: A Taste of the Real World

Susan Martonosi, Mathematics Dept., Harvey Mudd College, 301 Platt Blvd., 91711, Claremont, CA, United States, martonosi@math.hmc.edu

A senior capstone is a project conducted during a student's final year, whose intention is to synthesize the material they have learned in their courses. At Harvey Mudd College, mathematics students can choose a traditional thesis project or a "clinic" project. Clinics are industry-sponsored projects in which a team of students works on a real-world problem of interest to the sponsoring organization. This talk will present an overview of the clinic model and discuss its educational benefits and shortcomings.

■ MB-20

Monday, 14:00-15:30
Meeting Room 217

Soft OR II

Stream: Soft OR and Problem Structuring
Invited session

Chair: *Vicky Mabin*, Victoria Management School, Victoria University of Wellington, PO Box 600, 6140, Wellington, New Zealand, vicky.mabin@vuw.ac.nz

1 - PSM Approach: Some Applications

Arabinda Tripathy, Vinod Gupta School of Management, Indian Institute of Technology, 721302, Kharagpur, West Bengal, India, tripathy44@rediffmail.com

Problem Structuring Methods approach has been applied in various situations to address complex societal problems and such other issues and to manage them. Some of the areas where the concepts of problem structuring methods have been used are presented here. These relate to issues related to elected representatives, workers, performance management of academic institutes and the like. The approach and the outcomes are presented.

2 - Improving Service Delivery in a UK Police Force: Designing Control Processes using VSM and SSM

Chris Smith, OIM Group, Aston University, Aston Business School, Aston Triangle, B4 7ET, Birmingham, West Midlands, United Kingdom, smithcm2@aston.ac.uk

This presentation describes use of Viable System Modeling (VSM) and Soft Systems Methodology (SSM) to develop a control process for a new customer contact strategy in a UK police force. Spending cuts in the UK are driving a UK Police Force to restructure their customer contact, moving away from a costly front office network to partnering with local councils in One Stop Shops. Through using VSM and SSM to design the control processes for a new system a control process has been designed that is both viable while taking into account the different perspectives of actors who work within the system.

3 - Elder Care Decisions: A Multi-methodological Approach

Vicky Mabin, Victoria Management School, Victoria University of Wellington, PO Box 600, 6140, Wellington, New Zealand, vicky.mabin@vuw.ac.nz, *Kim Sommer*, *Gemma Clark*

The need for families to confront decisions relating to care of the elderly are becoming increasingly common with the aging population. This paper will draw on two different real-life cases, and demonstrate how different approaches taken from Soft Systems Methodology, Theory of Constraints and Multi-criteria decision making can be used in multi-methodological fashion tackle the many facets of how best to care for one's elder folk. Each method is able to complement the other to provide a more complete view.

■ MB-21

Monday, 14:00-15:30
Meeting Room 218

OR in Forestry

Stream: Forestry Applications
Invited session

Chair: *Andrés Weintraub*, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl

1 - Integrated Value Chain Planning

Patrik Flisberg, Linköping University, Division of Optimization, SE-58183, Linköping, Sweden, pafli@mai.liu.se, *Sophie Damours*, *Mikael Rönnqvist*, *Juan José Troncoso*, *Andrés Weintraub*

We present a mixed integer programming model to evaluate two different integration strategies in order to show the impacts of a fully demand driven integration of the value chain in the forest industry. To illustrate, we use forest, economic and production information from a Chilean forest company. We compare two different integration strategies: the first one where the forest and the industry planning are decoupled and the second, were all parts of the value chain (forest, transportation, mills) are driven by final product demand.

2 - Multiple Criteria and Participative Decision Making for Sustainable Forest Management using AHP and Goal Programming

Concepcion Maroto, Estadistica e Investigacion Operativa, Universidad Politecnica de Valencia, Camino de Vera S/N, 46022, Valencia, Spain, cmaroto@eio.upv.es, *Concepción Ginestar*, *Juan Uriol*, *Marina Segura*, *Baldomero Segura*

We have developed a Strategic Forest Management Model for a Mediterranean region, taking into account Multiple Criteria and Participative Decision Making. Firstly, we have identified forest stakeholders and carried out a workshop with representatives of stakeholders to test the proposed criteria. Secondly, we also carried out two surveys amongst the stakeholder representatives to determine the relative importance of the criteria, objectives and strategies. We obtained priorities using AHP and Goal Programming techniques. A complete analysis and discussion of results will be provided.

3 - Land Use Participatory Planning Process in the Delta of the Parana River, Argentina

Daniel Somma, EEA_Delta, INTA_Argentina, Rio Paraná de las Palmas y Canal L. Comas, 2804, Campana, Prov. Buenos Aires, Argentina, djsomma@yahoo.com.ar

The land use planning of forest resources is a complex problem because the multicriteria (MC) involved in the decision We address the resolution of this planning problem applying the MC decision making paradigm through a participatory approach. We characterize the spatial expression of relevant processes like subregional land use change and degradation of natural resources. Analysis is tuned to Parana Delta context. This allows a regional-focused interpretation of the process and the results are inputs for development(with stakeholders' participation)of a spatial DSS and scenarios design.

Monday, 16:00-17:30

■ MC-01

Monday, 16:00-17:30

Plenary Hall 3

Development Prize Presentations III

Stream: OR Development Prize

Invited session

Chair: *Subhash Datta*, NIILM CMS, 53 Knowledge Park V, 201310, Greater Noida, UP, India, subhash.datta@gmail.com

1 - A Decision Support Methodology for Increasing School Efficiency in Bolivia's Low-income Communities

João Neiva de Figueiredo, Department of Management, Saint Joseph's University, Haub School of Business, 5600 City Avenue, 19131, Philadelphia, PA, United States, jneiva@deps.ufsc.br

This paper presents a DEA-based decision-support methodology that has been implemented and is being used by a not-for-profit organization, Fe y Alegría, which runs 439 Bolivian schools reaching over 160,000 disadvantaged students in that poverty stricken Latin American nation. Bolivia is a poor country with the highest percentage of indigenous population and the lowest per capita income in South America and as such its inhabitants are in dire need of effective educational resources to help them out of poverty. The DEA-based methodology described in this paper has offered an objective way to compare network schools among themselves and with out-of-network schools, providing a deeper understanding of school efficiency levels in the face of scarce resources, and allowing for sharing of best practices across the network. The paper introduces the educational environment in Bolivia, presents the DEA model, describes the decision support methodology, and provides two examples of its use. The first example compares FyA secondary schools with out-of-network secondary schools using publicly available data, and the second compares FyA secondary schools among themselves using a proprietary data-base. The paper also comments on lessons learned and the need for broad consensus-building and organization-wide buy-in for successful adoption and maximum impact.

2 - Efficiency in Saving Infant Lives: the Influence of Water and Sanitation Coverage

Gustavo Ferro, Instituto de Economía, Universidad Argentina de la Empresa, C1073AAO, Ciudad de Buenos Aires, Argentina, gferro@uade.edu.ar

In this paper, we aim to assess the relationship between water and sanitation coverage and saved infant lives. Our hypothesis is that extended coverage implies measurable results in terms of reduced infant mortality. Moreover, we suspect that with the same resources, ceteris paribus, different countries can achieve better or worst results depending on the efficiency which the resources are used. We explore the policy consequences, simulating the effects that improvements in efficiency can yield in terms of the reduction in child mortality. Our approach is first to explore with a database of Latin American countries the "production function' of survivor infants on 1,000 births. Once we identify the causal relationship with an econometric model, we estimate a production frontier with Data Envelopment Analysis in order to determine the best performers: countries which can do better with the same "inputs'. Finally, we simulate the consequence of catching up to the frontier in each country. The impressive quantitative results are interesting for policy concerns, since efficiency is reconciled with equity (in the sense that the winners of the coverage increases and the health improvements are the poorer).

■ MC-02

Monday, 16:00-17:30

Meeting Room 101

Game Theory Applications in Operations Management II

Stream: Game Theory

Invited session

Chair: *Yong Won Seo*, Dept. of Business Administration, Chung-Ang University, 221 Heukseok Dongjak, 156-756, Seoul, Korea, Republic Of, seoyw@cau.ac.kr

1 - Capacity Commitment and Pricing for Substitutable Products

Hongyan Li, Department of Management Science and Engineering, Business and Administration School, Northeastern University, Post Box 329, Wenhua Road No. 3, Heping Dist,, 110819, Shenyang, China, hyli@mail.neu.edu.cn, *Tianhui You*

We address substitutable product pricing and multiple resource capacity planning problem with stochastic costs and demands. The companies need to determine a capacity commitment and a price for each product to maiximize total profit. We first analyze static pricing and capacity commitment problem for a single company which produces multiple products. We then exptend the price competition problem. At last, we consider a long term capacity commitment and dynamic pricing problem with cost uncertainty. The condition of the optimal solution are provided for each type of the three cases above.

2 - A Capacity Game in Transportation Management

Guillaume Amand, HEC-Ulg, University of Liège, boulevard du rectorat, 7 - Bât. B31, 4000, Liège, Belgium, guillaume.amand@ulg.ac.be

This study analyzes the contractual relation between a retailer and a carrier with the aim of determining possible deviations from the optimal system performance. In order to face a random demand, the retailer submits a contract to the carrier based on the number of units transported and on the number of truck used. Then, before uncertainty is resolved, the carrier decides of the number of trucks that he reserves. Once the demand is known, the carrier may also request additional trucks at a higher cost. The results show that the proposed contract does not coordinate the supply chain.

3 - Collaborative Contracts for Disruption Management in Urban Public Transport Systems

Amy Zeng, School of Business, Worcester Polytechnic Institute, 100 Institute Road, 01609, Worcester, Massachusetts, United States, azeng@wpi.edu, *Christian Durach*, *Yan Fang*

Trams are reviving in many cities of the world due to its low carbon emission and better resource utilization. However, this light-rail system is prone to unexpected disruptions and quick response to such disruptions is vital to the system's continuous operations and service quality. This research is inspired by the tram systems operated in Berlin, Germany and Dalian, China. Our preliminary studies provide a basis for our research that aims at designing collaborative contracts for coping with disruptions.

4 - Analyzing the Dysfunction of Shared Information in Supply Chains

Yong Won Seo, Dept. of Business Administration, Chung-Ang University, 221 Heukseok Dongjak, 156-756, Seoul, Korea, Republic Of, seoyw@cau.ac.kr, *Yung-Mok Yu*

Information sharing across supply chain often allows retailers to access the stock information of the warehouse and even the other retailers. Using the shared information the retailers may compete with each other to preempt the warehouse inventory. In this talk, we analyze the retailer competition under the fully shared stock information environment. The computational results show that the cost increase due to the retailers' competition is significant, which implies that the dysfunction of the shared information should not be neglected in a practical sense.

■ MC-03

Monday, 16:00-17:30
Meeting Room 102

Innovative Algorithms for Container Management

Stream: Meta-heuristics

Invited session

Chair: *Panagiotis Angeloudis*, Civil & Environmental Engineering Dept, Imperial College London, Centre for Transport Studies, Skempton Building, Rm 205, SW7 2BU, London, United Kingdom, pa01@ic.ac.uk

1 - Container Storage Arrangement on the Yard with Consideration of Block Sizing

Etsuko Nishimura, Graduate School of Maritime Sciences, Kobe University, Fukae-minami, Higashinada, 658-0022, Kobe, Japan, e-nisi@maritime.kobe-u.ac.jp, *Akio Imai*

This study is concerned with the container storage arrangement in the yard for transshipment containers, in order to carry out the ship handling operations efficiently. Objective functions are assumed that the total service time from the mega-containership to feeders for transshipment containers via yard blocks and the yard area size their containers require. The service time of containers movement from quay cranes assigned to the mega-containership to container blocks in the yard area depends on the block size. Therefore we consider the model with block sizing issue.

2 - Capacity Planning for Supply Chains Involving Mines, Ports and a Railway System

Joey Fung, Department of Mathematical Sciences, University of Technology, Sydney, Australia, joeyfung88@gmail.com, *Gaurav Singh*, *Yakov Zinder*

Transportation, storage and loading operations in a supply chain involving mines, ports and a railway system are governed by ship arrivals and their required loads. The talk presents models and methods intended for finding a minimal-cost capacity expansion allowing to meet the demand specified by ship arrivals. The methodology includes mixed-integer linear program for finding a lower bound on the minimal cost of capacity expansion, and metaheuristic procedures for finding an upper bound on this minimal cost. The talk also discusses implementation and results of computational experiments.

3 - Allocation of Empty Containers between Multi-ports with Lost Sales

Bo Zhang, Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, bo.zhang@polyu.edu.hk, *Chi To Ng*

We study how to allocate empty containers to minimize the cost under lost sales scenario. We find the optimal policy for a single port at period n is to import empty containers up to An if the number is fewer than An; export them down to Sn if the number is more than Sn; do nothing otherwise, and develop a heuristic algorithm to calculate An and Sn for each period. Next, for multi-ports, we prove a tight lower bound for the cost function and develop a heuristic algorithm to obtain a near-optimal policy. The result shows relative error is within five percent. Both algorithms work efficiently.

4 - A Container Repositioning Algorithm using Frequency-based Liner Service Modelling

Panagiotis Angeloudis, Civil & Environmental Engineering Dept, Imperial College London, Centre for Transport Studies, Skempton Building, Rm 205, SW7 2BU, London, United Kingdom, pa01@ic.ac.uk, *Michael Bell*

The classic frequency-based transit assignment method of Spiess and Florian has been previously used as the basis for a maritime assignment model that employs liner service frequencies instead of fixed sailing times. This paper focuses on the management of empty containers, a topic of great interest to the maritime logistics community given the effects of the global trade imbalance. We present a novel repositioning algorithm that can be applied across a large network of services by a single or several co-operating shipping lines.

■ MC-04

Monday, 16:00-17:30
Meeting Room 103

Production Line Design

Stream: Operations Management

Invited session

Chair: *Hicham Chehade*, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie, 10000, Troyes, France, chehadeh@utt.fr

Chair: *Lionel Amodeo*, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie BP2060, 10000, Troyes, France, lionel.amodeo@utt.fr

Chair: *Farouk Yalaoui*, Institut Charles Delaunay, ICD LOSI, University of Technology of Troyes, 12, Rue Marie Curie BP 2060, 10000, Troyes, France, farouk.yalaoui@utt.fr

1 - A New Hybrid Method for Robotic Cyclic Scheduling Problems

Farouk Yalaoui, Institut Charles Delaunay, ICD LOSI, University of Technology of Troyes, 12, Rue Marie Curie BP 2060, 10000, Troyes, France, farouk.yalaoui@utt.fr, *Slim Daoud*, *Lionel Amodeo*, *Hicham Chehade*

The problem studied in this paper is a cyclic job shop with transportation robots, in which assembly tasks have to be assigned to robotic workstations and with the objective of minimizing the cycle time and to define the gripping strategies for each robot. To optimize the system, we have developed a hybrid ant colony optimization algorithm with a guided local search to enhance the performances. We have chosen the Howard's algorithm to evaluate the solutions of our method and which aims to define the best combination of assigned assembly tasks and products for each robotic workstation.

2 - A New Cost-based Mathematical Model for a Two-machine One-buffer Design Problem

Hicham Chehade, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie, 10000, Troyes, France, chehadeh@utt.fr, *Yassine Ouazene*, *Alice Yalaoui*

The addressed paper presents a serial flow line with two machines and a finite intermediate buffer design problem. The processing times on each machine are deterministic and both failure times and repair times are assumed to be exponentially distributed. The availability of the system, the buffer average storing level and the throughput rate of the system are calculated. We develop a new cost-based mathematical model to find the optimal design of the machines and the buffer size. The proposed model is solved using Lingo solver. The obtained results are promising.

3 - Equipment Selection and Buffers Sizing in Assembly Lines using a Strength Pareto Evolutionary Algorithm with a Fuzzy Logic Controller

Lionel Amodeo, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie BP2060, 10000, Troyes, France, lionel.amodeo@utt.fr, *Hicham Chehade*, *Farouk Yalaoui*

In this paper, equipment selection and buffers sizing are considered in an assembly line design problem. Two objectives are considered: cost minimization and throughput rate maximization. For that, we first develop a SPEA-II algorithm. Then, we try to better set some parameters of the proposed algorithm. For that, we develop a fuzzy logic controller to set in an optimal way the crossover and mutation probabilities. We carry out several tests to assess the impact of the fuzzy logic controller. The numerical results show the advantages of the fuzzy logic controller with the SPEA-II algorithm.

4 - Optimum Quality Planning In a Sustainable Production Environment

Farhad Azadivar, Mechanical Engineering, University of Massachusetts Dartmouth, 285 Old Westport Rd, MA 02748, North Dartmouth, Massachusetts, United States, fazadivar@umassd.edu

Recycling good parts recovered from returned products will not only support a sustainable production environment it may also optimize the total cost of meeting the demand with a combination of the primary and aftermarket products. The system under consideration consists of two production lines; one assembling primary products from newly fabricated parts and sub-assemblies, the other assembling aftermarket products from good returned parts. A model will be presented for estimation and optimization of the total cost of supplying the demand as a function of the planned production quality.

■ MC-05

Monday, 16:00-17:30

Meeting Room 104

Sustainability and Service Provision

Stream: Service Science and Sustainability

Invited session

Chair: *Young Lee*, Mathematical Sciences Department, IBM Research, 1101 Kitchawan Road, 10598, Yorktown Heights, New York, United States, ymlee@us.ibm.com

Chair: *Grace Lin*, IEOR Dept., WRO & Columbia University, 9 Garey Drive, 10514, Chappaqua, NY, United States, gracelin.ny@gmail.com

1 - How Service Innovation Reshape Public Transportation and Mobility

Hervé Mathe, ISIS The Institute for Service Innovation & Strategy, ESSEC business school, ESSEC BP 50105 Cergy, F-95021, Cergy Pontoise - Cedex, France, hpmathe@yahoo.com

Developing sustainable transportation systems and mobility solutions raise specific questions and challenges. By exploring a series of recent attempts including Cyclocity, ZipCar, CityMobility, and Car sharing, we have identified and qualified three key steps of development and decision making processes: 1) market reading at user, payer, andprescriber's levels; 2) combination of service content, physical support, and user relationship monitored over time; and 3) definition of acceptable value equation including provision of value investors, beneficiaries, and the society

2 - Managing Roving Wildlife for Profit

John Hearne, Mathematical and Geospatial Sciences, RMIT University, GPO Box 2476v, 3001, Melbourne, Victoria, Australia, john.hearne@rmit.edu.au

There is an extensive literature on the 'tragedy of the commons' and strategies to manage a common resource. Although there are similarities the following problem is different. Roving wildlife traversing private land is also a common resource but it can only be utilised by the owner of the land on which it is on at any given time. Can the actions of one landowner affect the profitability of activities on the land of others? These issues will be explored with various models.

3 - Optimal coordination policy for a three echelon supply chain under price and effort sensitive market

Manjusri Basu, Department of Mathematics, University of Kalyani, 741235, Kalyani, West Bengal, India, manjusribasu2011@gmail.com

We consider a three echelon supply chain where demand depends on the selling price of the retailer and the individual or combine selling effort preferred by the channel members. We study a game theoretical model to examine the impact of rebate and effort on the pricing and sales decisions. First we study effect of instant rebate, where the consumer can cash in the rebate with virtually no effort. Then we discuss the effect of mail-in rebate, where some consumer effort is required to redeem the rebate. Effects of rebate and revenue sharing, and rebate and effort sharing are also discussed.

■ MC-06

Monday, 16:00-17:30

Meeting Room 105

Routing and Planning

Stream: Transportation

Invited session

Chair: *Martin Savelsbergh*, CSIRO, NSW 1670, North Ryde, Australia, Martin.Savelsbergh@csiro.au

1 - Orienteering Problems with Time Windows given Dynamic Service Times and Profits

Verena Schmid, Faculty of Business, Economics and Statistics, University of Vienna, Bruenner Strasse 72, 1210, Vienna, Austria, verena.schmid@univie.ac.at

In this talk we will present an extension of the Orienteering Problem with Time Windows. We aim at finding a profitable tour, such that the resulting route is feasible with respect to time windows without violating a maximum tour length restriction and the total profit is maximized. Profits are not fixed but depend on the length of service time. Additionally, diversity in locations should be favored, so we consider the number of locations visited as a secondary objective. The resulting biobjective optimization model can then be solved using any multiobjective approach such as NSGA2.

2 - Modeling the Profitable Mixed Capacitated Arc Routing Problem

Cândida Mourão, Dep. Matemática, Instituto Superior de Economia e Gestão / Centro IO, Rua do Quelhas, 6, Gabinete

203, 1200-781, Lisboa, Portugal, cmourao@iseg.utl.pt, *Enrique Benavent*, *Angel Corberan*, *Luis Gouveia*, *Leonor S.Pinto*

The Profitable Mixed Capacitated Arc Routing Problem is a generalization of the Profitable Arc Tour Problem. Tasks may be either mandatory or optional. Each task has an associated demand, a profit, a deadheading cost and a traversal time. The objective is to find a set of tours that maximize the total net profit, respecting a maximal tour length and the vehicles capacity. The profit over a link is available only once, when the service is performed. We present compact flow based models for the PMCARP. Valid inequalities are also presented. The quality of the models is tested and analysed.

3 - Optimization of Bus Schedules in Event Tourism using Mixed-integer Linear Programming

Gianluca Brandinu, Department of Business Administration, University of Bern, Schuetzenmattstrasse 14, 3012, Bern, Switzerland, gianluca.brandinu@pqm.unibe.ch, *Norbert Trautmann*

We study a bus tour of Bollywood-movie locations in Switzerland. The tour operator runs up to five busses per day; however, two or more busses cannot stay at the same location simultaneously. The planning problem consists in computing a feasible schedule for each bus such that a lexicographic combination of the total waiting and the total travel time is minimized. We formulate this problem as an MILP, and we report on numerical results obtained with the Gurobi Solver. We demonstrate how the computational effort can be reduced by introducing symmetry-breaking constraints.

4 - Optimized Long-term Freight Infrastructure Planning

Simon Dunstall, Mathematics, Informatics and Statistics, CSIRO, Private Bag 33, 3169, South Clayton, Victoria, Australia, Simon.Dunstall@csiro.au, *Andreas Ernst*, *Kim Levy*, *Stuart Woodman*, *Olena Gavriliouk*, *Andrew Higgins*, *Martin Savelsbergh*, *Gaurav Singh*

The improvement of transport infrastructure for minerals freight continues in Australia, particularly in Queensland where the government and CSIRO have constructed a freight network optimization system. This system is known as the "Infrastructure Futures Analysis Platform", has a GIS interface and optimizes the capacity of roads, railways and facilities yearly over a 25 year horizon while satisfying freight demand and various practical constraints. We describe the mathematical model and our experience in working with GIS packages and freight transport policymakers.

■ MC-07

Monday, 16:00-17:30
Meeting Room 106

OR Software

Stream: OR software

Invited session

Chair: *Pim Beers*, Paragon Decision Technology, Julianastraat 30, 2012ES, Haarlem, Netherlands, p.beers@aimms.com

1 - Tackling Large-scale Optimization Problems within a Python-based Modeling Environment (Pyomo)

William Hart, Data Analysis & Informatics, Sandia National Laboratories, P.O. Box 5800, 87185, Albuquerque, NM, United States, wehart@sandia.gov, *John Siirola*, *Jean-Paul Watson*

The Pyomo modeling package can be used to formulate optimization models natively within the Python scripting language. Pyomo is an open-source modeling language that is being actively developed to support COIN-OR users in a variety of application areas. This talk will highlight recent developments in Pyomo and related Coopr packages, focusing on the overall speed and scalability of the modeling environment for large-scale optimization problems.

2 - Attacking Hard Mixed-Integer Optimization Problems Using an Algebraic Modeling Language

Robert Fourer, AMPL Optimization LLC, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

There are many tricks for formulating complex optimization models by use of integer variables, but what's to be done when even the most advanced solvers can't produce results in reasonable time? Substantial improvements in performance can often be achieved through carefully focused troubleshooting and experimentation. And sometimes, much better results can be achieved by "cheating" a bit on the formulation. A series of case studies illustrate that although a few general principles can offer guidance, much trial and error is involved, for which purpose a flexible modeling language is ideal.

3 - AIMMS Modelling System - Demonstration

Pim Beers, Paragon Decision Technology, Julianastraat 30, 2012ES, Haarlem, Netherlands, p.beers@aimms.com

AIMMS is an advanced modeling system for building optimization-based decision support applications. It is used by leading companies to support decision making and by universities for teaching operations research courses and for research projects. The talk will consist of a basic introduction of the modeling system AIMMS. We will give a global overview of the model representation, the graphical user interface, the solver and algorithmic capabilities. The presentation will contain a demonstration on how to build a small transport model in AIMMS.

■ MC-08

Monday, 16:00-17:30
Meeting Room 107

Computational Methods in Biomolecular and Phylogenetic Analyses

Stream: Bioinformatics

Invited session

Chair: *Ming-Ying Leung*, The University of Texas at El Paso, TX 79968-0514, El Paso, United States, mleung@utep.edu

1 - An Optimization Approach to Efficient Sampling over Phylogenetic Trees

Russell Schwartz, Carnegie Mellon University, United States, russells@andrew.cmu.edu, *Navodit Misra*, *Guy Blelloch*, *R Ravi*

Phylogenetics, or the inference of evolutionary trees, is commonly solved by Monte Carlo sampling over tree topologies, but prevailing methods depend on heuristic mixing time bounds that provide no guarantees of adequate mixing. We present a new strategy for generating provably well mixed samples efficiently in practice for important special cases of the problem. Our method reformulates the problem to create a rapidly mixing chain by performing a theoretically hard but practically efficient optimization on each sampling step.

2 - Using Massively Parallel Ssequencing Data in Family Studies

Melanie Bahlo, The Walter and Eliza Hall Institute of Medical Research, 3052, Parkville, VIC, Australia, bahlo@wehi.edu.au

Massively parallel sequencing (MPS) data is making a strong impact in the field of disease gene identification, particularly in single gene disorders. We describe some of our recent work in extending methods using this new technology with two examples: (1) estimation of relatedness of individuals using RNA-seq data and (2) application of traditional statistical mapping techniques to MPS data to more effectively filter likely causal variants.

3 - Comparative Studies in Biological Networks via Graph-based Features

Kwok Pui Choi, National University of Singapore, 119077, Singapore, Singapore, stackp@nus.edu.sg

Biomolecules orchestrate higher cellular functions. Recent breakthroughs in biotechnology have generated much information on biomolecular interactions in a genomic scale. Mathematical and computational approaches prove to be indispensible in providing deeper insights into these networks. Various graph-based measures, including the well known node degree distribution and clustering coefficient, have been introduced. We will explore the relationships among these measures and how they can be collectively applied to assess which evolutionary network model best describe a given biological network.

4 - A Data Analysis System for iTRAQ

Penghao Wang, School of Mathematics and Statistics, University of Sydney, 2006, Sydney, NSW, Australia,

pwan9882@mail.usyd.edu.au, *Pengyi Yang*, *Jonathan Arthur*, *Jean Yang*

iTRAQ(TM) for protein quantisation using mass spectrometry is a powerful means of determining relative protein levels. A comprehensive iTRAQ data analysis comprises of several components including spectrum pre-processing, protein identification and protein quantisation. Each of these components involves its own statistical challenges. We are developing a comprehensive statistical analysis system with novel spectrum preprocessing and quantification algorithms. Our initial assessments demonstrate that our pipeline can produce comparable results to TransProteomicPipeline.

■ MC-09

Monday, 16:00-17:30
Meeting Room 108

Pick-up and Delivery

Stream: Vehicle Routing

Invited session

Chair: *Ronald Askin*, Industrial Engineering, Arizona State University, Computing, Informatics and Dec. Systems Engineering, PO Box 8809, 85287-8809, Tempe, AZ, United States, ron.askin@asu.edu

1 - Methods for Dynamic Vehicle Routing Problems with Pickups, Deliveries and Time Windows

Penny Holborn, School of Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, United Kingdom, holbornpl@cf.ac.uk, *Jonathan Thompson*, *Rhyd Lewis*

To solve the dynamic pickup and delivery problem with time windows we are investigating methods embedded in a rolling horizon framework. The problem is thus viewed as a series of static problems. Our initial research has focused on this static variant, and after producing an initial feasible solution we use various neighbourhood operators in conjunction with tabu search and branch and bound to make further improvements. Our current algorithm gives results that are competitive with the state of the art, and we will discuss how these methods can be applied to the dynamic variant of the problem.

2 - Saving Based Algorithm for Multi-depot Version of Vehicle Routing Problem with Simultaneous Pickup and Delivery

Yuvraj Gajpal, Systems Engineering Department, King Fahd University of Petroleum and Minerals, KFUPM Box 634, 31261, Dhahran, Saudi Arabia, gajpal@kfupm.edu.sa, *Prakash Abad*

The paper presents saving based algorithm for the multi-depot version of VRP-SPD. We developed four saving based algorithms for the problem. These algorithms are 1) Partition based algorithm, 2) Nearest depot algorithm, 3) Saving algorithm and 4) Tillman's saving algorithm. We also use cumulative-net pick approach for checking the feasibility when two existing routes are merged. The numerical results performed on benchmark problem instances show that the performance of the proposed heuristics is qualitatively better than the existing insertion based heuristics.

3 - Heuristic Methods for Formation of Compact Pickup and Delivery Districts

Ronald Askin, Industrial Engineering, Arizona State University, Computing, Informatics and Dec. Systems Engineering, PO Box 8809, 85287-8809, Tempe, AZ, United States, ron.askin@asu.edu, *Rosa Gonzalez-Ramirez*, *Neale Smith*, *Jose Luis Gonzalez-Velarde*

We consider partitioning a geographical region into smaller districts to balance expected workloads and district size while meeting demand and other constraints. Demand varies daily. Each district is assigned a single vehicle that departs daily from the central depot and must satisfy all service requests in that district with high probability. The problem is motivated by a parcel company that picks up and delivers packages daily. A solution approach based on a hybrid algorithm that combines GRASP and Tabu Search is compared to CPLEX under a variety of geographical and demand conditions.

■ MC-10

Monday, 16:00-17:30
Meeting Room 111

Metaheuristics for Time-Definite Logistics

Stream: Time-Definite Logistics

Invited session

Chair: *Christine Vanovermeire*, University of Antwerp, 2000, Antwerp, Belgium, christine.vanovermeire@ua.ac.be

1 - Sustainable Supply Chains through Flexible Horizontal Collaboration

Christine Vanovermeire, University of Antwerp, 2000, Antwerp, Belgium, christine.vanovermeire@ua.ac.be, *Kenneth Sörensen*

Horizontal collaboration among distributors is one of the most promising approaches to decrease supply chain costs and increase supply chain sustainability. In order to exploit the possibilities of such alliances to the fullest, this research investigates how and to which extent orchestrating the supply chain —i.e. synchronizing orders in time to optimize truck loads- can positively influence such alliances. Additionally, a profit allocation method based on concepts from game theory is proposed as an incentive for partners to allow flexibility in their due dates.

2 - Deconstructing Record-To-Record Travel for the Vehicle Routing Problem with Time Windows

Kenneth Sörensen, Faculteit Toegepaste Economische Wetenschappen, Universiteit Antwerpen, Prinsstraat 13, 2000, Antwerpen, Belgium, kenneth.sorensen@ua.ac.be, *Patrick Schittekat*

In this paper, a simple and well-performing metaheuristic, Record-To-Record Travel, is deconstructed for the Vehicle Routing Problem with Time Windows in order to gain insight in the inner workings of each of its components. A detailed statistical experiment is set up to determine how each of its components contribute to the effectiveness of the metaheuristic, and what the optimal parameter levels are.

3 - Exact Solutions to the Pickup and Delivery Problem with Time Windows using Search Algorithms

Richard Kelly, Information Technology, Monash University, 6/200 Glen Eira Road, 3185, Elsternwick, VIC, Australia, richard.adam.kelly@monash.edu.au

We compare the performance of four search algorithms for exact solving of the pickup and delivery problem with time windows (PDPTW). The four algorithms used are A*, DFS*, IDA* and depth-first branch and bound. The performance impact of using different methods for calculating lower bounds and the techniques for determining query order is also investigated. We present a new method for calculating the lower bound using a minimum spanning tree with time window constraints.

■ MC-11

Monday, 16:00-17:30
Meeting Room 112

Queueing Models and Analyses II

Stream: Submodular Structures and Optimization

Invited session

Chair: *Yutaka Takahashi*, Graduate School of Informatics, Kyoto University, Sakyo-ku, 606-8501, Kyoto, Japan, takahashi@i.kyoto-u.ac.jp

1 - Analysis of Thinning Input Queue

Takaichi Fujiwara, Information Sciences Dept., Kanagawa University, 2946, Tsuchiya, Hiratsuka-shi, 259-1293, Kanagawa-ken, Japan, r200970213oj@kanagawa-u.ac.jp

Closed-form solution of T(m,n)-thinning input queue with an exponential single server is given in this paper. The T(m,n)-thinning input process is constructed by thinning customers from a Poisson arrival process repeating the thinning procedure such that m-consecutive arrivals are picked up and next n-consecutive arrivals are discarded. Interarrival time sequence of the T(m,n)-thinning input process is not a sequence of i.i.d.r.v.'s. To analyse the T(m,n)-thinning input queue, generating function, phase-method and Rouche's theorem are used.

2 - Performance Analysis of Large-Scale Parallel-Distributed Processing System in Cloud Computing

Tsuguhito Hirai, Department of Systems Science, Graduate School of Informatics, Kyoto University, 606-8501, Kyoto, Japan, tsugu@sys.i.kyoto-u.ac.jp, *Hiroyuki Masuyama*, *Shoji Kasahara*, *Yutaka Takahashi*

In cloud computing, a large-scale parallel-distributed processing system handles huge tasks with many data processing workers. In this system, the processing time of the slowest worker determines the response time (the issue of stragglers). An efficient way for this problem is to execute alternative processes (backup tasks) for slow workers. In this paper, we consider the effectiveness of backup tasks by queueing theoretical approach. Numerical examples show that the response time is significantly improved by backup tasks when the processing time of workers follows a heavy-tailed distribution.

3 - Performance Analysis of Dynamic Spectrum Handoff Scheme for Cognitive Radio Networks: A Case of Fixed Number of Subbands Allocation

Yasuharu Konishi, Dept. of Systems Science, Graduate School of Informatics, Kyoto University, 606-8501, Kyoto, Japan, konishi@sys.i.kyoto-u.ac.jp, *Hiroyuki Masuyama*, *Shoji Kasahara*, *Yutaka Takahashi*

In cognitive-radio (CR) networks, spectrum resource is dynamically assigned to the secondary users (SUs) by spectrum handoff on a primary user arrival. In this paper, we analyze a spectrum handoff scheme in which a fixed number of subbands are allocated to an SU. We model a CR base station as a multiple-server queueing system without waiting facility. Performance measures such as the blocking probability and SU throughput are analyzed with a continuous-time Markov chain. Numerical results show that the number of subbands allocated to an SU affects the performance measures significantly.

4 - Performance Analysis of Application-layer Rate-control Mechanism for Video Streaming using a Single-server Queue with a State-dependent Arrival Process

Marino Mitsumura, Dept. of Systems Science, Graduate School of Informatics Kyoto University, 606-8501, Kyoto, Japan, mitsumura@sys.i.kyoto-u.ac.jp, *Hiroyuki Masuyama*, *Shoji Kasahara*, *Yutaka Takahashi*

In this paper, we consider the effect of various rate controls on video streaming service. Focusing on the behavior of video data blocks stored in a receiver buffer, we model it as a finite-capacity single-server queue with a state-dependent arrival process. The buffer-overflow and starvation probabilities are analyzed with a discrete-time Markov chain. Numerical examples show that the rate control which is sensitive to the number of data blocks in the receiver buffer makes the buffer-overflow and starvation probabilities significantly small.

■ MC-12

Monday, 16:00-17:30
Meeting Room 205

Travel Behaviour 1

Stream: Travel Behaviour
Invited session

Chair: *Song Gao*, U Massachusetts, 01003, Amherst, United States, songgao@ecs.umass.edu

1 - Advanced Optimization Methods for Discrete Choice Models

Cinzia Cirillo, University of Maryland, 20742, College Park, MD, United States, ccirillo@umd.edu

This talk presents an overview of the results obtained by adopting advanced optimization techniques for maximum likelihood estimation in travel behavior analysis. The topics to be presented include: an adaptive algorithm based on trust region methods, constrained optimization for non-parametric models and the relative properties of the information matrix, bias and error estimation in simulated maximum likelihood estimation. The discussion will be extended to the study of dynamics in travel behavior and the necessity to develop appropriate optimization algorithms.

2 - Demand Modeling for Congestion Pricing Analyses

Moshe Ben-Akiva, Massachusetts Institute of Technology, 02139, Cambridge, MA, United States, mba@mit.edu

For congestion pricing analyses traditional methods are deficient in the treatment of the value of time (VOT), travel time reliability and choice of time-of-travel. Advanced models to capture the distribution of VOT are presented: logit mixture, latent class and hybrid with attitudinal indicators. Recent research on travelers' response to travel time reliability is presented, including models based on non-expected utility theories. A method to model the time-of-travel choice without data on desired arrival/departure times is presented, along with an extension to continuous time-of-travel.

3 - Information Impacts on Route Choice and Learning Behavior in a Congested Network: An Experimental Approach

Song Gao, U Massachusetts, 01003, Amherst, United States, songgao@ecs.umass.edu, *Xuan Lu*, *Eran Ben-Elia*

This paper studies the impacts of two types of information on route choice, namely en route real-time information on the occurrence of an incident and ex post information on foregone payoffs (FPs), i.e., travel times on non-chosen routes. Data were collected from an interactive experiment, where human subjects made multiple rounds of route choices in a hypothetical network subject to random capacity reductions, and travel times were determined by performance functions of route flows from the previous round.

■ MC-13

Monday, 16:00-17:30
Meeting Room 206

Optimal Control

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Hans Josef Pesch*, Department of Mathematics, University of Bayreuth, Chair of Mathematics in Engineering Sciences, 95440, Bayreuth, Bavaria, Germany, hans-josef.pesch@uni-bayreuth.de

1 - Optimal Control of a Particle Accelerator

Christian Meyer, Graduate School Computational Engineering, TU Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, cmeyer@gsc.tu-darmstadt.de

The talk is concerned with the control of a particle beam by adjusting exterior magnetic fields. The physical model consists of a nonlinear system of Maxwell's equations and an ODE for the motion of the particle beam. The optimization is subject to state constraints on the particle position to ensure the particle beam to stay inside the interior of the accelerator. Moreover, div- and curl-constraints on the control guarantee that the computed controls can be realized in practice. The talk presents first- and second-order optimality conditions and shows preliminary numerical results.

2 - Bang-bang and Singular Controls in Optimal Collision Avoidance for a Planar Close Proximity Encounter

Tanya Tarnopolskaya, Mathematics, Informatics and Statistics, CSIRO, Locked Bag 17, 1670, North Ryde, NSW, Australia, tanya.tarnopolskaya@csiro.au, *Helmut Maurer*, *Neale Fulton*

We establish the conditions under which singular controls exist in optimal collision avoidance strategies for a planar close proximity encounter. We prove that both controls cannot be singular simultaneously, and that that the only possible singular control is a zero control. Numerical simulations suggest that zero control strategy only exists for a slower participant. Several numerical techniques, including discretisation by nonlinear programming method and a direct optimization, are used to calculate the optimal trajectories, controls and adjoint variables.

3 - Interpolating Curves via Optimal Control Theory

C Yalcin Kaya, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, SA, 5095, Adelaide, South Australia, Australia, yalcin.kaya@unisa.edu.au, *J. Lyle Noakes*

We consider the problem of finding an interpolating curve passing through a number of given points in the Euclidean space. The interpolating curve is required to minimize the maximum length of its acceleration. We reformulate the problem as an optimal control problem, which allows us to use results from optimal control theory and this in turn helps us characterize the interpolating curves.

4 - On Some Intrinsic Difficulties in Solving State-constrained Optimal Control Problems for Dynamical Systems of ODEs and PDEs

Hans Josef Pesch, Department of Mathematics, University of Bayreuth, Chair of Mathematics in Engineering Sciences, 95440, Bayreuth, Bavaria, Germany, hans-josef.pesch@uni-bayreuth.de, *Stefan Wendl*, *Armin Rund*

Motivated by an optimization problem for a hypersonic aircraft, a class of apparently simple problems (hypersonic rocket car problems) have been invented to analyze the mathematical difficulties hidden behind the engineering problem. These problems consist of a minimum-time optimal control problem for a second order ODE and a semi-linear heat equation which is controlled by one of the ODE state variables. The PDE state variable is constrained. Despite their simplicity these problems show some new phenomena not yet observed so far. Different approaches to solve these problems will be discussed.

■ MC-14

Monday, 16:00-17:30
Meeting Room 207

Stability in Optimal Control and Optimal Control Applications in Economics

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Musa Mammadov*, Graduate School of Information Technology and Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, m.mammadov@ballarat.edu.au

Chair: *Andreas Novak*, Business Administration, Bruennerstrasse 72, A-1210, Vienna, andreas.novak@univie.ac.at

Chair: *Vladimir Veliov*, Institute of Mathematical Methods in Economics, Vienna University of technology, ORCOS, Argentinierstr. 8/119, 1040, Vienna, Austria, veliov@tuwien.ac.at

1 - Asymptotical Stability of Opitimal Trajectories in Continuous Systems with Time Delay

Musa Mammadov, Graduate School of Information Technology and Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, m.mammadov@ballarat.edu.au

A nonlinear differential equation with delay serving as a mathematical model of several applied problems is considered. Sufficient conditions for the global asymptotic stability and for the existence of periodic solutions are given. Two particular applications are treated in detail. The first one is a blood cell production model of M.C. Mackey, for which new periodicity criteria are derived. The second application is a modified economic model with delay due to F.P. Ramsey. An optimization problem for a maximal consumption is stated and solved for the latter.

2 - Optimization Models of the Vehicle Suspension Systems for Improved Comfort Level and Advanced Steering Performance

Alexey Kuznetsov, Information Technologies and Mathematical Sciences, University of Ballarat, University Drive, Mount Helen Campus, PO Box 663, Ballarat, Victoria, Australia, alexeykuznetsov@students.ballarat.edu.au

This research presents multi-objective optimization models of the vehicle suspension systems for improved comfort level and advanced steering performance. It adopts a new representation of the ISO 2631 standards that uses the steady-state vibrations for evaluating comfort levels and does not depend on the duration of vibration exposure period. A similar approach is applied to describe the steering performance of the vehicle that considers the steady-state vibrations imposed on the wheels when the time of exposure goes to infinity.

3 - When to Make a Software Open Source

Andrea Seidl, Vienna University of Technology, 1040, Vienna, Austria, aseidl@eos.tuwien.ac.at, *Jonathan Caulkins*, *Gustav Feichtinger*, *Dieter Grass*, *Peter M. Kort*

We will present a multi-stage optimal control model dealing with the question whether it might be optimal for a firm to make a proprietary software open source at some optimally determined time. While the firm might lose revenue from sales of the software when making it open source, it might profit from user contributions leading to a higher quality, affecting both demand for the software itself and for a commercial complementary product. We will consider how choices regarding pricing and R&D efforts as well as certain key parameters such as switching costs affect the optimal solution.

4 - Some Extensions of Schelling's Binary Corruption Model

Andreas Novak, Business Administration, Bruennerstrasse 72, A-1210, Vienna, andreas.novak@univie.ac.at, *Jonathan Caulkins*, *Gustav Feichtinger*, *Richard Hartl*, *Peter M. Kort*, *Andrea Seidl*, *Franz Wirl*

Schelling (1978) suggested a simple binary choice model to explain the variation of corruption levels across societies. His basic idea was that expected profitability of engaging in corruption depends on its established frequency. The key result of the so-called Schelling diagram is the existence of multiple equilibria and tipping points. The present paper puts Schelling's essentially static approach in an intertemporal setting. By using optimal control theory we show how the existence of an unstable interior steady state leads to indifference thresholds (so-called Skiba points).

■ MC-15

Monday, 16:00-17:30
Meeting Room 208

Military Soft Operations Research

Stream: Military, Defense and Security Applications
Invited session

Chair: *Adrian Pincombe*, Defence Science and Technology Organisation, PO Box 1500, 5111, Edinburgh, South Australia, Australia, Adrian.Pincombe@dsto.defence.gov.au

1 - Towards a Set of Vignettes to Explore the Use of Non-lethal Weapons

Peter Williams, LOD, DSTO, PO Box 1500, Edinburgh, 5111, Adelaide, South Australia, Australia, peter.b.williams@dsto.defence.gov.au, *Neville Curtis*, *Kasia Krysiak*

Non-lethal weapons are now a part of the military inventory. A rationale is presented to develop a set of vignettes for comparison of acquisition options; to explore tactics, techniques and procedures; and to develop difficult issues of combining lower level physics and psychological terms. Classification according to a set of descriptors including: evidence of lethal threat, verified red force, red force arms, presence of third parties and intent of the operation led to a distilled set of vignettes designed to cover a broad range of representative use cases for analysis of Army operations.

2 - Collecting the Right Data in Military Field Activities

Leanne Rees, DSTO, Defence, South Australia, Australia, Leanne.rees@dsto.defence.gov.au, *Neville Curtis*

With better preparation both in determining what to collect and in the manner in which collection is done, field exercises and experiments can become more fruitful sources of data for the military analyst. We discuss protocols that improve issues identification through sequential activity analysis and influence diagrams and this allows better direction of data collection. Appreciation of the notion of perceptual positions, combining subjective, speculative and objective input, and good field practice allows more structured and insightful understanding of the system to be gained.

3 - Data Driven Theming of Vignettes for Army Analysis

Jessica Murray, DSTO, PO Box 1500, 5111, Edinburgh, South Australia, Australia, jessica.murray@dsto.defence.gov.au, *Brandon Pincombe*, *Neville Curtis*

Vignettes, tactical snapshots from scenarios, provide the context for military simulations and experiments. Sets of vignettes are used to investigate concepts, acquisitions, tactics, techniques and plans. We use data driven theming to examine previous Land Operations Division studies to define an encompassing set of factors and describe a representative set of vignettes. These balance analytical usefulness and military relevance, covering the range of likely analytical studies dictated by Army strategic guidance and surveying of field grade officers.

4 - How Short can Sustained Darwin-Dili Army Deployment Rotations Be?

Brandon Pincombe, Defence Science and Technology Organisation, Australia, Brandon.Pincombe@dsto.defence.gov.au, *Adrian Pincombe*

Deployment entails pre-training, ramp up to a plateau of effectiveness, adaptation, eventual degradation of performance and habituation on return; all experienced differently between individuals. We use adversarial scenario analysis to balance constraints and determine a minimum length for sustainable Darwin-Dili rotation schedules. Training flexibility has the largest effect. Combat-home transition problems limit this approach to low-risk situations. We identify measures to be calibrated before introduction and monitored to identify harm to soldier effectiveness or wellbeing.

■ MC-16

Monday, 16:00-17:30
Meeting Room 209

Task Scheduling with Learning Effects

Stream: Scheduling

Invited session

Chair: *Albert Corominas*, IOC-DOE, UPC, Av. Diagonal, 647, 08028, Barcelona, Spain, albert.corominas@upc.edu

Chair: *Jordi Olivella*, Institute of Industrial and Control Engineering and Department of Management, Technical University of Catalonia, Avda Canal Olimpic, s/n, 08860, Castelldelfels, Barcelona, Spain, jorge.olivella@upc.edu

1 - Task Assignment Considering Cross-training Goals and Due Dates

Jordi Olivella, Institute of Industrial and Control Engineering and Department of Management, Technical University of Catalonia, Avda Canal Olimpic, s/n, 08860, Castelldelfels, Barcelona, Spain, jorge.olivella@upc.edu, *Albert Corominas*, *Rafael Pastor*

The assignment of a set of tasks to a set of workers considering cross-training goals and due dates for some of the tasks is presented and modelled. The influence of the experience of one task on the performance on other tasks is considered. Such a model allows (1) to test the feasibility of a certain combination of cross-training goals and due dates; (2) to obtain the task assignment that maximizes the total work done; and (3) to calculate the change on the total quantity of work performed when imposing certain cross-training goals or due dates. A computational experience is carried out.

2 - Exact and Metaheuristic Solutions to a Two-agent Time-dependent Scheduling Problem

Stanislaw Gawiejnowicz, Faculty of Mathematics and Computer Science, Adam Mickiewicz University, Umultowska 87, 61-614, Poznan, Poland, stgawiej@amu.edu.pl, *Cezary Suwalski*

We present properties, an exact and a metaheuristic algorithm for the following problem of single machine scheduling a set of independent nonpreemptable jobs by two agents. A job is defined by a common release date, a processing time, a weight and a due date. The job processing time is a linear function of the job starting time. Each agent constructs a partial schedule that includes only the agent's jobs and is evaluated by the agent's criterion: the total weighted completion time or the maximum lateness. The aim is to find a complete schedule with minimal weighted sum of the criteria.

3 - Batching and Scheduling with Competitive Agents

Ammar Oulamara, Ecole des Mines de Nancy, LORIA-INRIA Lorraine, Parc de Saurupt, 54000, Nancy, France, oulamara@loria.fr, *Ameur Soukhal*

We consider the batch scheduling problem on a serial batching machine with two competitive agents. There are two agents A and B, each agent has it own set of jobs to be processed on a common machine. The machine can process several jobs sequentially as a batch. The length of a batch equals the sum of processing times of its jobs. A schedule consists of jobs of both agents processed on a common machine. The objective function of agent A is minimized under the condition that the value of the objective function of agent B will not exceed a fixed value Q. Several objective will be considered.

4 - A Logistic Problem under Uncertainties in the Processing Times

Ubirajara Ferreira, DPD, UNESP / FEG, Av. Ariberto Cunha, 333, 12523-210, Guaratingueta, SP, Brazil, ferreiur@feg.unesp.br

A simple logistic problem, to minimize the total operation time for jobs with only 3 tasks in sequence: Loading, Transportation, Unloading, with stochastic processing times, is discussed here. The model considers the processing times as a Normal Distribution and develops a system to evaluate when the jobs could start and to avoid crash between the tasks that must to stay in sequence. Considering 'The Start Interval Concept', which permits to formulate the problem looking for the success in preserving the sequence and constraints, as a no-wait flow-shop NP-complete problem.

■ MC-17

Monday, 16:00-17:30
Meeting Room 214

Multi-Objective Combinatorial Optimization

Stream: Multicriteria Decision Analysis and Multiobjective Optimisation

Invited session

Chair: *Jacques Teghem*, Mathro, Faculté Polytechnique de Mons, 9, rue de Houdain, 7000, Mons, Belgium, jacques.teghem@fpms.ac.be

1 - Comparing Bicriteria Cost/ Labels Path and Spanning Tree Problems

João Clímaco, Faculdade de Economia da Universidade de Coimbra and INESC-Coimbra, 3004-512, Coimbra, Portugal, jclimaco@fe.uc.pt, *Marta Pascoal*, *Maria Eugénia Captivo*

Bicriteria cost/labels path and spanning tree problems have practical interest in multimodal transportation networks and some telecommunication problems. We consider graphs where arcs are associated with a cost and a label, and discuss the problems of computing paths or spanning trees with respect to cost and number of different labels minimization. Theoretical results and methods dedicated to the calculation of the set of non-dominated solutions for both problems are described and compared. Results of computational tests on random instances are reported.

2 - A Multicriteria Problem for Parallel Machines with Eligibility and Release and Queue Times

Manuel Mateo, Departament Business Administration, Universitat Politecnica Catalunya, Avda Diagonal, 647, 7th, E-08028, Barcelona, Spain, manel.mateo@upc.edu, *Jacques Teghem*, *Xavier Garriga*

The problem dealt is the scheduling of parallel machines when not all the jobs can be manufactured in any machine. Besides, there are release times and queue times for the operation to be carried in the parallel machines. A set of n jobs to be scheduled on m parallel machines distributed among levels. The proposed algorithm solves the problem with two criteria: the minimization of the completion time Cmax and the number of jobs manufactured in a different predefined level and determines the Pareto front.

3 - Solving Real Problems in Sugar and Ethanol Milling Companies with an Extended Goal Programming Model

Fernando Marins, Production, UNESP - São Paulo State University, Av. Ariberto Pereira da Cunha, 333, 12516-410, Guaratinguetá, SP, Brazil, fmarins@feg.unesp.br, *Aneirson Silva*, *Isabela Ribeiro*, *José Arnaldo Montevechi*

The key element of a Goal Programming model is the achievement function that incorporates the minimization of the unwanted deviation variables. An extended Goal Programming model (EGP) for aggregate production planning in sugar and ethanol milling companies is presented, represents the production system of sugar, ethanol, molasses and their derivatives, and includes decisions in the agricultural, in production and storing, and in distribution stages. An application to Brazilian sugar and ethanol milling company was made with interesting results that are reported and commented in this paper.

4 - A Bi-objective Approach to Reschedule New Jobs in an One Machine Model

Jacques Teghem, Mathro, Faculté Polytechnique de Mons, 9, rue de Houdain, 7000, Mons, Belgium, jacques.teghem@fpms.ac.be, *Daniel Tuyttens*

We consider an one machine scheduling model with a classical objective - either total completion time or maximal tardiness - and two sets of jobs: one with initial jobs already scheduled and one with new jobs which must be inserted in the schedule. As this reschedule can create a disruption, a second disruption objective - which can be formulated in four different ways- is considered.So there exist eight possibilities for this pair of objectives. This model has been introduced by Hall and Potts, minimizing either a linear aggregation of the two objectives or the initial objective under a constraint imposing an upper limit to the disruption objective. In this paper the aim is to obtain the set of efficient schedules in regard of the two objectives. Algorithms are provided for the eight possible bi-objective problems.

■ MC-18

Monday, 16:00-17:30
Meeting Room 215

Applications of DEA in Agriculture and Farm efficiency

Stream: Data Envelopment Analysis
Invited session

Chair: *Gloria Rodriguez Lozano*, Faculty of Economics Sciences, National University of Colombia, Ciudad Universitaria, Facultad de Ciencias Económicas Edificio 311 Of. 308, Bogota, Colombia, girodriguezl@unal.edu.co

1 - A Multistage Method to Measure Efficiency at Estonian Dairy Farms

Reet Poldaru, Institute of Economics and Social Sciences, Estonian University of Life Sciences, Kreutzwaldi 1, 0020, 50413, Tartu, Estonia, reet.poldaru@emu.ee, *Jyri Roots*

This paper investigates the formulation of multi-stage (three-stage) DEA models for milk production at Estonian dairy farms and analyses the results of modelling. The data is a balanced panel of Estonian dairy farms drawn from FADN database observed during the period of 2000 to 2009. The method starts with the data envelopment analysis (DEA) to estimate efficiency scores and the input and output slacks. The second stage is a stochastic frontier analysis (SFA) to explain the variation in performance measured in the first stage. In the third stage we then estimate scores again using adjusted data from the second stage.

2 - Nonparametric Approach for Measuring the Productivity Change and Assessing the Water Use Efficiency in the Irrigated Areas of Tunisia

Fraj Chemak, Economie Rurale, INRAT, Rue Hedi Karray, 2049, Ariana, Tunisia, fr_chemak@yahoo.fr

This work aims to analyze technical efficiency, water use efficiency and productivity change of the irrigated areas. Farm surveys have been carried out during 2003 and 2007 cropping years and technology performance has been assessed using the DEA model. Malmquist index has been computed in order to characterize the productivity change. The results reveal that the technical efficiency has increased by 17% leading to an improvement of the water use efficiency up to 22%. The technical efficiency change as well as the technical change reveal a positive impact on the productivity change.

3 - Economics of Proliferation of Small Tea Gardens in North Bengal — A Study of Optimum Economic Size by Applying DEA

Ajit Kr Ray, Department of Commerce, University of North Bengal, Dakhshini Apartment, 17/18/4 J.C.Bose Road, Subhaspally, 734001, Siliguri, West Bangal, India, akr.nbu@gmail.com

Century old Tea industry in the eastern part of India has traditionally been considered as large scale. This perception has worn away by the emergence of the small tea gardens of local entrepreneurs. A key identifying factor which allows small tea plantations to proliferate is perhaps low initial capital investment, besides the adaptation of the concept that tea can be grown as a small holder crop. We studied the economics of proliferation and the optimum efficient size of small tea garden by applying DEA on the basis of field survey data.

4 - Measurement of the Relative Technical Efficiency of the Farms Associated to Coounion in Guasca Cundinamarca Colombia

Gloria Rodriguez Lozano, Faculty of Economics Sciences, National University of Colombia, Ciudad Universitaria, Facultad de Ciencias Económicas Edificio 311 Of. 308, Bogota, Colombia, girodriguezl@unal.edu.co, *Wilson Oviedo Garcia*

This research measures the relative technical efficiency in twelve cattle farms associated with the Cooperative Coounión in the municipality of Guasca-Cundinamarca, Colombia, by DEA, for a period of time between 1 June 2008 to May 31, 2009. Using six variables in two models CRS with input orientation. For the first model: Inputs: nutrition, maintenance, milking; and Output: milk. Second model: Inputs: nutrition, maintenance, Outputs: meat and calves.

■ MC-19

Monday, 16:00-17:30
Meeting Room 216

Games and OR Education

Stream: Education and Operations Research
Invited session

Chair: *James Cochran*, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu

1 - An Educational Game in Collaborative Logistics

Sophie D'Amours, FORAC Consortium, G1V 0A6, Quebec, Canada, Sophie.Damours@gmc.ulaval.ca, *Mikael Rönnqvist*

We describe an educational game in collaborative logistics. The game is based on an award-winning application in cost allocation in transportation. The purpose of the game is to acquire an understanding of negotiation, coalition building and cost/profit sharing when the players have different power and hold different levels of information. The objective of the game is to find an efficient plan and to share the benefits of the collaboration. We describe the underlying case study, basic concepts in game theory, and outline the game and discuss experiences from running the game in several countries and those with students registered in business schools, engineering and forestry faculties.

2 - Teaching OR with Games and Discovery

Kevin Hutson, Furman University, SC 29613, Greenville, SC, United States, kevin.hutson@furman.edu

After teaching several introductory OR courses, I found that students did not internalize the course material as I would have liked and walked away with a mechanical understanding of OR. After this, I adopted a problem-based approach to teaching the course, focusing on three main topics: formulation, algorithm design, and economic interpretations. In this talk, I discuss how this problem-based approach allows students to discover and internalize concepts for themselves and allows for the use of games to illuminate formulations, mathematical concepts, and bigger picture ideas in the course.

3 - Rogo, a TSP-based Paper Puzzle: Problem Features and Human Solutions

Nicola Ward Petty, Creative Heuristics Ltd, P.O. Box 21 390, 8142, Christchurch, New Zealand, drRogo@me.com, *Shane Dye*

Rogo, a pencil and paper puzzle, is based on a subset-selection travelling salesperson problem with a known optimal score. There is an infinite number of possible Rogo puzzles, with at least twelve features. In order for puzzles to be appealing, they should be difficult enough to be challenging and interesting, but not intractable or tedious. Through examination, mathematical modelling and experimentation on human subjects, we begin research into what elements affect the degree of difficulty of Rogo puzzles. Comparisons are made with other puzzles. Some preliminary results are given.

4 - Using Games and Active Learning Exercises to Engage and Re-engage Students

James Cochran, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu

Education research provides evidence that student attention wanes after approximately ten minutes. An instructor can reengage students (and herself or himself) by abruptly altering the classroom environment periodically. In this session we will discuss several ways to alter the classroom enviroment with a variety of games and active learning exercises.

■ MC-20

Monday, 16:00-17:30
Meeting Room 217

Soft OR III

Stream: Soft OR and Problem Structuring
Invited session

Chair: *Leroy White*, Management Department, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

1 - Visions-based Consensus Formation on the Future Energy System by Analytical Facilitation

Evelina Trutnevyte, Institute for Environmental Decisions (IED), Natural and Social Science Interface (NSSI), ETH Zurich, Universitätstrasse 16, CHN J 70.1, 8092, Zurich, Switzerland, evelina.trutnevyte@env.ethz.ch, *Michael Stauffacher*, *Roland W. Scholz*

Strategic discussions about the future energy system often take place on the basis of visions, e.g. oil-free energy system or 30% lower primary energy demand. In such discussions, different stakeholders support different visions. Whilst some visions are in fundamental conflict, others offer a space for compromise. We propose a novel approach for analytical facilitation of consensus formation in visionary discussions. Our approach estimates if several visions intersect or are mutually exclusive, it also helps to identify the conflicting aspects and to propose options for reaching consensus.

2 - Challenges in Strategy-led Decision Support

Andrea Hadley, DSTO, Dept of Defence, Russell Offices, 2600, Canberra, Australia, andrea.hadley@defence.gov.au, *Sharon Boswell*, *Nitin Thakur*

The 2009 Defence White Paper commits the government to an improved force structure and capability development process within Defence. This will be achieved by creating stronger linkages between strategic guidance, force development and capability decisions. DSTO has studied Soft Systems Methodologies to support capability development and force structure analysis since the 2000 Defence White Paper. This paper presents an analysis of the impact of strategy-led capability development since the 2008 Force Structure Review, which has evolved from the previous concept-driven approach. Lessons learned, and the types of frameworks and taxonomies used to support strategic level decisions, are discussed.

3 - Understanding PSM Interventions: Expertise and Brokerage

Leroy White, Management Department, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

Understanding PSM interventions: expertise and brokerage

■ MC-21

Monday, 16:00-17:30
Meeting Room 218

OR in Forestry II

Stream: Forestry Applications
Invited session

Chair: *Hayri Onal*, University of Illinois, United States, h-onal@uiuc.edu

1 - Hard Combinatorial Problems in Spatial Forest Planning

Andrés Weintraub, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl, *Marcos Goycoolea*, *Juan Pablo Vielma Centeno*

Due to environmental considerations, spatial constraints have been imposed for forest harvesting. One particular form for these constraints is that of maximum opening size of harvested areas, the adjacency problem for blocks to be harvested. It has been shown that forming those block from basic cells as part of the model improves solutions. This is a hard combinatorial problem usually solved through heuristics. In the last decade exact formulations to solve this problem of different forms have been presented. We show these formulations and how they compare computationally on test problems

2 - Designing Conservation Reserves with Efficiency, Contiguity and Compactness Considerations

Hayri Onal, University of Illinois, United States, h-onal@uiuc.edu, *Kevin Patrick*

The conservation reserve design problem is often formulated as an integer program (IP) using the set covering or maximal covering frameworks. Typically, they result in undesirable reserve configurations where selected ites are highly scattered across the landscape without any spatial coherence. This has been addressed in several recent studies which incorporated spatial criteria in addition to the usual financial and ecological. This paper presents an IP approach incorporating compactness and contiguity considerations along with the usual site selection criteria and numerical applications.

3 - Cost-effective Compensation to Reduce Carbon Emissions due to Forest Loss: An Approach Considering Risk-aversion and Non-Gaussian Returns Effects

Ricardo Acevedo Cabra, Institute of Forest Management, Technische Universität München, 85354, Freising, Germany, Ricardo.Acevedo@lrz.tu-muenchen.de, *Thomas Knoke*

Analyses were carried out on compensation payments to encourage protection of tropical forests and reduction of related carbon emissions within a risk averting perspective. Land use portfolio-allocation (forest, pastures and crops) was modeled using the method of higher-moments, which does not constrain returns to be Gaussian distributed. Preliminary results show, that in order to encourage forest land use over other portfolio assets, higher payments are necessary than those found using the Capital Asset Pricing Model (CAPM).

Tuesday, 9:00-10:30

■ TA-01

Tuesday, 9:00-10:30
Plenary Hall 3

IFORS Survey on OR Practice 1

Stream: OR Practice

Invited session

Chair: *John Ranyard*, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

1 - Some Overall Results from the Global OR Practice Survey

John Ranyard, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

IFORS have commissioned a survey of OR practice in member countries, so as to gain a better understanding of the usage of quantitative tools, techniques and approaches and their impact on decision-making in organisations, as well as the background of the OR analysts involved. It is expected that the results will enable IFORS to improve their support to and promotion of OR in member countries. Over 250 practitioners from 28 member countries completed a comprehensive on-line questionnaire and some overall results will be presented.

2 - OR Practice in the United States

Karla Hoffman, Department of Systems Engineering and Operations Research, George Mason University, Mail Stop 4A6, 4400 University Drive, 22030, Fairfax, Virginia, United States, khoffman@gmu.edu

We present results from a survey on OR practice that was distributed to a few of the practice subdivisions within INFORMS. We also describe the recent activities related to the new theme of "analytic" that has made the sale of OR activities much easier and understandable to a wider business community.

3 - IFORS OR Practice Survey: Some Key UK Results

John Ranyard, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

Over 80 responses were received from the UK and some key results will be presented, covering the location of OR services, techniques, methodologies and software used, barriers to the use of OR and personal education and training received. Changes compared to a similar survey which was carried out 15 years ago will be highlighted. Some comments on current issues facing OR practitioners in the UK will be made.

■ TA-02

Tuesday, 9:00-10:30
Meeting Room 101

Game Theory Applications in Operations Management III

Stream: Game Theory

Invited session

Chair: *Vincent Knight*, School of Mathematics, Cardiff University, CF24 4AG, Cardiff, United Kingdom, Knightva@cf.ac.uk

1 - A Search Problem on a Finite Network with Traveling and Examination Costs

Kensaku Kikuta, School of Business Administration, University of Hyogo, Gakuen-nishi 8-2-1,Nishi-ku, 651-2197, Kobe, Japan, kikuta@biz.u-hyogo.ac.jp

We analyze mathematically variations of a search problem on a finite network : There is an immobile hider in a node. A seeker inspects each node until he finds the hider, traveling along edges. Associated with an inspection of a node is the inspection cost, and associated with a movement from a node to a node is a traveling cost. A strategy for the seeker is an ordering of nodes in which the seeker inspects each node in that order. The seeker wishes to minimize the sum of these costs which are required to find the hider.

2 - Sell E-Readers or E-Books? A Competitive Perspective

Lijun Ma, Management School, Shenzhen University, Rm1416, Arts Building, Shenzhen, Guangdong, China, lijun.ma@gmail.com, *Xiaoying Liang*, *Houmin Yan*

Motivated by observations of the e-book reader market, in this paper we consider the competition in a market composed of both integrated and unintegrated firms with vertically complementary and horizontally substitutable products. Using a stylized game-theoretical model, we find that the orders of access costs, equilibrium prices, and customer characteristics are all correlated, which is the case under both duopoly and oligopoly. This reveals strategic positions of different types of firms in the competitive market.

3 - Analyses of Location-Price Game on Networks with Stochastic Customer Behavior and its Heuristic Algorithm

Fengmei Yang, Dept. of Mathematics and Informatics, Beijing University of Chemical Technology, School of Science, 100029, Beijing, China, yang_fengmei@sina.com

In this paper, a two-stage model is developed to investigate the location strategy and the commodity pricing strategy for a retail firm that wants to enter a spatial market with multiple competitive facilities. Expected market shares are calculated based on the stochastic customer behavior on networks. We provide a sufficient condition for the existence of equilibrium prices in the price game for the first time. The existence and uniqueness of the pure strategy Nash equilibrium price with a specified utility function is proved in the subgame. A metaheuristic based on Tabu search is proposed.

4 - The Price of Anarchy of Health Care

Vincent Knight, School of Mathematics, Cardiff University, CF24 4AG, Cardiff, United Kingdom, Knightva@cf.ac.uk, *Paul Harper*

It is well observed that individual behavior can have an effect on the efficiency of queuing systems. In this paper we present a routing game model for the choices made by individuals when choosing between health care facilities. These choices take in to account travel distance, facility congestion and reputation. Results concerning the price of anarchy, an analytical measure of the inefficiency of choice, are obtained. The theoretical ideas presented are demonstrated by calculating the price of anarchy for a large case study.

■ TA-03

Tuesday, 9:00-10:30
Meeting Room 102

Simulation at Container Terminals

Stream: Meta-heuristics

Invited session

Chair: *Carsten Boll*, Fachbereich 2, Hochschule Bremerhaven, An der Karlstadt 8, 27568, Bremerhaven, Bremen, Germany, cboll@hs-bremerhaven.de

1 - Evaluation of AGV Dispatching Plans in Seaport Container Terminals using Simulation

Evelina Klerides, Business School, Imperial College London, Flat 43 Apsley House, 23-29 Finchley Road, NW8 0NY, London, United Kingdom, e.klerides@hotmail.com, *Panagiotis Angeloudis*, *Eleni Hadjiconstantinou*, *Michael Bell*

We consider the Automated Guided Vehicle (AGV) dispatching problem in container terminals where vehicles are allowed to carry more than one container at a time. This paper presents a micro-simulation framework that seeks to a real-life automated port. The framework validates/evaluates the operational results obtained from an optimization model designed specifically to find the optimal solution to the dual-load AGV dispatching problem. We report on various performance measures associated to container terminals and compare the results to those obtained using heuristic rules.

2 - Simulation on Yard Planning of Container Terminal

Andre Sugiyono, Engineering and Industrial Sciences, Swinburne University of Technology, 0392145263, 3122, Melbourne, Victoria, Australia, asugiyono@groupwise.swin.edu.au

The main objective of this case study is to analyze the yard planning process to increase the utilization of available resources and capacity planning of The Semarang Container Terminal system in Indonesia. The simulation is focused on scenario of yard planning to analyze the time of service (how long containers wait for service), completion time (how long it takes to complete process of unloading, loading, transport and stacking process), and the utilization of available resources. The model considers arrivals of sea vessels with TEU and 2 TEU size containers to be loaded and unloaded with quay crane, trucks, and Rubber Tire Gantry / Rail Mounted Gantry. The simulation model shows that the utilization of the resources in the system can be increased up to 98%.

3 - Round Trip Planning Simulation for Container Vessel Fleets

Carsten Boll, Fachbereich 2, Hochschule Bremerhaven, An der Karlstadt 8, 27568, Bremerhaven, Bremen, Germany, cboll@hs-bremerhaven.de

The precarious situation of world economy leads to a difficult situation for the maritime industry as well. So the shipping lines suffer on declining volume, overcapacities, high fuel costs etc. They can react to these trends by e.g. different port call strategies i.e. direct calls vs. hub-and-spoke, resp. mixed concepts or port/ terminal choice i.e. capacity and performance, fees, handling rates or vessels used i.e. size, fleet, operation speed. With the help of a comprehensive simulation model, there can be described and evaluated different scenarios for the influential variables.

■ TA-04

Tuesday, 9:00-10:30
Meeting Room 103

Issues in Supply Chain Procurement

Stream: Operations Management
Invited session

Chair: *Hao Zhang*, Information and Operations Management, University of Southern California, 3670 Trousdale Pkwy, BRI 401F, 90089, Los Angeles, CA, United States, zhanghao@usc.edu

1 - How Much is an Announcement Worth? A Study of Commitment Timing in Supply-chain Contracting

Harry Groenevelt, Simon School of Business, University of Rochester, Wilson Blvd, 14627, Rochester, NY, United States, groenevelt@simon.rochester.edu, *Bo Hu*

We study wholesale price contracts between a single supplier and a single buyer, which helps both reduce the risk of relying solely on a spot market. The supplier decides on contract price and spot market output quantity (which influences price), while the buyer decides on contract quantity and uses the spot market in case of shortage. The supplier may pre-announce the spot market output quantity. Such an announcement changes the buyer's outlook on future spot prices, and we examine its impact on the contract price and quantity and the players' profits, and supply chain coordination.

2 - The Role of Asymmetric Cost Information in a Finite Repeated Supply Chain Relationship

Deming Zhou, Faculty of Business Administration, The Chinese University of Hong Kong, Hong Kong, dzhou@cuhk.edu.hk

We consider the problem of procurement contracting in a one-supplier-one-buyer relationship, where the supplier's cost information is private, but they have opportunities to transact repeatedly. The key interest of this paper is to see if the supplier's true cost information can be revealed during the repeated interactions (without a screening contract). We find that the supplier's 'information advantage' persists in the initial phase of the repeated game. However, as the game goes on, such an information advantage gradually dissipates, and the supplier starts to randomize between accept and reject the contract. Therefore, his private information is revealed in a probabilistic fashion. These results indicate that repeated supply chain relationships have significantly different dynamics than those observed in a one-shot supply chain relationship. We discuss insights that are helpful to firms in shaping their strategies in their long-time supplier relationship.

3 - Bundled Procurement for (free) Technology Acquisition and Future Gain

Leon Chu, Information and Operations Management, University of Southern California, 90089, Los Angeles, CA, United States, leonyzhu@usc.edu, *Yunzeng Wang*

We study the effectiveness of a procurement mechanism that bundles the product procurement with the technology acquisition. Using the two-seller case, each seller has a dominant bidding strategy for the technology provision that is solely depends on the sellers' technology difference and the ratio between current project size and future market size, while the sellers' responses may not be continuous functions of the parameters. For most reasonable market conditions, a ratio of 10% is found sufficient for the sellers to provide best technologies and for the buyer to profit in the future.

4 - Revenue Sharing and Information Leakage in a Supply Chain

Hao Zhang, Information and Operations Management, University of Southern California, 3670 Trousdale Pkwy, BRI 401F, 90089, Los Angeles, CA, United States, zhanghao@usc.edu, *Guangwen Kong*, *Sampath Rajagopalan*

While information sharing has many benefits in a supply chain, firms are reluctant to share information with suppliers due to the fear of leaking it to a competitor. We analyze a supply chain with one supplier and two retailers, one of whom orders first and has private information about uncertain market potential. We show that there exists a non-leakage equilibrium under a revenue sharing contract and there exist many such contracts (with various wholesale prices and revenue share rates) under which the supplier will not leak the order quantity of the informed supplier to the uninformed one.

■ TA-05

Tuesday, 9:00-10:30
Meeting Room 104

Marketing/Operations Interfaces I

Stream: OR and Marketing
Invited session

Chair: *Xiaobo Zhao*, Industrial Engineering, Tsinghua University, 100084, Beijing, China, xbzhao@tsinghua.edu.cn

1 - Equilibrium Channel Strategy of Competing Suppliers facing Heterogeneous Customers

Stephen Shum, School of Business and Management, Hong Kong University of Science & Technology, Hong Kong, sshum@ust.hk, *Qian Liu*, *Ruirui Li*

Supplier-owned stores have emerged as an important channel strategy. We study a model with two competing supplier and an independent retailer. Each supplier can sell through a supplier-owned store, the independent retailer or both. Customers have heterogeneous valuations and decide where to go to shop for a product. We characterize suppliers' equilibrium channel strategies and pricing decisions. We also find using supplier-owned store may lead to a win-win situation for both suppliers.

2 - Bounded Rationality in Capacity Allocation Games

Yefen Chen, Department of Industrial Engineering, Tsinghua University, Shunde Building, Room 605, 100084, Beijing, China, chenyefen@gmail.com, *Xuanming Su*, *Xiaobo Zhao*

This paper studies buyers' ordering behavior in capacity allocation games. Using laboratory experiments, we find that their ordering behavior does not conform to standard game theoretic predictions. We consider a model of bounded rationality based on the Quantal Response Equilibrium (QRE) framework. We structurally estimate our model and provide evidence of suboptimal decision making and persistent bounded rationality that is not eliminated by learning over time.

■ TA-06

Tuesday, 9:00-10:30
Meeting Room 105

Workforce Management in Vehicle Routing

Stream: Transportation

Invited session

Chair: *Maciek Nowak*, Information Systems and Operations Management, Loyola University Chicago, 1 E. Pearson Ave., 60611, Chicago, IL, United States, mnowak4@luc.edu

Chair: *Karen Smilowitz*, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Technological Institute M233, 60208-3119, Evanston, Illinois, United States, ksmilowitz@northwestern.edu

1 - Workforce Management in Periodic Routing: Lessons Learned on a UPS Package Car

Karen Smilowitz, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Technological Institute M233, 60208-3119, Evanston, Illinois, United States, ksmilowitz@northwestern.edu, *Maciek Nowak*

Service quality and driver efficiency in delivery operations may be enhanced by increasing the regularity with which drivers visit customers. However, such consideration can increase travel distance. In this talk, we discuss how workforce management impacts periodic routing decisions. We review the treatment of workforce management in routing models from the academic literature and commercial software.

2 - Impact of Consistency of Care on Home Healthcare Routing

Maciek Nowak, Information Systems and Operations Management, Loyola University Chicago, 1 E. Pearson Ave., 60611, Chicago, IL, United States, mnowak4@luc.edu, *Mike Hewitt*, *Ashlea Bennett*

For some organizations, cost is one of many factors used to measure the quality of a route. In home health care, consistency with respect to the nurse that visits a patient or the time of day a patient is visited can be just as important. Also, advances in information technology devices provide a new method for providing care. We present an integer programming model with multiple objectives to study these conjoined factors and the impact devices have on the ability to achieve them.

3 - The Value of a Priori and Partial Information for Probabilistic Vehicle Routing

Richard Wong, United Parcel Service, 2311 York Road, 21093, Timonium, Maryland, Afghanistan, rtwong@ups.com, *Si Chen*, *Hongsheng Zhong*

Phase I considers a probabilistic vehicle routing problem with route duration constraints. In phase II, customer locations are gradually revealed but adjusting a customer's phase I assignment incurs a penalty. This problem arises in several logistics contexts including small package delivery. We present models and computational results evaluating operating/optimization strategies for balancing workloads under varying amounts of partial information.

■ TA-07

Tuesday, 9:00-10:30
Meeting Room 106

Flow Problems - Easy, Hard, and (almost) Impossible

Stream: Discrete Optimisation

Invited session

Chair: *Gregor Pardella*, University of Cologne, Pohligstr. 1, 50969, Cologne, Germany, pardella@informatik.uni-koeln.de

Chair: *Birgit Engels*, AFS, University of Cologne, Weyertal 80, 50931, Cologne, NRW, Germany, engels@zpr.uni-koeln.de

1 - Preprocessing Strategies for Max-Flow on Structured Graphs

Gregor Pardella, University of Cologne, Pohligstr. 1, 50969, Cologne, Germany, pardella@informatik.uni-koeln.de, *Frauke Liers*

Max-flow problems occur in a wide range of applications and, although already well-studied and equipped with fast implementations, they are still an area of active ongoing research. Motivated by the physics application of so-called random field Ising models we introduce flow conserving shrinking rules. Additionally we present a hybrid max-flow algorithm that finds a good initial solution and then extends this to the optimum. The considered graphs are structured in the sense that a larger set of nodes is either connected to the source or the sink. This is joint work with Frauke Liers.

2 - Matching under an Edge-Disjoint-Paths Constraint

Birgit Engels, AFS, University of Cologne, Weyertal 80, 50931, Cologne, NRW, Germany, engels@zpr.uni-koeln.de

We introduce a constrained matching problem (MEDP) on a graph G=(V,E) and a 'constraint' graph C whose node set contains V. Then (MEDP) is solved by a matching M in G of maximal cardinality, such that C contains a set P(M) of edge-disjoint paths between all pairs u,v with (u,v) in M. We use M to round a half-integral minimal cost generalized flow with minimal constraint violation in an application-oriented setting. For general C and |M|>2 the constraint is NP-hard to check. We present a polynomial time dynamic programming algorithm to solve (MEDP) optimally if C is a tree.

3 - Integer Multicommodity Flows in Graph Drawing

Daniel Schmidt, Computer Science, University of Cologne, Germany, schmidt@informatik.uni-koeln.de, *Michael Juenger*

The maximum planar subgraph problem asks for a subgraph of a given graph G that is planar and has maximum weight. This problem is NP hard, but the polytope P of incidence vectors of planar subgraphs of G is well-studied: It turns out that subdivisions of the k33 or the k5 induce facet defining inequalities of P. This allows for a branch and cut approach in which we look for subdivisions of k33 of minimum weight w.r.t. a lp solution in the cutting step. So far, this could only be done heuristically. We propose an exact separation algorithm based on integer multicommodity flows.

■ TA-08

Tuesday, 9:00-10:30
Meeting Room 107

Health Care Operations I

Stream: Service & Health Care Operations

Invited session

Chair: *Christiane Barz*, UCLA Anderson School of Management, 110 Westwood Plaza, B520 Gold Hall, 90095, Los Angeles, California, United States, cbarz@anderson.ucla.edu

1 - Minimizing the Waiting Time for Emergency Surgery

Theresia van Essen, Discrete Mathematics and Mathematical Programming, University of Twente, P.O. Box 217, 7500 AE, Enschede, Netherlands, j.t.vanessen@ewi.utwente.nl

Emergency surgeries should be scheduled as quick as possible to reduce complications and morbidity. The waiting time of emergency surgeries can be reduced by scheduling them in one of the elective operating rooms instead of an emergency operating room. The emergency patients are operated once an ongoing elective surgery is finished. These moments in time are denoted by 'break-in-moments' (BIMs). By spreading the BIMs as evenly as possible over the day, the waiting time of emergency surgeries can be reduced even further. In this presentation, we discuss several solution methods for the off-line and on-line version of this BIM optimization problem.

2 - Managing Limited Bed Capacity of a Hospital

Burhaneddin Sandikci, Booth School of Business, University of Chicago, 5807 South Woodlawn Avenue, 60637, Chicago, IL, United States, burhan@chicagobooth.edu, *Don Eisenstein*, *Tom Best*, *David Meltzer*

To address adverse effects of limited capacity, the University of Chicago Medical Center (UCMC) received special dispensation from the state of Illinois, through which it partitions its inpatient beds into mini-hospitals or wings. Each wing has a specific designation of the types of patients it can admit, and the number of beds it is allocated. A patient requesting hospital services can be admitted only if a bed is available in the appropriate wing. We model and solve the computationally hard problem of forming wings to near optimality using data from UCMC as well as national databases.

3 - Diagnostic Accuracy Under Congestion

Peng Sun, Fuqua School of Business, Duke University, Durham, NC, United States, psun@duke.edu, *Saed Alizamir*, *Francis de Vericourt*

In diagnostic services, agents typically need to weigh the benefit of running an additional test and improving the accuracy of diagnosis against the cost of congestion, i.e., delaying the provision of services to others. Our paper analyzes how to dynamically manage this accuracy/congestion tradeoff. We study an elementary congested service facing an arriving stream of customers. The diagnostic process consists of a search problem in which the agent conducts a sequence of imperfect tests to determine whether a customer is of a given type.

4 - Patient Admissions under Multiple Resource Constraints

Christiane Barz, Anderson School of Management, UCLA, 110 Westwood Plaza, Gold Hall, B510, 90024, Los Angeles, CA, United States, christiane.barz@anderson.ucla.edu, *Kumar Rajaram*

We consider a patient admission problem to a hospital with two potential bottlenecks: beds and OR capacity. While there is an uncontrolled arrival process of emergency patients (which must be accepted and taken care of immediately), the hospital has the freedom to postpone or even reject the admission of non-emergency patients. We use approximate dynamic programming to suggest an operating policy and compare its performance to simple heuristics

■ TA-09

Tuesday, 9:00-10:30

Meeting Room 108

Arc Routing & Node Routing

Stream: Vehicle Routing

Invited session

Chair: *Tolga Bektas*, University of Southampton, School of Management, Highfield, SO17 1BJ, Southampton, United Kingdom, T.Bektas@soton.ac.uk

Chair: *Michel Gendreau*, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca

1 - The Restricted Capacitated Arc Routing Problem

Sanne Wøhlk, Department of Business Studies, Aarhus School of Business, Fuglesangs alle 4, DK-8210, Aarhus V, Denmark, sanw@asb.dk, *Lise Bach Lystlund*

The Capacitated Arc Routing Problem (CARP) is the problem of servicing a set of edges with demand using a fleet of capacitated vehicles, such that each edge is serviced by exactly one vehicle, the vehicle capacities are respected and the total routing cost is minimized. We consider a variation of the problem with the additional constraint that any deadheading of an edge must take place at a later time than the time of service of the edge. This problem has practical applications in snow removal. We discuss the difficulties of modeling the problem and suggest a heuristic solution procedure.

2 - The Generalized Arc Routing Problem

Elena Fernandez, Statistics and Operations Research, Technical University of Catalonia, Campus Nord, C5-208, Jordi Girona, 1-3, 08034, Barcelona, Spain, e.fernandez@upc.edu, *Julian Aráoz*, *Carles Franquesa*

In this talk we study the Generalized Arc Routing Problem (GARP), which is the arc routing version of the Generalized Vehicle Routing Problem. The set of demand arcs is partitioned into clusters and vehicles must visit exactly one (or at least one) demand arc per cluster. We introduce the GARP and describe potential applications and some interesting particular cases. We present an integer programming formulation and discuss several families of valid inequalities that reinforce the Linear Programming relaxation of the formulation. Preliminary computational results are presented and analyzed.

3 - An Approximation Algorithm for Hamiltonian Path with 3 Depots

Kheffache Rezika, Mathematiques, Université Mouloud Mammeri de Tizi Ouzou, Faculté des Sciences ,Université de Tizi Ouzou, Algérie, Alger, Algeria, kheffache.rezika@yahoo.fr, *Ouafi Rachid*

In literature, the traveling salesman problem (TSPs) and the Hamiltonian path problem with multiple depot and its variants (HPPS) admit algorithms approximation ratio of 2. However, currently, there no algorithm available for these problems is related approximation better than 2. Following the article: 3/2-approximation algorithm for two variants of 2-depot Hamiltonian path problem by Sivakumar Rathinam and Raja Sengupta where it was demonstrated the existence of an approximation algorithm of 3/2. Two variants of the Hamiltonian path problem with two depots, we consider another variant of the problem and 3 depots present an algorithm with an approximation ratio of 3/2 in the case where the costs are symmetric and satisfy the inequality triangular.

4 - A Hybrid Genetic Algorithm for Multi-depot and Periodic Vehicle Routing Problems

Michel Gendreau, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca, *Thibaut Vidal*, *Teodor Gabriel Crainic*, *Nadia Lahrichi*, *Walter Rei*

We present an algorithmic framework that successfully addresses three vehicle routing problems: the multi-depot VRP, the periodic VRP, and the multi-depot periodic VRP with capacitated vehicles and constrained route duration. Extensive computational experiments show that the method performs impressively, in terms of computational efficiency and solution quality, identifying either the best known solutions or new best solutions for all currently available benchmark instances for the three problem classes. The proposed method also proves extremely competitive for the capacitated VRP.

■ TA-10

Tuesday, 9:00-10:30

Meeting Room 111

Robust Planning and Rescheduling

Stream: Public Transit

Invited session

Chair: *Leena Suhl*, Int. Graduate School of Dynamic Intelligent Systems, University of Paderborn, Decision Support & OR Lab, Warburger Str. 100, 33098, Paderborn, Germany, suhl@upb.de

Chair: *Natalia Kliewer*, Information Systems, Freie Universitaet Berlin, Garystr. 21, 14195, Berlin, Germany, natalia.kliewer@fu-berlin.de

1 - Crew Re-scheduling During the Operations

Dennis Huisman, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl

The Dutch railway network experiences about three large disruptions per day on average. One of the major problems is to re-schedule the crew such that all crew reach their crew base at the end of their duty and as many trains as possible are operated. During the last couple of years, we have developed an algorithm, which uses column generation and large neighborhood search techniques to solve the crew re-scheduling problem. This algorithm is now part of a system, called CREWS Real-time Dispatcher. In this talk, we present the first, practical experiences at Netherlands Railways with this algorithm.

2 - Fast Heuristics for Delay Management with Passenger Re-Routing

Twan Dollevoet, Econometric Institute, Erasmus University Rotterdam, 3000DR, Rotterdam, Netherlands, dollevoet@ese.eur.nl

Delay management models determine which connections should be maintained in case of a delayed feeder train. Recently, delay management models are developed that take into account that passengers will adjust their routes when they miss a connection. However, for large-scale real-world instances, these extended models become too large to be solved with standard integer programming techniques. We have therefore developed several heuristics to tackle these larger instances. We compare the quality of these heuristic solution methods on real-life instances from Netherlands Railways.

3 - Increasing Stability and Flexibility of Vehicle and Crew Schedules in Public Transport

Bastian Amberg, Information Systems, Freie Universitaet Berlin, Garystr. 21, 14195, Berlin, Germany, bastian.amberg@fu-berlin.de, *Boris Amberg*, *Natalia Kliewer*

In public bus transport delays occur frequently during execution of vehicle and crew schedules. Then planned schedules can become infeasible and the operations control has to initiate expensive recovery actions. We present offline approaches to increase robustness of vehicle and crew schedules. In order to absorb possible delays we propose models and methods increasing delay-tolerance (stability). Further we consider methods providing additional possibilities for low-cost recovery actions within the schedules (flexibility). The approaches are compared with regard to planned cost and robustness

4 - Incorporating Stability and Flexibility Aspects in Crew and Aircraft Scheduling

Lucian Ionescu, Information Systems, Freie Universität Berlin, Garystr. 21, 14195, Berlin, Germany, Lucian.Ionescu@fu-berlin.de, *Natalia Kliewer*

In this talk we discuss robustness aspects of crew and aircraft schedules. The scope of the talk is two-folded. In the first part we propose an indicator for stability of crew and aircraft schedules based on a stochastic model for delay propagation. In a second stage we discuss an extension of the approach by considering swapping opportunities of crews and aircraft during operations. Swaps are used to adhere to cost-efficient schedules while still hedging against possible reactionary delays. This enables us to both consider stability and flexibility simultaneously during scheduling.

■ TA-11

Tuesday, 9:00-10:30

Meeting Room 112

Simulation Optimization

Stream: Simulation - Sponsored by I-SIM

Invited session

Chair: *Loo Hay Lee*, Industrial & Systems Engineering Dept., National University of Singapore, 10 Kent Ridge Crescent, 119260, Singapore, iseleelh@nus.edu.sg

1 - Optimal Computing Budget Allocation (OCBA) Algorithm for constraint and multi-objective problem

Loo Hay Lee, Industrial & Systems Engineering Dept., National University of Singapore, 10 Kent Ridge Crescent, 119260, Singapore, iseleelh@nus.edu.sg, *Ek Peng Chew*, *Chun-Hung Chen*

In this talk, we will share some of the new development in OCBA. We have developed algorithms for constraints optimization problem as well as multi-objective problem. Correlation information between performance will be considered in the algorithm.

2 - OCBA Framework for AHP in Supplier Selection Problem

Ek Peng Chew, Industrial and Systems Engineering, Faculty of Engineering, National University of Singapore, 10 Kent Ridge Crescent, 119260, Singapore, isecep@nus.edu.sg, *Loo Hay Lee*

In this work, we look at a supplier selection problem using Analytical Hierarchy Process (AHP). However, as the information is clouded by a lot of uncertainty, the solution generated by AHP might not be the best one. We propose an optimal computing budget allocation (OCBA) framework to reduce the degree of uncertainty in the information efficiently so that solution obtain will meet the goal of the decision makers with high confidence.

3 - Augmenting Regression with Direct Stochastic Gradient Estimates

Michael Fu, Smith School of Business, University of Maryland, Van Munching Hall, 20742, College Park, MD, United States, mfu@umd.edu, *Huashuai Qu*

In the sequential response surface methodology approach to simulation optimization, regression plays a central role. Traditional regression assumes the only data available are measurements of the dependent variable for each value of the independent variable. We propose an augmented linear regression model that incorporates direct stochastic gradient estimates, comparing it with the traditional model both analytically and numerically on a simple queueing model.

4 - Power Management in Buildings Facilitated by Simulation-based Policy Improvement

Qing-Shan Jia, Department of Automation, Tsinghua University, CFINS, 100084, Beijing, China, jiaqs@tsinghua.edu.cn, *Jian-Xiang Shen*, *Zhan-Bo Xu*, *Xiaohong Guan*

Buildings are one of the largest consumers of energy, accounting for between 30-40% of global energy use. In this talk, we schedule solar power, wind power, combined cooling, heating, and power generation (CCHP), battery, and high temperature chiller to satisfy the load on electricity, sensible heat load, and latent heat load in buildings with the minimal average cost. The rollout method is applied to improve from given base policies through simulations. Numerical results show that the method obtains policies better than the base policies.

■ TA-12

Tuesday, 9:00-10:30

Meeting Room 205

Production Systems

Stream: Contributed Talks

Contributed session

Chair: *Kazuyoshi Tsurusaki*, Faculty of Economics, Nagasaki University, 4-2-1 Katafuchi, 850-8506, Nagasaki, Japan, turusaki@nagasaki-u.ac.jp

1 - A New Production Planning System by Advance Demand Information Based on Unfulfilled-order-rate for Uncertain Demand

Nobuyuki Ueno, Dept. of Management Information Systems, Prefectural University of Hiroshima, 1-1-71 Ujina-Higashi, Minami-Ku Hiroshima-City, 734-0003, Hiroshima, Japan, ueno@pu-hiroshima.ac.jp, *Koji Okuhara*

We propose a production planning model with uncertain demand based on unfulfilled-order-rate by Advance Demand Information. It is formulated as a nonlinear stochastic problem which minimizes the sum of production cost and inventory holding cost subject to a probabilistic constraint and linear constraints. We develop the new upper bound to estimate unfulfilled-order-rate when inventory in two periods is correlated and a near-optimal solution algorithm on the basis of relaxation strategy. The technique decreases inventory more than by base-stock policy with multi-period under the conditions.

2 - Simulation and Control of Shrinkages in the Ready Mix Concrete Production Process

Fredy Huayta, Ingeniería Industrial, Pontificia Universidad Católica del Perú, Av. Universitaria 1801, Lima, Peru, fhuayta@pucp.edu.pe, *Wilmer Atoche*, *Fernando Ormachea*

Article shows the ready-mix concrete production process, which identifies the shrinkage, generated in the unit operation. Monitoring indicators are identified and shrinkage, are simulated using computational tools process. Also calculated the economic losses generated by the shrinkage and the water wasted in the process. The company analyzed processes 1000 tons per day, in which they identify points of leakage, we measured the losses generated in the process, were determined by mass balance calculations, was formulated and finally the model simulated the losses of the unit operation.

3 - Proposed Improvements in Non Direct Process of a Socks Company

José Rau, FCI, PUCP, Av. Universitaria 1851, Peru, jrau@pucp.edu.pe

Improvements presented correspond to an average manufacturing plant, which showed a low productivity of human and material resources. It were chosen and described development in reduce consumption of energy resource and increase productivity, progress in an air system to transport and carry on knitting and innovation in improving the organization of work and material consumption.

4 - Development of Ubiquitous Sensing System to Visualize Current Status of Production of Plant Manufacturing Industries

Kazuyoshi Tsurusaki, Faculty of Economics, Nagasaki University, 4-2-1 Katafuchi, 850-8506, Nagasaki, Japan, turusaki@nagasaki-u.ac.jp

The product management, which has been evolved continuously in mass-production goods, such as cars and electronic products since the beginning of last century, has been left behind in the evolution in plant industries such as power plants. One of key issues to prevent the evolution is considered to be its difficulty of visualization of production status in plant manufacturing. The authors examined several procedures to sense status of manufacturing with ubiquitous sensors attached on equipments and materials in production in the factories and demonstrated it at a factory.

■ TA-13

Tuesday, 9:00-10:30
Meeting Room 206

Perturbations, Graphs and Games

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Jerzy Filar*, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au

Chair: *Vladimir Gaitsgory*, University of South Australia, 5095, Mawson Lakes, South Australia, Australia, Vladimir.Gaitsgory@unisa.edu.au

1 - Polynomial Limit Control Algorithm to Identify Nearly all Cubic, Non-Hamiltonian, Graphs

Jerzy Filar, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au, *Ali Eshragh Jahromi*

Determining whether a cubic graph is non-Hamiltonian is an NP-complete problem. However, by embedding the Hamiltonian Cycle Problem in the space of occupational measures of a discounted Markov control problem, we can construct a limit-control linear program that correctly identifies a majority of non-Hamiltonian cubic graphs. Furthermore, by adding graph specific constraints to the latter, all but extremely rare instances can be correctly identified.

2 - Non-Linearity in Non-Zero Sum Games with Incompetent Players

Justin Beck, Centre for Industrial and Applied Mathematics, University of South Australia, 5095, Mawson Lakes, South Australia, Australia, justin.d.beck@hotmail.com

Game Theory is a well established area of mathematics dealing with problems where there is more than one player. In these "games' the fortunes of the players are coupled by their actions. An implicit assumption in many of these models is the players are capable of executing their optimal strategies. However, in reality a player may not have the ability to execute their chosen strategy. This presentation will explore this topic with reference to theory and applications with a focus on the non-linear and discontinuous behaviour which can arise in non-zero sum games.

3 - Genetic Theory of Cubic Graphs

Michael Haythorpe, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Boulevard, Mawson Lakes, 5095, Adelaide, SA, Australia, michael.haythorpe@unisa.edu.au, *Pouya Baniasadi*, *Vladimir Ejov*, *Jerzy Filar*

Cubic graphs are widely researched, as they represent arguably the simplest subset of graphs for which common graph theory problems remain non-trivial. We investigate the generation of cubic graphs, and show that they can (in polynomial time) be identified as one of two types - genes and descendents. We show that any descendent can be generated from a set of genes via the use of six breeding operations. We consider the application of this theory to the Hamiltonian cycle problem, whereby finding a Hamiltonian cycle (HC) in a graph is reduced to finding the HCs of that graph's ancestor genes.

4 - Pseudo Singularly Perturbed Linear Programs

Vladimir Gaitsgory, University of South Australia, 5095, Mawson Lakes, South Australia, Australia, Vladimir.Gaitsgory@unisa.edu.au

We study a linear programming problem with a linear perturbation introduced through a small parameter epsilon. We identify and analyze an unusual asymptotic phenomenon. Namely, discontinuous limiting behavior of the optimal objective function value of such a linear program may occur even when the rank of the coefficient matrix of the constraints is unchanged by the perturbation. Under mild conditions, this phenomenon is a result of the classical Slater constraint qualification being violated at the limit. An iterative, constraint augmentation approach for resolving this problem is proposed.

■ TA-14

Tuesday, 9:00-10:30
Meeting Room 207

Global Optimization

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Nelson Maculan Filho*, COPPE / PESC, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br

Chair: *Emilio Carrizosa*, Estadistica e Investigacion Operativa, Universidad de Sevilla, Matematicas, Reina Mercedes s/n, 41012, Sevilla, Spain, ecarrizosa@us.es

Chair: *Rommel Regis*, Mathematics, Saint Joseph's University, 5600 City Avenue, 19131, Philadelphia, PA, United States, rregis@sju.edu

1 - Effective and Efficient Hybrid Methods for Solving Global Optimization Problems Including the Lennard-Jones Potential Energy Global Optimization Problem

Jiapu Zhang, CIAO & School of ITMS, The University of Ballarat, MT Helen Campus Ballarat University, 3350, Ballarat, VIC, Australia, j.zhang@ballarat.edu.au

In recent years large-scale global optimization (GO) problems have drawn considerable attention. These problems have many applications, in particular in data mining and biochemistry. Some successful hybrid methods and numberical computing experiences for GO will be reported.
The Lennard-Jones potential energy minimization problem is a benchmark for testing new GO algorithms. It is studied through the optimal atomic-resolution molecular structure constructions of amyloid fibrils. This is very useful in furthering the goals of medicinal chemistry.

2 - Optimal Controlled-limit and Preventive Maintenance Policy within Life Cycle of Products

Wen Liang Chang, Department of Information Management, Cardinal Tien College of Healthcare & Management, Taipei, Taiwan, D9101402@mail.ntust.edu.tw

This paper investigates controlled-limit and preventive maintenance (PM) policy. When the product fails, the failed product is rectified using minimal repair. In order to reduce the number of product failures, the seller performs imperfect PM actions when the age of the product reaches a controlled-limit. After the base warranty period expires, the seller gives a discount of purchasing extended warranty (EW) expense if the consumer purchases the EW for products. Under this maintenance scheme, the profit model is constructed and then the optimal policy is obtained. Finally, numerical examples are given to illustrate the influences of the optimal policy for profit model.

3 - A Continuous Optimization Approach for Determining the Stability Number of a Graph

Jitamitra Desai, School of Mechanical and Aerospace Engineering, Nanyang Technological University, Systems and Engineering Management, 50 Nanyang Avenue, N3.2 - 02-53, 639798, Singapore, jdesai@ntu.edu.sg

In this talk, we determine the stability number of a graph via a fractional programming formulation. The problem of finding the stability number is a well-studied problem in IP literature, but solving this problem using continuous optimization techniques is a relatively new area of research. We showcase several convexity results, and prove that the fractional program yields the stability number. Characterizations of the local maxima are described, and these results are utilized in developing a new optimization algorithm. Detailed computational results are provided using standard test sets.

4 - The Back Propagation Algorithm Using the Bi-Hyperbolic Activation Function

Geraldo Miguez, COPPE / PESC, Universidade Federal do Rio de Janeiro, Brazil, R Mariz e Barros, 652/502, 20270-002, Rio de Janeiro, RJ, Brazil, geraldomiguez@yahoo.com, *Nelson Maculan Filho*, *Adilson Elias Xavier*

Back propagation algorithm is one of the most used tools for training artificial neural networks. However, in some practical applications it may be very slow. To allow a broader use, many techniques were discussed to speed up its performance. This paper presents a new strategy based in the use of the Bi-hyperbolic function that offers more flexibility and a faster evaluation time. The efficiency and the discrimination capacity of the proposed methodology are shown through a set of computational experiments with traditional problems of the literature.

■ TA-15

Tuesday, 9:00-10:30
Meeting Room 208

Weapon Systems Analysis

Stream: Military, Defense and Security Applications
Invited session

Chair: *Won Joon Jang*, Defense Industry Team, Korea Institute for Industrial Economics and Trade, Hoegi-ro 66, Dongdaemun-gu, 133-771, Seoul, Korea, Republic Of, wjjang47@snu.ac.kr

1 - The RAM Goal Setting Model with the use of OMS/MP Analysis for the Weapon System Development

Won Joon Jang, Defense Industry Team, Korea Institute for Industrial Economics and Trade, Hoegi-ro 66, Dongdaemun-gu, 133-771, Seoul, Korea, Republic Of, wjjang47@snu.ac.kr, *Kyung Yong Kim*

The paper presents the RAM Goal Setting model with the basis of wartime/peacetime OMS/MP results and its Total Down Time factors for the development of the weapon system. Based on both previous studies, the peer review results and various proven techniques, it presents the RAM goal setting model with its real implementation case study result. It verifies with ALPHA simulation tools, too. It could provide the basis of its development of weapon system and it could contribute both to enhance its operational availability and to reduce the Total Ownership Cost during its whole service life time.

2 - Integrated Survivability for ADF Land Platforms

Patrick Taliana, Defence, DSTO, PO Box 1500, 5111, Edinburgh, South Australia, Australia, patrick.taliana@dsto.defence.gov.au

Land platforms may be engaged by a wide variety of threats which can be difficult to predict and are constantly evolving. There are numerous technologies that have the potential to improve the probability of survival of land platforms. Deciding what mix of technologies maximises probability of survival is a non trivial task. Many researchers have adopted the Classical Survivability Onion model to represent the integrated survivability problem space. This report will outline the limitations of the classical Onion model and preset an alternative Integrated Survivability strategy called DESIST.

3 - Network Optimization Models for Resource Allocation in Developing Military Countermeasures

Boaz Golany, Industrial Engineering & Management, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, golany@ie.technion.ac.il, *Moshe Kress*, *Michal Penn*, *Uriel G. Rothblum*

The paper considers an arms race where an attacker develops new weapons and a defender develops countermeasures that mitigate the effects of the weapons. We address the defender's decision problem: given limited resources, which countermeasures to develop and how much to invest in their development so as to minimize the damage caused by the attacker's weapons over a certain horizon. The problem is formulated as constrained shortest path model and variants thereof. The potential applicability and robustness of this approach with respect to various scenarios is demonstrated.

■ TA-16

Tuesday, 9:00-10:30
Meeting Room 209

Metaheuristics for Scheduling in Manufacturing

Stream: Scheduling
Invited session

Chair: *Frédéric Dugardin*, LOSI, University of Technology of Troyes, 12, rue Marie Curie, 10010, Troyes, France, frederic.dugardin@utt.fr

Chair: *Farouk Yalaoui*, Institut Charles Delaunay, ICD LOSI, University of Technology of Troyes, 12, Rue Marie Curie BP 2060, 10000, Troyes, France, farouk.yalaoui@utt.fr

Chair: *Lionel Amodeo*, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie BP2060, 10000, Troyes, France, lionel.amodeo@utt.fr

1 - Fuzzy-Lorenz Algorithm to Solve Multi-objective Reentrant Scheduling Problem

Frédéric Dugardin, LOSI, University of Technology of Troyes, 12, rue Marie Curie, 10010, Troyes, France, frederic.dugardin@utt.fr, *Farouk Yalaoui*, *Lionel Amodeo*

This paper deals with the multi-objective scheduling of a reentrant hybrid flow-shop. In this study the two different objectives are the makespan and the sum of the total tardiness minimization. The system is composed of several stages which involves several parallel identical machines. Moreover each task must be processed more than once at each stage. This problem is solved using the Lorenz dominance which involves more parameters than the Pareto one. In this study we use Fuzzy logic Controller to adapt the value of these parameters to improve the results of the previous algorithm. This algorithm is tested on several instances from the literature and compared with some of the best known algorithms.

2 - New Heuristic for Solving the Minimization of Tool Switches Problem

Horacio Yanasse, LAC, INPE, Av. dos Astronautas 1758, CP 515 - INPE/CTE, 12227-010, São José dos Campos, SP, Brazil, horacio@lac.inpe.br, *Edson Senne*, *Rita de Cássia Meneses Rodrigues*

In the minimization of tool switches problem we seek a sequence to process a set of jobs so that the number of tool switches required is minimized. In this work we present a new heuristic for solving this problem based on generating a surrogate potentially smaller sized instance of MTSP, whose solution can be used to build a solution to the original instance. To obtain this solution to the MTSP we propose a heuristic based on partial ordered job sequences. Computational test results are presented showing that the proposed heuristic has an improved performance compared with previous proposed schemes.

3 - A Fuzzy Logic Controller to Solve a Scheduling Problem

Naim Yalaoui, Institut Charles Delauney, Université de Technologie de Troyes, 12, Rue Marie Curie, 10000, Troyes, France, naim.yalaoui@utt.fr, *Lionel Amodeo*, *Farouk Yalaoui*, *Halim Mahdi*

In this paper, we deal with a specific scheduling problem. This one is an hybrid flow shop problem. The jobs are processed on parallel unknown machines in each stage. Those are pre assigned to the machines. In some stages, the jobs are processed on a fictive machine. The objective function is to minimize the total tardiness. We propose an exact method based on a complete enumeration and different metaheuristics such as a genetic algorithm, genetic algorithm under fuzzy logic-control, a particle swarm algorithm and particle swarm algorithm under fuzzy logic-control. The tests examples were generated using a specific protocol. The obtained results are very interesting.

■ TA-17

Tuesday, 9:00-10:30
Meeting Room 214

Fundamentals of Multicriteria Decision Analysis

Stream: Multicriteria Decision Analysis and Multiobjective Optimisation

Invited session

Chair: *Jyrki Wallenius*, Helsinki School of Economics, POB 1210, 00101, Helsinki, Finland, jyrki.wallenius@aalto.fi

1 - Can a Linear Value Function Explain Choices

Jyrki Wallenius, Helsinki School of Economics, POB 1210, 00101, Helsinki, Finland, jyrki.wallenius@aalto.fi, *Pekka Korhonen*, *Anssi Oorni*, *Kari Silvennoinen*

We investigate in a simple bi-criteria experimental study, whether subjects are consistent with a linear value function, while making binary choices. Many inconsistencies appeared in our experiment. However, the impact of inconsistencies on the linearity vs. non-linearity of the value function was minor. Interestingly, consistency with a linear value function was restored for 83% of the cases if one or two of the response constraints (with highest shadow prices) were purged from the model, implying that one should incorporate a preference statement only if sure about its correctness. Moreover, a linear value function seems to predict choices for bi-criteria problems quite well. Predictability is independent of whether the value function is diagnosed linear or not. Inconsistencies in responses did not necessarily change the original diagnosis of the form of the value function. Our findings have implications for the design and development of decision support tools for Multiple Criteria Decision Making problems.

2 - Scholarly Communities of Research in Multiple Criteria Decision Making: A Bibliometric Research Profiling Study

Hannele Wallenius, Industrial Engineering and Management, Aalto University School of Science, P.O. Box 15500, 02015 HUT, 00076 Aalt, Espoo, Finland, hannele.wallenius@tkk.fi, *Johanna Bragge*, *Pekka Korhonnen*, *Jyrki Wallenius*

Electronic journal databases allow efficient retrieval and processing of bibliometric data, making possible enhanced literature reviews called research profiling studies. We have conducted such a study of Multiple Criteria Decision Making using the ISI Web of Science. We report statistics regarding how our field has developed based on variations of a set of broad search words. We have produced detailed correlation maps based on most cited authors for different decades, showing the birth and evolution of different schools of thought. Our study shows that our field has experienced exponential growth. At the same time it has penetrated other neighboring domains of knowledge, such as Information ICT and engineering.

3 - Value-Focused Brainstorming

Ralph Keeney, Fuqua School of Business, Duke University, 101 Lombard Street, #704W, 94111, San Francisco, CA, United States, KeeneyR@aol.com

Brainstorming can be a useful technique to create alternatives for complex decisions. To enhance the quality and innovativeness of the created alternatives, value-focused thinking is used to specify the valued aspects of the alternatives. These valued aspects, specified as distinct objectives, focus brainstorming to create alternatives of greater value. Relevant concepts and procedures of the approach are discussed. A public policy application concerning the emergency evacuation of individuals from large buildings is summarized.

4 - Estimation Methods for Choice-based Conjoint Analysis Utility Functions

Merja Halme, Information and Service Economy, Aalto School of Economics, Pl 11000, 00076, Aalto, Finland, merja.halme@aalto.fi, *Markku Kallio*

Conjoint analysis, a method expanding in many disciplines is one way to assess value functions. Choice-based conjoint analysis (CBC) is currently the most popular type. In its questionnaire the respondents are made to choose from among a number of product profiles the most preferred one. The profiles consist of attributes whose values have been defined. We compare optimization based estimation approaches, including a new one, convex penalty minimization (CP) with the benchmark Hierarchical Bayes (HB) estimation. Of the optimization methods CP performs best, and is equally good as HB.

■ TA-18

Tuesday, 9:00-10:30
Meeting Room 215

Applications of DEA in Education sector

Stream: Data Envelopment Analysis

Invited session

Chair: *M^a Teresa Cáceres*, Matemática Aplicada I, Universidad de Sevilla, Avenida Reina Mercedes s/n, Sevilla, Spain, caceres@us.es

1 - DEA and SFA for Benchmarking of Public Services: The Case of Universities and Research Centers

José L. Pino, Estadística e Investigación Operativa, Universidad de Sevilla, Avenida Reina Mercedes s/n, 41012, Sevilla, Spain, jlpino@us.es, *M^a Teresa Cáceres*, *Gerardo Valeiras*, *Luisa Jurado*

The principle 10 (Cost —Effectiveness) of the European Statistics Code of Practice indicates that resources must be effectively used. One of the objectives of the Andalusia Statistical Plan 2007-2010 is to contribute to the construction of procedures for the design of efficiency indicators of public services. In this issue we show how we are applying Data Envelopment Analysis and Stochastic Frontier Analysis methods as tools to build useful indicators for the benchmarking of universities and research centers, avoiding the limitations of using only one or a few Key Performance Indicators.

2 - Supporting External Assessors' Judgements on Secondary School Performance

Cláudia S. Sarrico, ISEG- School of Economics and Management, UTL - Technical University of Lisbon, Rua Miguel Lupi n^o 20 - Office 310, 1249-078, Lisboa, Portugal, cssarrico@iseg.utl.pt, *Margarida F. Cardoso*, *Maria J. Rosa*

This paper uses parametric and non-parametric techniques to assess the performance of secondary schools in Portugal. Schools are classified using a typology based on a matrix of measured performance vs perceived performance. Schools' performance is to some extent dependent on variables not under the control of the school, such as pupils' prior attainment, and socioeconomic background. However, taking those into account, it is found that schools' performance varies considerably and that there is significant room for improvement. The results are used to inform external assessors' judgements.

3 - Technical Efficiency and Productivity among Swedish Higher Education Institutions

Christian Andersson, Swedish National Audit Office (SNAO), Nybrogatan 55, 11490, Stockholm, Sweden, christian.andersson@riksrevisionen.se, *Jesper Antelius*, *Månsson Jonas*, *Krister Sund*

We study technical efficiency and productivity among Swedish higher education institutions (HEI's). Efficiency and productivity are computed using a DEA-framework. Our results indicate an average inefficiency of 7% and a productivity increase of around 2%. The analysis reveals that HEI's with large proportions of on—campus program students have high efficiency. HEI's with a large proportion of students enrolled in distance education are more likely to be inefficient. Our results show that highly specialized HEI's are more efficient than HEI's that cover many academic disciplines.

4 - Efficiency Assessment of Education Faculties

Erhan Berk, Defence Science, Hava Duragi Lojmanlari 4.Blok Daire:1, 06790, Ankara, Turkey, erhanberk@hotmail.com, *Diyar Akay*

Today, the development level of a country is measured with the investments made on human resources, and the biggest among them is education. Even education is in the every phase of the life, elementary education is the utmost important since it is the initial step in the education; and for that reason elementary school teachers have great responsibility. In this study, efficiency assessment of education faculties in Turkey is performed by analyzing the data, related to 2010, collected from 56 education faculties located in Turkey. The assessments are made using six different models.

■ TA-19

Tuesday, 9:00-10:30
Meeting Room 216

Attracting and Retaining Students in OR Programs

Stream: Education and Operations Research
Invited session

Chair: *Maseka Lesaoana*, Statistics and Operations Research Dept., University of Limpopo, Private Bag X1106, Sovenga, 0727, Polokwane, Limpopo Province, South Africa, maseka.lesaoana@ul.ac.za

1 - OR in High Schools — New MINDSET for Teaching Mathematics

Kenneth Chelst, Industrial and Manufacturing Engineering, Wayne State University, 4815 Fourth St., Room #2149, 48202, Detroit, MI, United States, kchelst@wayne.edu, *Thomas Edwards*

Project MINDSET has developed and implemented a full year high school mathematics curriculum based on OR. The curriculum and textbook are being piloted in several dozen high school classrooms. We explore how this curriculum requires a fundamentally different mindset for teaching math in high schools. It presents mathematics in real-world contexts to explore and discuss the robustness of decisions. It de-emphasizes the idea of finding the single right answer that is the core of traditional mathematics. We present a summary of the experiences of the first 1,000 students and their teachers.

2 - Operations Research at Historically Disadvantaged Institutions in South Africa with reference to the University of Limpopo

Maseka Lesaoana, Statistics and Operations Research Dept., University of Limpopo, Private Bag X1106, Sovenga, 0727, Polokwane, Limpopo Province, South Africa, maseka.lesaoana@ul.ac.za

In South Africa the development of OR and its applications have remained dominant among the "historically advantaged institutions". The aim of this paper is to establish reasons why the "historically disadvantaged institutions" in South Africa are invisible in the OR field. The most important recommendation made is collaborative programmes in OR across the country and beyond that will enable easy movement between universities.

■ TA-20

Tuesday, 9:00-10:30
Meeting Room 217

Soft OR IV

Stream: Soft OR and Problem Structuring
Invited session

Chair: *John Yearwood*, School of InformationTechnology and Mathematical Sciences, University of Ballarat, Univerity Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, j.yearwood@ballarat.edu.au

1 - The Evolution of Knowledge Representations over the Course of an Operations Research Study

Cherylne Fleming, DSTO, 2600, Canberra, Australia, cherylne.fleming@dsto.defence.gov.au, *Lydia Byrne*

An Operations Research (OR) study goes through a number of stages in its life-time. This evolution can be likened to the development knowledge in a scientific domain following the discovery of a new phenomenon. Such developments have long been accomplished through the use of representations of information and data that evolve in type and content as understanding of the phenomena develops. This paper argues that, like scientific studies of new phenomena, OR studies should leverage the science of knowledge representation development to construct tailored knowledge representations that evolve as the study progresses.

2 - An Approach to the Decomposition of Large-scale Stochastic Scheduling Problems

Geoff Robinson, Mathematics, Informatics and Statistics, CSIRO, 3168, Melbourne, VIC, Australia, Geoff.Robinson@csiro.au, *Andreas Ernst*, *Gaurav Singh*

We consider problems that arise in scheduling of various activities in the entire coal industry of Bowen Basin. This includes scheduling of trains, stackers, reclaimers and ships. We also assume that the duration of these activities is stochastic. We present an approach to decomposing such problems into subproblems based on a single computational procedure for evaluation of plans. Options (such as the order of berthing ships at a wharf) for decision variables can be evaluated by fleshing them out into detailed plans and then evaluating those detailed plans.

3 - Features of Aggregation Feedback for Individuals Engaged in Problem Solving within a Reasoning Community

John Yearwood, School of InformationTechnology and Mathematical Sciences, University of Ballarat, Univerity Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, j.yearwood@ballarat.edu.au, *Andrew Stranieri*

Reasoning for most practical problem solving involves communicative exchanges of assertions within participants in a community we call a reasoning community. The feedback individuals in a reasoning community receive can include forms of aggregation of individual views ranging from numerical preference schemes to structured representations such as argument schemes. We draw on reasoning communities in water management and law to illustrate that the type of aggregation that enhances reasoning depends on features of the community including the decision making and communication protocols adopted.

■ TA-21

Tuesday, 9:00-10:30
Meeting Room 218

Airline Scheduling

Stream: Airline Applications
Invited session

Chair: *Francois Soumis*, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca

1 - Introducing Competition in Airline Schedule Development

Luis Cadarso, Matemática Aplicada y Estadística, Universidad Politécnica de Madrid, Pz. Cardenal Cisneros, 3, 28040, Madrid, Spain, luis.cadarso@upm.es, *Ángel Marín*

The airline schedule design and fleet assignment problems consist of determining departure time and fleet type for each flight. We propose an integrated approach to design flight legs accounting for fleet assignment and market competition, providing robust itineraries. As we are designing the timetable, we focus on providing smooth connections to passengers so as to avoid misconnections. The introduction of competition leads us to a mixed integer nonlinear program. We solve it using Taylor's series approach to the competition. An application of the model for IBERIA's network is shown.

2 - Using Network Optimisation to Solve a Vehicle Scheduling Problem

Juan José Salazar González, Estadística e Investigación Operativa, Universidad de La Laguna (Tenerife), Av. Astrofísico Francisco Sánchez, s/n, Facultad de Matemáticas, 38271, La Laguna, Tenerife, Spain, jjsalaza@ull.es

"Binter Canarias" is a private regional air transport group with 19 aircrafts ATR 72 and more than 1000 employees flying close to 150 daily flights on average. The airline operates in eight Canary airports and supports routes with Northern Africa and Madeira. The operations management is critical to the business because Binter Canarias operates very short flights of 30 minutes flight time on average. In this paper we present, model and solve the vehicle-and-crew schedulling problem of the airline through network optimisation techniques.

3 - A Column Generation Formulation for the Integrated Aircraft Routing, Crew Pairing, and Tail Assignment Problem

Sebastian Ruther, University of Newcastle, Australia, Sebastian.Ruther@uon.edu.au, *Natashia Boland*, *Faramroze Engineer*, *Ian Evans*

A common problem when integrating airline planning stages is the long planning horizon of the crew pairing problem. We propose an approach in which crews initially are only told when they work. This enables us to generate an overall schedule much closer to the start of the planning horizon. Therefore, along with a short planning horizon, more detailed and accurate schedules can be generated. We propose a model based on the Branch-and-Price method where both the aircraft routing and crew pairing problems are formulated as subproblems. We present results for small and medium size instances.

4 - Integrated Crew Pairing and Assignment by Column Generation and Dynamic Constraint Aggregation

Francois Soumis, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca, *Mohammed Saddoune*, *Issmail Elhallaoui*, *Guy Desaulniers*

The crew scheduling problem is commonly decomposed into two stages which are solved sequentially. Crew pairing generates a set of pairings covering all flight legs. Crew assignment generates anonymous blocks covering all pairings. The simultaneous problem generates a set of blocks covering all flight legs. It is a large set covering problem highly degenerated. We combine the column generation and the dynamic constraint aggregation methods to solve it and save 5% on real-life problems. We will also present the extension to the personalized case where the blocks of pilots and co-pilots are different but the pairings need to be the same for robustness.

Tuesday, 11:00-12:30

■ TB-01

Tuesday, 11:00-12:30
Plenary Hall 3

IFORS Survey on OR Practice 2

Stream: OR Practice
Invited session

Chair: *John Ranyard*, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

1 - OR Practice in the Philippines

Elise del Rosario, ORSP, 14A Cyber One, 11 Eastwood Ave., Bagumbayan, 1110, Quezon City, Philippines, elise@jgdelrosario.com

OR practice has a definite presence in the Philippines but it is not widespread in the business community, with Internal OR consultants in less than 10 companies. Size of group, experience and training of analysts, barriers to the use of OR, OR techniques and software used will be given. Companies without in-house OR relegate quantitative analysis to engineering, corporate planning and management services departments. External consulting firms do not ordinarily use OR methodologies, whereas academic consultants do. OR applications cover long-range to operational decisions, in the areas of logistics, facilities, manpower, service operations planning, risk management and marketing. The most used tool reported is spreadsheet modelling. The Philippine OR community is tightly knit and practitioners, from a diversity of industries, are members of the national OR society, which aims to link academe with practice. Whilst some OR groups have disbanded, others have formed, and so the size of the OR community has stayed around the same level.

2 - OR Practice in South Africa

Hans W. Ittmann, CSIR Built Environment, P O Box 395, 0001, Pretoria, South Africa, hittmann@csir.co.za

IFORS commissioned a survey of OR practice in member countries. A number of OR practitioners in South Africa also responded. In this talk the results from the survey will be presented. In addition further background will be given to the practice and use of OR in the country as well as where the major challenges lie. The OR society in South Africa organises an annual conference and publishes it own journal bi-annually. Information from these sources will be used to supplement the results from the IFORS survey.

3 - OR Practice in Australia and New Zealand

Simon Dunstall, Mathematics, Informatics and Statistics, CSIRO, Private Bag 33, 3169, South Clayton, Victoria, Australia, Simon.Dunstall@csiro.au, *Baikunth Nath*, *Andrew J Mason*

The survey findings for the two countries will be summarised and key features of OR practice will be described. Several organisations in both countries have strong OR teams, some of which have received international acclaim e.g. via the INFORMS Edelman competition. Some challenges facing the OR practice communities will be outlined.

■ TB-02

Tuesday, 11:00-12:30
Meeting Room 101

Game Theory Applications in Economics I

Stream: Game Theory
Invited session

Chair: *Andrea Mantovani*, Department of Economics, University of Bologna, Strada Maggiore 45, 40125, Bologna, Italy, a.mantovani@unibo.it

1 - The Use of Genetic Algorithm into the Marketing Equilibrium Analysis

Gülfem Isiklar Alptekin, Computer Engineering, Galatasaray University, Turkey, gisiklar@gsu.edu.tr

An electronic book will be considered as the digital version of a traditional printed book to be read digitally on a PC, PDA or a dedicated e-book reader.In this paper, a strategic market analysis framework in a publishing market is proposed in the presence of multiple competing publishers.The proposed publishing market consists of p-publishers that try to decide on whether or not switch to e-publishing.The framework computes the unit prices, and profits of the publishers in each market scenario.

2 - Leader-follower Optimization in Product Design

Gang Du, School of Management, Tianjin University, 300072, Tianjin, China, tddg@tju.edu.cn, *Yan Li*, *Yi Xia*

Based on the summarize of the problems of leader-follower optimization in product design, the types and the decision systems are proposed in this paper. The models and the methods are discussed which involved Stackelberg Games and engineering optimization methods. Furthermore the product family and complex product optimization problems are discussed.

3 - The Welfare Effects of Horizontal Mergers in Markets with Negative Welfare Effects

Andrea Mantovani, Department of Economics, University of Bologna, Strada Maggiore 45, 40125, Bologna, Italy, a.mantovani@unibo.it, *Luca Lambertini*

We model horizontal mergers in a differential Cournot game with pollution, obtaining an admittedly provocative result. Given that the externality increases in industry output, it turns out that any horizontal merger poses a tradeoff between the increase in concentration and the external effect. We single out the size of the horizontal merger beyond which the reduction in the externality more than compensate the price increase. Additionally, we calculate the level of Pigouvian taxation that would reproduce exactly the same welfare effect of such a merger.

■ TB-03

Tuesday, 11:00-12:30
Meeting Room 102

Modern Heuristics in Transportation

Stream: Meta-heuristics
Invited session

Chair: *Ana Costa*, Civil Engineering Dept., University of Coimbra, Rua Luís Reis Santos, Polo II da UC, 3030 - 788, Coimbra, Portugal, alcosta@dec.uc.pt

1 - Passenger and Pilot Risk Minimization in Offshore Helicopter Transportation

Fubin Qian, Molde University College, Fannestrandveien 76, 6416, Molde, Norway, fubin.qian@himolde.no, *Irina Gribkovskaia*, *Gilbert Laporte*, *Oyvind Halskau*

In the offshore petroleum industry, employees are transported to and from the offshore installations by helicopter, which represents a major risk. This paper analyzes how to improve transportation safety by solving the helicopter routing problem with an objective expressed in terms of expected number of fatalities. A mathematical model is proposed and a tabu search heuristic is applied to this problem. Three routing policies are considered: a direct service policy, a Hamiltonian solution policy, and a general solution policy.Extensive computational experiments are conducted.

2 - Efficient Metaheuristics for Intermodal Terminal Location

Kenneth Sörensen, Faculteit Toegepaste Economische Wetenschappen, Universiteit Antwerpen, Prinsstraat 13, 2000, Antwerpen, Belgium, kenneth.sorensen@ua.ac.be, *Christine Vanovermeire*

Determining the optimal number and location of intermodal transshipment terminals is a decision that strongly influences the viability of the intermodal transportation alternative. In this talk, we discuss a model and two different metaheuristic procedures to solve it. The first metaheuristic constructs solutions using a GRASP procedure, the second one uses the relatively unknown Attribute Based Hill Climber (ABHC) heuristic. Innovative in our approach is the integration of a fast heuristic procedure to approximate the total cost given the set of open terminals.

3 - Addressing a Last Mile Transportation Problem

Kwong Meng Teo, Industrial & Systems Engineering, National University of Singapore, Singapore, kwongmeng@alum.mit.edu, *Viet Anh Nguyen*

Mobility-on-demand can improve urban transportation by removing commuters from the system more quickly while reducing vehicles on the road. We study a system of delivering passengers from a transportation hub to their individual destinations, or the Last Mile Problem. We extend a heuristics-based routing routine, which address the static problem in seconds, to (i) accept first-mile commuters, (ii) handle practical exceptions such as unanticipated spike in demand and weather-related delays, and (iii) handle the dynamic problem, where each vehicle will make multiple deliveries from the hub.

4 - A Tool for High-speed Railway Alignment Optimization: Application to Case Studies of Increasing Complexity

Ana Costa, Civil Engineering Dept., University of Coimbra, Rua Luís Reis Santos, Polo II da UC, 3030 - 788, Coimbra, Portugal, alcosta@dec.uc.pt, *Maria Cunha*, *Paulo Coelho*, *Herbert Einstein*

Planning of High-Speed Railways must consider multiple and uncertain future conditions under which to perform (e.g. floodings, earthquakes). Options in corridors and technical solutions to adopt exist and different solutions may yield different overall performance. This paper discusses a systematic tool developed to address this specific problem. The Simulated Annealing Algorithm (SAA) is implemented to solve the alignment optimization model. Applications to case studies of increasing complexity and size are presented. The estimation of the SAA parameter combination yielding the best results and the influence of the problem specifics in the process are discussed.

■ TB-04

Tuesday, 11:00-12:30
Meeting Room 103

New Directions in Operations Management

Stream: Operations Management
Invited session

Chair: *Ronald Askin*, Arizona State University, 85287, Tempe, AZ, United States, ron.askin@asu.edu

1 - Qualification Management for Semiconductor Assembly and Test Facilities

Ronald Askin, Industrial Engineering, Arizona State University, Computing, Informatics and Dec. Systems Engineering, PO Box 8809, 85287-8809, Tempe, AZ, United States, ron.askin@asu.edu, *John Fowler*, *Mengying Fu*, *Muhong Zhang*

We consider a multiproduct flexible flow system with parallel machines at each stage. Machine qualification is necessary prior to utilizing a specific machine for a product. Qualification consumes valuable production and engineering time but increases flexibility that is useful for accommodating random, bulk demands. In this talk we provide deterministic and stochastic models to optimize qualification decisions and implement these models in a user-friendly system.

2 - Effect of Retailer and Consumer Stockpiling on Pass-Through of Manufacturer's Discounts

Candace Yano, University of California, Berkeley, United States, yano@ieor.berkeley.edu, *Huanhuan Qi*

Empirical studies indicate that when manufacturers offer discounts to retailers, retailers rarely pass on the full amount of the discount to customers. We study a scenario in which retailers stockpile inventory in response to manufacturer-offered discounts and customers stockpile in response to retailer-offered discounts. We characterize the retailer's optimal discounting and ordering policy and the manufacturer's optimal discounting strategy in view of the retailer's response to it, and the customer's response to the retailer's strategy.

3 - Evolution of Manufacturing Systems: A Model Based View

John Buzacott, Schulich Business School, York University, 203-955 Millwood Road, M4G 4E3, Toronto, Ontario, Canada, jbuzacot@schulich.yorku.ca

Mathematical models are used to explain why manufacturing systems evolved as they did over the last 300 years. I begin with the motives for the factory system, then move to the introduction of flow lines, the survival of batch production systems, the advent of moving belt assembly lines, transfer lines, group technology, flexible manufacturing systems and the Toyota sewing system. The talk will show how system improvement arose from an understanding of both variability and its sources and the characteristics of workers and machines. Some current challenges will be discussed.

■ TB-05

Tuesday, 11:00-12:30
Meeting Room 104

Marketing/Operations II

Stream: OR and Marketing
Invited session

Chair: *Rick So*, UC Irvine, 92697, Irvine, CA, United States, rso@uci.edu

Chair: *Kumar Rajaram*, UCLA Anderson School, 100 Westwood Plaza, 90095, Los Angeles, CA, United States, krajaram@anderson.ucla.edu

1 - Distribution Planning to Optimize Profits in the Motion Picture Industry

Kumar Rajaram, UCLA Anderson School, 100 Westwood Plaza, 90095, Los Angeles, CA, United States, krajaram@anderson.ucla.edu

We consider the distribution planning problem in the motion picture industry. This problem involves forecasting theater-level box office revenues for a given movie and using these forecasts to choose the best locations to screen a movie. We develop and test our methods on realistic box office data and show that it has the potential to significantly improve the distributor's profits. We also develop some insights into why our methods outperform existing practice, which are crucial to their successful practical implementation.

2 - Supply Chain Models with Preferred Retailer Privy to Supplier's Inventory Information

Hamed Mamani, Dept of Information Systems and Operations Management, University of Washington, Foster School of Business, 98195, Seattle, WA, United States, hmamani@u.washington.edu, *Kamran Moinzadeh*, *Apurva Jain*

In a supply chain consisting of a supplier and several retailers, some of the retailers have preferred status, providing them with information about the supplier's inventory level. Such status can be due to strategic behavior of retailers and learning the supplier's replenishment policy. Preferred retailers, thus, can be proactive and inflate their orders when supply gets short. We study the dynamics of such supply chains as a Stackelberg game where retailers react after the supplier has fixed his strategy. We evaluate outcome of the resulting game with solution of the centralized problem.

3 - The Planning of Guaranteed Targeted Display Advertising

John Turner, Paul Merage School of Business, UC-Irvine, 92697, Irvine, CA, United States, john.turner@uci.edu

Ad networks increasingly strive to apply planning models to broad classes of targeted display advertising, including banner ads, in-game advertising, and digital TV ads. We formulate a broadly-applicable ad planning problem as a quadratic transportation problem, and show that the quadratic objective is a good surrogate for several important performance metrics. Moreover, we exploit the quadratic objective and develop two complimentary algorithms which intelligently aggregate the audience space in a manner that dramatically reduces problem size while obtaining near-optimal solutions.

4 - Diffusions of Mobile Cellular Phones in Sub Sahara Africa

Chaiho Kim, OMIS Department, Santa Clara University, 500 El Camino Read, 95070, Santa Clara, CA, United States, ckim@scu.edu

It is widely believed that mobile phones will play critically important roles for economic developments of countries in Sub Sahara Africa. Using statistical models, this paper will examine how the diffusions of mobile phones in Sub Sahara Africa are related to economic, cultural, and other variables such as different geographical regions. The paper will also examine whether the relations found for the mobile phones are significant different from those found for the main fixed phone lines.

■ TB-06

Tuesday, 11:00-12:30
Meeting Room 105

Routing Problems :Innovative Applications and Solution Techniques

Stream: Transportation
Invited session

Chair: *Pierre Dejax*, IRCCyN, Ecole des Mines de Nantes, La Chantrerie, 4, rue Alfred Kastler, BP 20722, 44307, Nantes cedex 3, France, Pierre.Dejax@emn.fr

1 - The Split Delivery Capacitated Team Orienteering Problem

M. Grazia Speranza, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it, *Claudia Archetti*, *Nicola Bianchessi*, *Alain Hertz*

We study the capacitated team orienteering problem with split deliveries. Potential customers are associated with a demand and a profit. The customers to be served by a fleet of capacitated vehicles have to be identified to maximize the collected profit, with constraints on the maximum time duration of each route and the vehicle capacity constraints. We show that the profit collected by allowing split deliveries may be as large as twice the profit collected without split deliveries. We present exact and heuristic algorithms and test the proposed approaches on several sets of instances.

2 - Flexible Buses for Manhattan

Felisa Vazquez-Abad, Computer Science Dept., City University New York, 695 Park Ave, Room HN1000E, 10065, New York, United States, felisav@hunter.cuny.edu, *Jennie Lioris*, *Guy Cohen*

Few privately owned cars circulate in Manhattan, yet the traffic congestion has become a serious problem. People with limited mobility and senior citizens avoid subways, cannot afford taxis and face excessive delays travelling by bus. We explore an alternative formulation where cars adjust their routes on demand, but may take several passengers. Pilot studies in Paris show that this system can achieve 80% occupation rate, instead of the 60% idle taxis roaming the streets today. We will present online routing allocation algorithms that use threshold optimization under different pricing models.

3 - Enhanced Variable Neighborhood Search for Multi- Period Inventory Routing Problem Model with Time Varying Demand

Noor Hasnah Moin, Institute of Mathematical Sciences, University of Malaya, 50603, Kuala Lumpur, Malaysia, noor_hasnah@um.edu.my

We consider a multi-period Inventory Routing Problem (IRP) that faces time varying demand of multi-product from the assembly plant, in a many-to-one distribution network consisting of an assembly plant and many geographically dispersed suppliers each supplying a distinct product to the plant. The product is ready for collection when the vehicle arrives and all demand must be met without backlogging. The inventory holding cost is product specific and a fleet of capacitated homogeneous vehicles transport products from the suppliers to meet the demand of the plant in each period. The problem is formulated as a mixed integer programming problem. We propose a solution method based on the Variable Neighborhood Search where several heuristics are incorporated at various stages of the algorithm. The algorithms are run on several problems from the literature and the results are compared with the Genetic Algorithms. VNS performs better on larger problems.

4 - Robust Scenario Generation for a Real Large-Scale Inventory Routing Problem

Pierre Dejax, IRCCyN, Ecole des Mines de Nantes, La Chantrerie, 4, rue Alfred Kastler, BP 20722, 44307, Nantes

cedex 3, France, Pierre.Dejax@emn.fr, *Hugues Dubedout*, *Thomas Yeung*

Real-life IRPs are often subject to uncertainties such as customer demand and supply disruption. In order to deal with these uncertainties, robust solutions are often proposed. To that aim, we propose a methodology consisting of the 1. scenario generation to model the uncertainties, 2. obtaining robust IRP solutions from custom heuristics, and 3. evaluation of the impact of the different uncertainties on the robust solutions. This methodology was tested on both simulated test-cases and real-life problems as encountered in cryogenic gas distribution at Air Liquide.

■ TB-07

Tuesday, 11:00-12:30
Meeting Room 106

Discrete Optimisation

Stream: Discrete Optimisation
Invited session

Chair: *François Vanderbeck*, Institut de Mathématiques de Bordeaux, Université Bordeaux1 & INRIA Bordeaux, 351 cours de la Libération, F-33405, Talence- CEDEX, France, fv@math.u-bordeaux1.fr

1 - Bi-dynamic Constraint Aggregation and Subproblem Reduction for Crew Pairing Problem

Francois Soumis, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca, *Mohammed Saddoune*, *Issmail Elhallaoui*, *Guy Desaulniers*

Bi-dynamic constraint aggregation is a new approach introduced to speed up the column generation method when solving degenerate set partitionig problems. The agregation profits from degeneracy to reduce the size of the master problem. The subproblems reduction eliminates arcs with less promising marginal costs. This reduces significantly the number of column generation iterations when we start from a good heuristic solution. These reductions lead to big savings in solution time. Tests on some hard real life crew pairing problems will be presented with the trivial initial solution: "follow the aircraft" and with an initial solution obtained with a linear programing approximation.

2 - Large Sized Extended Formulations for Routing and Scheduling Problems

Eduardo Uchoa, Engenharia de Produção, Universidade Federal Fluminense, Rua Passo da Pátria 156, São Domingos, 22430-210, Niterói, Rio de Janeiro, Brazil, uchoa@producao.uff.br, *Artur Pessoa*, *Marcus Poggi de Aragão*, *Rosiane de Freitas Rodrigues*, *Lorenza Moreno*

We present an extended formulation that allow viewing and parallel machine scheduling and capacitated vehicle routing problems in a very similar way: the machines correspond to the vehicles, jobs to the clients, and the processing times to client demands. This means that known VRP cuts can be effectively used in those scheduling problems and vice versa. However, the pseudo-polynomially large size of the formulation requires a sophisticated branch-cut-and-price implementation. Computational results show good results in comparison with other known methods

3 - Using the Cost Splitting Dual for Multiple Resource Constrained Shortest Path Problems

Olivia Smith, Mathematics and Statistics, University of Melbourne, 3052, Parkville, Vic, Australia, livsmith21@gmail.com, *Natashia Boland*

Shortest path problems with a single resource constraint are much easier to solve than problems where there are many resource constraints. This makes decomposition approaches attractive as they can exploit the easier problem structure. We explore a reformulation in which we define a set of variables for each resource with extra constraints enforcing the equality of these variables. Relaxing these constraints in a Lagrangean fashion leads to a dual known as the Cost Splitting Dual. We investigate the use of this dual to assist in preprocessing and solving the multiple resource problem.

4 - Numerical Experiments with Column Generation for Extended Formulations

François Vanderbeck, Institut de Mathématiques de Bordeaux, Université Bordeaux1 & INRIA Bordeaux, 351 cours de la Libération, F-33405, Talence- CEDEX, France, fv@math.u-bordeaux1.fr

Extended formulations for integer programs are often tight but too large for a direct treatment. When they stem from a decomposition principle, a hybrid column generation procedure applies that mimics that for the Dantzig-Wolfe reformulation. Pricing subproblem solutions can be expressed in the extended space and added to the current restricted formulation along constraints that become active. Such “column-and-row generation” has a comparative advantage over standard column generation: in the extended space, subproblem solutions can be recombined resulting in faster convergence.

■ TB-08

Tuesday, 11:00-12:30
Meeting Room 107

Health Care Operations II

Stream: Service & Health Care Operations
Invited session

Chair: *Karen Smilowitz*, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Technological Institute M233, 60208-3119, Evanston, Illinois, United States, ksmilowitz@northwestern.edu

1 - Improving Access to Community-based Chronic Care through Improved Capacity Allocation

Karen Smilowitz, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Technological Institute M233, 60208-3119, Evanston, Illinois, United States, ksmilowitz@northwestern.edu, *Sarang Deo*, *Seyed Iravani*

Most health care operation models focus either on efficiency improvements in the delivery system or improvements in clinical decisions. We consider a novel setting of community-based delivery of chronic asthma care, where it is necessary to integrate these two approaches. We develop and analyze a joint disease progression and capacity allocation model to investigate how operational decisions can improve population level health outcomes. We test our findings using data provided by Mobile C.A.R.E, a community-based provider of asthma care to public school students in Chicago.

2 - Role of Flexibility in Managing Operating Room Resources in Hospitals

Kannan Sethuraman, Melbourne Business School, 3441 Woodcliff Road, Melbourne, Australia, K.Sethuraman@mbs.edu, *Devanath Tirupati*

We examine the role of flexibility in managing operating room resources in a tertiary hospital providing elective surgeries in a variety of specialties. We consider two kinds of flexibility and develop a queueing theoretic stochastic model based on approximations that is useful for a preliminary analysis to assess the impact of alternative strategies. The analytic model is complemented by a simulation model to provide detailed performance evaluation. Managerial insights are derived from computational results based on representative data from a real life case study.

3 - Drivers of Excellence in Veterans' Administration Clinics

Subramaniam Ramanarayanan, Anderson School of Management, UCLA, 90403, Los Angeles, CA, United States, subbu@anderson.ucla.edu, *Kumar Rajaram*

Although there is clear consensus about a demonstrable need for improvement of outcomes such as access, wait times and quality in healthcare, there is little clarity about how this might be achieved. While there is a significant amount of research focused on the impact of external structural forces on outcomes, our understanding of the importance of various intra-organizational characteristics in determining outcomes is still fairly limited. We address this research gap by focusing on the structural determinants of outcomes in a sample of Veteran's Administration Clinics in the US.

■ TB-09

Tuesday, 11:00-12:30
Meeting Room 108

Meta-heuristic Approaches to Vehicle Routing

Stream: Vehicle Routing
Invited session

Chair: *Bülent Çatay*, Faculty of Eng. & Natural Sciences, Sabanci University, Tuzla, 34956, Istanbul, Turkey, catay@sabanciuniv.edu

Chair: *Louis-Martin Rousseau*, Mathematics and Industrial Engineering, École Polytechnique de Montréal, CP6079 succ centre-ville, H3C 3A7, Montreal, QC, Canada, louism@crt.umontreal.ca

1 - Optimizing Cash Delivery Operations for Bantas Using Tabu Search: A Case Study

Burcin Bozkaya, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, bbozkaya@sabanciuniv.edu, *Alper Erdemir*

Bantas A.S., a company formed as a joint venture of 3 major banks in Turkey, must deliver cash everyday to more than 1200 branches and ATMs in Turkey, using a fleet of 120+ vehicles. The solution we implemented at Bantas utilizes ArcLogistics, a commercial route optimization software built on Tabu Search heuristic optimization principles. We describe details of this implementation along with an overview of the meta-heuristic used and some numerical results. We also describe the integration of this system with a vehicle tracking application that allows comparison of planned vs. actual routes.

2 - Solving Bakery Distribution Planning Problem Using a Genetic Algorithm

Timur Keskinturk, School of Business, University of Istanbul, Turkey, tkturk2010@gmail.com, *Mehmet Bayram Yildirim*

In this paper, we analyze a distribution problem at a bakery company. This bakery utilizes its own truck fleet to deliver different types of breads to serve grocery stores in a large metropolitan area. Problem is modeled as a variation of a capacitated vehicle routing problem with time windows. To obtain good quality solutions in a reasonable amount of time, a genetic algorithm with a two exchange improvement local search heuristic is proposed. The proposed algorithm which improves the bakery's distribution significantly is also tested on several problems.

3 - Route Optimization for Mobile Phone Distribution and Repair Service

Vincent F. Yu, Department of Industrial Management, National Taiwan University of Science and Technology, 43, Sec. 4, Keelung Rd., 106, Taipei, Taiwan, vincent@mail.ntust.edu.tw, *Shan-Huen Huang*, *Tirza Naftali*, *Hsiu-I Ting*

Mobile phone distributors dispatch vehicles from several distribution centers (DCs) to service points to deliver new phones, parts, and repaired products, and pick up recycled phones and repair orders. Under such distribution mode, it is important to appropriately select the location of DCs and plan vehicle routes to minimize the total distribution cost. We formulate the problem as the location routing problem with simultaneous pickup and delivery problem (LRPSPD). A mathematical programming model and a heuristic based on genetic algorithm are developed for solving the LRPSPD.

4 - Metaheuristics for an Oil Delivery Vehicle Routing Problem

Louis-Martin Rousseau, Mathematics and Industrial Engineering, École Polytechnique de Montréal, CP6079 succ centre-ville, H3C 3A7, Montreal, QC, Canada, louism@crt.umontreal.ca, *Guy Desaulniers*, *Eric Prescott-Gagnon*

Companies distributing heating oil typically solve vehicle routing problems on a daily basis. Their problems may involve various features such as a heterogeneous vehicle fleet, multiple depots, intra-route replenishments, time windows, driver shifts and optional customers. In this paper, we consider such a rich vehicle routing problem that arises in practice and develop three metaheuristics to address it, namely, a tabu search (ts) algorithm, a large neighborhood search (lns) heuristic based on this ts heuristic and another lns heuristic based on a column generation (cg) heuristic. Computational results obtained on instances derived from a real dataset indicate that the lns methods outperform the ts heuristic. Furthermore, the lns method based on cg tends to produce better quality results than the ts-based lns heuristic, especially when sufficient computational time is available.

■ TB-10

Tuesday, 11:00-12:30
Meeting Room 111

Railway Applications I

Stream: Public Transit
Invited session

Chair: *Dennis Huisman*, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl

1 - Passenger Oriented Disruption Management: the Value of Smart Card Data

Evelien Van der Hurk, Erasmus University, NL-3000 DR, Rotterdam, Netherlands, EHurk@rsm.nl

In disruption management the emphasis is shifting from rescheduling resources (rolling stock and crew) to passenger service. For passenger oriented disruption management, information is needed on passengers' movements, destination and behavior during a disruption. Our case study shows that smart card data provides this information. The value of smart card data for disruption management is twofold. We can better predict passenger flows and thus the seat demand during a disruption. Also, it can be used for estimating passenger delays and for evaluating the disruption management strategy.

2 - Passenger Oriented Disruption Management by Adapting Stopping Patterns & Rolling Stock Schedules

Lucas Veelenturf, Department of Decision and Information Sciences, Rotterdam School of Management, Erasmus University, Postbus 1738, NL-3000 DR, Rotterdam, Netherlands, LVeelenturf@rsm.nl, *Gabor Maroti*, *Leo Kroon*

Often unforeseen disruptions require railway operators to quickly adjust the timetable and resource schedules, and passengers to adapt their routes to their destinations. The railway operator has to take the changed passenger behavior into account. Next to increasing capacities of trains for which the operator expects more demand it may be useful to operate additional trains or to adapt stopping patterns, e.g. intercity trains also dwell at regional stations. In this research we construct a passenger oriented rolling stock rescheduling approach which integrates such stopping pattern decisions.

3 - Minimization of Delay Propagation in Multi-area Railway Traffic Control

Dario Pacciarelli, Dipartimento di Informatica e Automazione, Università Roma Tre, via della vasca navale, 79, 00146, Roma, Italy, pacciarelli@dia.uniroma3.it, *Francesco Corman*, *Andrea D'Ariano*, *Marco Pranzo*

Optimization of multi-area railway traffic control is a bilevel programming problem in which a coordinator imposes constraints at the border of several dispatching areas. Each area is controlled by a dispatcher which reschedules trains by minimizing delays in its area. The coordinator objective is to attain global feasibility and optimality of the decisions taken by all dispatchers. We present a branch and bound procedure for the coordinator problem that has been tested on a large real railway network in the Netherlands with busy traffic conditions. Experimental results are very promising.

4 - Mathematical Model Analyses for the Optimal Railway Track Maintenance Strategy with Consideration on Risk for Derailment Accident

Masashi Miwa, Track Management, Railway Technical Research Institute, 2-8-38 Hikari-cho Kokubunji-shi, 185-8540, Kokubunji, Tokyo, Japan, miwa@rtri.or.jp, *Tatsuo Oyama*

This paper aims at investigating an optimal railway track maintenance strategy for minimizing total cost by taking both track tamping cost and risk for derailment accident into account. Firstly, we develop an mathematical programming model for obtaining the optimal railway track maintenance plan. Next, we develop a mathematical model to estimate the risk for derailment accident to be caused by large track irregularities. Finally, by applying these models to actual railway data, we obtain the optimal maintenance strategy including range of surface irregularities to maintain.

■ TB-11

Tuesday, 11:00-12:30
Meeting Room 112

Modeling of Military Systems

Stream: Simulation - Sponsored by I-SIM
Invited session

Chair: *Raymond Hill*, Operational Sciences, Air Force Institute of Tech, 2950 Hobson Way, AFIT/ENS Bld 641 Suite 201, 45433-7765, WPAFB, OH, United States, raymond.hill@afit.edu

1 - Filling in the Past—A Simulation Modelling Technique to Assess the Ability of a Patrol Boat Fleet to Deliver Presence.

Timothy Surendonk, Defence Science and Technology Organisation, PO Box 44, 2009, Pyrmont, NSW, Australia, Timothy.Surendonk@dsto.defence.gov.au, *Peter Taylor*

Patrol boat fleet effectiveness can be measured by how well it maintains a presence in specified patrol areas, given constraints on the frequency of port visits for supplies, maintenance and crew refreshment. This paper describes a novel framework where simulation and optimisation are attacked at the same time. A range of possible 'virtual boat histories' are created and a heuristic choice is made of a good way to get boats into the right place at the right time. The paper shows how a combinatorial explosion can be contained and valuable insights into patrol fleet performance can be obtained.

2 - High Level Military Decision Analysis: Problems and approaches

Winnie Pelser, Defence Institute, Armscor, PO Box 38738, Garsfontein-East, 0060, Pretoria, Gauteng, South Africa, winniep@sadi.co.za

This presentation will illustrate the issues regarding Decision Making in the Military and the added issue of High Level or Strategic Decision Analysis.
The nature of decisions needed at high levels are not necessarily appropriate for the application of traditional "hard' OR methods. The availability of data at those levels is often not good. Individual or Service bias may also be an issue. This may have a detrimental influence for very important decisions. Is there a solution to this dilemma?
Possible methods or approaches that are effective and/or possible will be discussed.

3 - Simulation and Analysis of USAF Maintenance and Supply Processes for the B-1 Bomber

Jo Miller, Operational Sciences Dept., Air Force Institute of Technology, 2950 Hobson Way, 45433, WPAFB, OH, United States, john.miller@afit.edu

We discuss recent discrete event simulations for examining the aircraft maintenance and supply chain process for the B-1 bomber. Specific areas explored include High Velocity Maintenance (HVM) and core AF supply chain processes and their impacts on Total Non-Mission Capable [due to] Supply (TNMCS) rates

4 - Building a Model for Ballistic Impact Flash Simulation

Raymond Hill, Operational Sciences, Air Force Institute of Tech, 2950 Hobson Way, AFIT/ENS Bld 641 Suite 201, 45433-7765, WPAFB, OH, United States, raymond.hill@afit.edu

Fires onboard aircraft are leading mechanisms for mishaps and losses during peacetime and combat operations. Typical ignition sources causing fires onboard aircraft include electrical sparks and hot surfaces. However, impact and penetration of common threats encountered during combat operations, such as armor piercing incendiary projectiles and missile fragments, generate short-lived, but thermally-intense clouds (flashes) capable of igniting fires. Fire simulations supporting system-level survivability analyses depend on accurate characterization of these flash clouds. The Air Force Institute of Technology is developing empirical models that describe time-dependent flash cloud geometries given impact conditions. This research presents the modeling approach used to develop the deterministic boundary model representation of impact flashes and the overall approach coupling physics-based energy models with empirical-based boundary models to realize a simulation-based approach to the characterization of ballistic impact flashes. Potential use of these combined models in survivability simulations is discussed as well.

■ TB-12

Tuesday, 11:00-12:30
Meeting Room 205

Supply Chains and Auctions

Stream: Contributed Talks
Contributed session

Chair: *Xun Li*, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, malixun@inet.polyu.edu.hk

1 - A Study on Joint Replenishment Problem

Jing-An Li, MADIS, Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No. 55, Zhongguancun East Road, Haidian District, 100190, Beijing, China, ajli@amss.ac.cn

This paper studies the joint replenishment problem(JRP), the special case of the one-warehouse multi-retailer problem. First, we describe the characteristics of JRP. And based on this knowledge, we build models to analyze the joint replenishment policy. Especially, we study the power-of-two policy. Besides, we present an algorithm to calculate the joint replenishment policy.

2 - On Mixture of Centralized and Decentralized Supply Chains

Takamichi Hosoda, Aoyama Business School, Tokyo, Japan, taka.hosoda@gmail.com

A two-echelon supply chain consisting of two retailers and one manufacturer is established to consider the following setting. A retailer and the manufacturer form an order-smoothing scheme aiming to minimize the scheme wide predetermined cost function. The other retailer acts selfishly, as its only concern is minimizing its own cost. Under this context, a question put to the order-smoothing scheme is that how much the expected benefit is, if only one of two retailers is cooperative. We have addressed this question via the analytical method.

3 - Real options exchange and its impact on the supply chain management

Gang Hao, City University of Hong Kong, Dept of Management Sciences, Kowloon, Hong Kong, msghao@cityu.edu.hk

We propose an unprecedented study on real options exchange. Real options exchange has been a common practice in some large scale manufacturing and distribution systems, which, for example, accounts for about 15% sales in the auto industry. However, many issues are unexplored. By formulating a mixed Stackelberg and Nash-bargaining game, we examine the system of one of the world largest auto-manufacturers. We observe that, among other interesting findings, options exchange does not always benefit the manufacturer and the chain, and full disclosure of inventory benefits the retailers the most.

4 - Search-based Advertising Auctions with Choice-based Budget Constraint

Cheng Ma, Department of Applied Mathematics, The Hong Kong Polytechnic University, Kowloon, Hong Kong, mc_0812@163.com, *Tsan-Ming Choi*, *Xun Li*

We model and explore search-based advertising auction with multiple slots, advertiser choice behavior and the popular generalized second-price mechanism. A Lagrangian-based method is proposed for solving this problem. This method includes two phases: (1) subgradient algorithm phase; (2) column generation phase. We present an extension to the method in order to improve the dual multipliers and accelerate convergence. Simulation results show that the proposed model is efficient and it shows significant improvement compared to the greedy algorithm.

■ TB-13

Tuesday, 11:00-12:30
Meeting Room 206

Mathematical Programming VI

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Luciana Casacio*, FEEC, Unicamp, Rua João da Silva Martins, 1192, 13274320, Valinhos, São Paulo, Brazil, luciana@densis.fee.unicamp.br

1 - Convex Optimization in Sinusoidal Modeling for Audio Signal Processing

Michelle Daniels, University of California, San Diego, La Jolla, CA, United States, michelledaniels@ucsd.edu

Sinusoidal modeling is a method for analyzing digital audio signals in which a signal is decomposed into component sinusoids and residual noise. This work expands on an analysis process for building such a model which involves detecting and extracting sinusoids from the original signal. After identifying approximate frequency, magnitude, and phase for each sinusoid, parameters are optimized to minimize the energy in the residual. This problem is shown to be convex in magnitude and phase for known frequency. Results of the optimization are compared to non-optimized results and are promising.

2 - Robust Design Model for Quality Control in Supply Chain with Quality Prevention Uncertainty

Cuihua Zhang, Manaement Science and Engineering Dept., Northeastern University, School of Business Administration, China, chzhang@mail.neu.edu.cn

The robust operation of quality control in a multi-product, multi-stage supply chain consisting of a manufacturer and a buyer is studied. We develop an objective programming model. And the model is optimized consequently. The model guarantees coordination of supply chain operation, the maximum profit of the manufacturer and the buyer, and robustness under quality prevention uncertainty. The result of a numerical example shows that uncertainty of quality prevention to some extent cann't change the quality control strategy .

3 - Optimal Adjustment Algorithm for p Coordinates to Accelerate the Convergence of Interior Point Methods

Carla Ghidini, Computational & Applied Mathematics, State University Of Campinas, Campinas, São Paulo, Brazil, carla@ime.unicamp.br, *Aurelio Oliveira*, *Jair Silva*

Optimal adjustment algorithm for p coordinates is a generalization of the optimal pair adjustment algorithm for linear programming, which, in turn, is based on von Neumann's algorithm. Its main advantages are simplicity and fast initial convergence. To accelerate the convergence of the interior point method few iterations of the generalized algorithm are applied into the Mehrotra's heuristic to determine a good starting solution and in the transition between two preconditioners, since a hybrid preconditioner approach is used for solving the linear systems.

4 - On Hybrid Preconditioners for Large-scale Normal Equations Arising from Interior-point Methods

Luciana Casacio, FEEC, Unicamp, Rua João da Silva Martins, 1192, 13274320, Valinhos, São Paulo, Brazil, luciana@densis.fee.unicamp.br, *Aurelio Oliveira*, *Carla Ghidini*, *Christiano Lyra*

The hybrid approach for solving the linear systems arising from interior point methods uses two preconditioners. A generic one for the first iterations and a specially tailored one for the final iterations at the end. This work proposes new approaches for combining both preconditioners, designing new heuristics at the transition in order to solve large-scale linear programs still faster. Numerical experiments comparing with previous heuristics exhibit the good performance of the new approach.

■ TB-14

Tuesday, 11:00-12:30
Meeting Room 207

Memorial Session in Honour of Professor Alexander Rubinov

Stream: Continuous and Non-Smooth Optimization
Panel session

Chair: *Andrew Eberhard*, Mathematical and Geospatial Sciences Dept., RMIT University, GPO Box 2476V, 3001, Melbourne, Victoria, Australia, andy.eb@rmit.edu.au

Chair: *Regina Burachik*, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, 5095, Adelaide, South Australia, Australia, regina.burachik@unisa.edu.au

Chair: *Zari Dzalilov*, School of Information Technology and Mathematical Sciences, University of Ballarat, 1, University Drive, 3353, Ballarat, VIC, Australia, z.dzalilov@ballarat.edu.au

Chair: *Adil Bagirov*, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

Chair: *Alexander Kruger*, Graduate School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

Chair: *Musa Mammadov*, Graduate School of Information Technology and Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, m.mammadov@ballarat.edu.au

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *John Yearwood*, School of InformationTechnology and Mathematical Sciences, University of Ballarat, Univerity Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, j.yearwood@ballarat.edu.au

Chair: *Patrick Tobin*, Arts and Sciences, Australian Catholic University, St Patricks Campus, Victoria Pde Fitzroy, 3065, Melbourne, Victoria, Australia, patrick.tobin@acu.edu.au

Chair: *David Yost*, Science, Information Technology and Engineering, University of Ballarat, PO Box 663, 3353, Ballarat, Vic., Australia, d.yost@ballarat.edu.au

Chair: *Xiaoqi Yang*, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, mayangxq@polyu.edu.hk

Chair: *Marco A. López-Cerdá*, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es

Chair: *Juan Enrique Martínez-Legaz*, Departament d'Economia, Universitat Autònoma de Barcelona, 08193, Barcelona, Spain, JuanEnrique.Martinez.Legaz@uab.cat

Chair: *Vaithilingam Jeyakumar*, Applied Mathematics, University of New South Wales, School of Mathematics, 2052, Sydney, NSW, Australia, jeya@maths.unsw.edu.au

Chair: *Moshe Sniedovich*, Dept. of Mathematics and Statistics, University of Melbourne, Parkville, 3010, Melbourne, Victoria, Australia, m.sniedovich@ms.unimelb.edu.au

1 - Memorial Session in Honour of Professor Alexander Rubinov

Regina Burachik, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, 5095, Adelaide, South Australia, Australia, regina.burachik@unisa.edu.au, *Gerhard-Wilhelm Weber*, *David Yost*

Aleksander Moiseevich Rubinov (1940-2006) made an enormous contribution to optimization, nonlinear analysis, and related areas, seriously raising Australia's profile in these fields. He had broad ranging interests and always believed in the essential unity of pure and applied mathematics. Over the years, he moved comfortably between abstract generalizations of classical convexity, practical algorithms for computationally complex problems in data analysis and telecommunications and various topics in between. Despite his great achievements, he was a humble and courteous man, always generous with his time and ideas. He was an exemplary supervisor, having about 45 graduate students altogether in his long career.

Alex was born in Leningrad (now Saint Petersburg) to Moisei Solomonovich Rubinov, a Professor of Economics at Leningrad Economics Institute, and Elza Abramovna Rubinova (née Okoun), an accountant. He spent the war years in Pskov, some 300 km to the south, thus escaping the siege of Leningrad. They returned after the war and Alex enrolled at Leningrad State University, beginning his Ph.D. under the supervision of Gleb Akilov. When Akilov moved to the newly-organized Siberian Branch of the USSR Academy of Sciences in Academgorodok near Novosibirsk in 1963, Alex moved with him. Akilov had been invited there by famous Leonid Kantorovich. Economics gives rise to many optimization problems for which traditional calculus is of little help. Kantorovich studied this new branch, now known as linear programming, long before its examination in the west. Alex spent seven years in Siberia, working primarily on mathematical economics, and its functional analysis underlying. During this period he began his long professional collaboration with an old friend Vladimir Demyanov. Their first book, "Approximate methods in optimization problems", was published in Russian in 1968 and translated into English in 1970.

Next he went to the new university at Kalinin (Tver) between Moscow and Leningrad. After 4 years, he was able to return to Leningrad, where he stayed until 1988. His position there was at the Social Economics Institute, which dealt with the problems of socialist society. He remained productive and wrote the textbook "Elements of Economic Theory" with A.T. Nagiev, which was published in 1992. Alex and K. Shapiev also published a textbook for school teachers "Elements of Mathematical analysis".

During this period Alex and Semen Kutateladze began to develop the theory of abstract convexity, detailed in their book "Minkowski duality and applications". Much of optimization theory is devoted to optimizing convex functions over convex sets, but convexity is lacking in many practical situations. A convex set can be defined as the intersection of sets defined by affine inequalities. If we replace these affine functions by a fixed but more general class of functions, called elementary functions, the resulting inequalities will define a more general class of sets, called abstract convex sets. Likewise, the pointwise supremum of a collection of elementary functions is called an abstract convex function. A particularly interesting case is when each elementary function is the pointwise minimum of a finite set of linear functions; then the abstract convex sets are star shaped. During this period, Alex and Demyanov introduced the theory of quasidifferential calculus, which arises from the need to optimize functions which are not smooth enough for traditional calculus. Rather than a single-valued derivative, they defined two compact convex sets, called subdifferential and superdifferential, and developed rules of calculus, leading to a linearization process for a significant class of functions. Quasidifferentiability does lead to good numerical methods for solving some complicated problems concerning moderately smooth functions.

Alex had extensive contact with Azeri mathematicians beginning in the early 1980s. In 1989 he moved to the Azerbaijan Academy of Sciences in Baku, as head of the Department of Mathematical Economics. The beginning of this period was very happy professionally, but the collapse of the Soviet Union, and subsequent economic deterioration, made life increasingly hard. In 1993 he emigrated to Israel.

Alex spent 1993-95 at Ben Gurion University of the Negev, in Beer-Sheva, unable to find a continuing position. His research fame led to an invitation from Barney Glover to visit Ballarat in 1994. Their successful collaboration led to his appointment by the University of Ballarat in 1996, first as a research fellow, and eventually as a professor and founding director of the Research Centre CIAO (Centre for Informatics and Applied Optimization). Under his leadership, CIAO successfully became a research centre of international repute. He considered the time spent in Ballarat to be his best years.

In Ballarat, Alex moved on from mathematical economics and concentrated on practical optimization problems, in particular the application of abstract convexity to global optimization. Together Glover, Alex, and former students Mikhail Andramonov and Adil Bagirov, developed the Cutting Angle Method. This can be used for global optimization of a Lipschitz function over a simplex. A natural outcome of this, Alex had been working more recently in monotonic analysis and non-linear Lagrange-type functions. Much of this is detailed in his last book, "Abstract convexity and global optimization". He organized a number of conferences in Melbourne and Ballarat, most notably ICOTA6 in 2004, and was active in advancing the Pacific Optimization Research Activity Group. He struggled with cancer for most of 2006, and passed away peacefully in September. Active right up to his passing, he had been honoured only four days earlier with appointment as the inaugural EUROPT Fellow by the Continuous Optimization Working Group of EURO.

■ TB-15

Tuesday, 11:00-12:30
Meeting Room 208

Mathematics of Defence Decision Support

Stream: Military, Defense and Security Applications
Invited session

Chair: *Brandon Pincombe*, Defence Science and Technology Organisation, Australia, Brandon.Pincombe@dsto.defence.gov.au

1 - The Dangers of Data Aggregation

Adrian Pincombe, Defence Science and Technology Organisation, PO Box 1500, 5111, Edinburgh, South Australia, Australia, Adrian.Pincombe@dsto.defence.gov.au, *Brandon Pincombe*, *Charles Pearce*

Analysis of campaigns and dispersed battles is compromised by invalid aggregation of component sub-battles. We adopt a bottom-up approach, working from the small battles of the Falklands War using historical data and simulation, guided by an aggregation model, to explore the link between data aggregation and model performance, and demonstrate several mechanisms that cause actual outcomes to deviate from predictions.

2 - Sensitivity of the Sensor Range Limited Attrition Equation to Differing Tactics

Lesley Kosowski, LOD, DSTO, PO Box 1500, 5111, Edinburgh, SA, Australia, les.kosowski@dsto.defence.gov.au, *Adrian Pincombe*, *Brandon Pincombe*

The Sensor Range Limited Attrition Equation (SRLAE) yields casualty predictions that are closer to those of the MANA agent based distillation than the Fractal Attrition Equation (FAE). Both equations require calibration of a fitting factor for each tactical vignette investigated. We generalise this fitting factor to a range of tactical vignettes, explore the loss of accuracy that this entails and determine the sensitivity of the SRLAE to differing tactics.

3 - The System Instantiation Comparison Method (SICM) used to Inform a Capability Decision

Barry Stanton, Department of Defence, R1-4-B105, Russell Offices, 2611, Canberra, ACT, Australia, barry.stanton@defence.gov.au, *Leanne Rees*, *Fred Bowden*

A Defence operation is a complex matter; analyses undertaken to inform decisions that occur in that environment are also complex. Analysts do not always have the luxury of the time they might desire nor might they be able to control the design or conduct of the activities that are the source of their data. The SICM was developed as a flexible method to support and guide analysts under such conditions. The paper demonstrates the application of SICM in a capability selection decision and applies the analytical hierarchy process to use the outputs of the SICM to inform the decision maker.

■ TB-16

Tuesday, 11:00-12:30
Meeting Room 209

OR for Health Policy Decisions I

Stream: Health Care Applications
Invited session

Chair: *Thomas Yeung*, Department of Industrial Engineering & Automatic Control, Ecole des Mines de Nantes / IRCCyN, 4, rue Alfred Kastler B.P. 20722, La Chantrerie, 44307, Nantes, France, thomas.yeung@emn.fr

1 - A POMDP Approach to Cervical Cancer Screening and Treatment

Thomas Yeung, Department of Industrial Engineering & Automatic Control, Ecole des Mines de Nantes / IRCCyN, 4, rue Alfred Kastler B.P. 20722, La Chantrerie, 44307, Nantes, France, thomas.yeung@emn.fr, *Diana Sanchez*, *Raha Akhavan-Tabatabaei*

Pap smears administered to women with proper frequency can reduce incidents of cervical cancer by 60% by signaling a need for further tests. However, the Pap smear is subject to sensitivity and specificity errors. To account for this uncertainty, we propose a partially observable Markov decision process (POMDP) in order to formulate an optimal policy for the screening and treatment of cervical cancer. This policy considers the risk factors of the patient as well as test results and observations on disease progression. The model is applied to patient data from a healthcare provider in Colombia.

2 - An Inferential Problem of Recurrent Breast Cancer in Survival Analysis

Chichang Chang, Dept of Applied Information Sciences, Chungshan Medical University, 110, Sec. 1, Chien-Kuo N. Rd., 40201, Taichung, Taiwan, threec@csmu.edu.tw

All cancers are classified according to the stage so that therapies may be tailored to the particular situation. Detection of asymptomatic recurrences is associated with prolonged survival and from the initial detection. This paper applied Bayesian reference analysis to produce objective, model-based, posterior distributions, to an inferential problem of recurrent breast cancer in survival analysis. The sampling distribution is modeled through a proportional intensity homogeneous Poisson process. And, attempts to improve surveillance and assessment of recurrent status could improve outcome.

3 - An Empirical Study of the Electronic Medical Record Project in Taiwan

Yunglin Cheng, Applied Information Sciences, Chungshan Medical University, Taiwan, hdst520@hotmail.com, *Chichang Chang*

This research is going to offer cautions of Electronic Medical Record security and measure risks successfully by building a frame of information security management in hospital. This research developes an alerted model by two-step preference decision of parameter-free method which can reflect risky attitude and decision behavior of the participants completely.The result shows that our research meet with prior literature which evidences that preferences between risky prospects are not linear in probabilities, and the methods of measuring risk was thought to be more reliable then Riskit model.

4 - OR in healthcare: how to win friends and influence people

Don Campbell, General Medicine, SouthernHealth, Monash Medical Centre, 246 Clayton Road, 3168, Clayton, Victoria, Australia, donald.campbell@monash.edu, *Keith Stockman*

Whilst it has been clear for years that OR has great potential in health it's influence has been limited. Asking "What are the problems?" and "How can OR help?" yields little. Expanded close collaboration between OR and Health is needed. OR must more effectively embed itself in the system and learn how to influence decisions. It must better understand the problems that health faces and the realities of making change. Education of healthcare workers in OR is needed along with the injecton of break through ideas and thinking. How this might be achieved will be discussed.

■ TB-17

Tuesday, 11:00-12:30
Meeting Room 214

Network Design and Routing

Stream: Network Optimisation and Telecommunications
Invited session

Chair: *Bernard Fortz*, Département d'Informatique, Université Libre de Bruxelles, CP 210/01, Bld du Triomphe, 1050, Bruxelles, Belgium, bfortz@euro-online.org

1 - Models for Optimal Survivable Routing with a Minimum Number of Hops: Comparing Disaggregated with Aggregated Models

Luis Gouveia, DEIO, University of Lisbon, Campo Grande, Bloco C6, 1749-016, Lisbon, Portugal, legouveia@fc.ul.pt, *Pedro Patrício*, *Amaro de Sousa*

Given an undirected network with link capacities and a set of commodities with known demands, this paper addresses the problem of determining D hop-constrained node disjoint paths for each commodity while minimizing the average or the maximum number of hops. These paths are defined according to two survivability mechanisms: Path Diversity and Path Protection. We present two classes of ILP models, disaggregated and aggregated, for both problems, study the relationship between their linear programming relaxations and compare their effectiveness through a set of computational experiments.

2 - K-edge Survivability in Ring Networks

Young-Soo Myung, Dept. of Business Administration, Dankook University, 330-714, Cheonan, Korea, Republic Of, myung@dankook.ac.kr

Given an undirected network with a set of source-sink pairs, we are assumed to get a benefit if a pair of source and sink nodes are connected. The k-edge survivability of a network is defined as the total benefit secured after arbitrarily selected k edges are destroyed. The problem of computing k-edge survivability is known to be NP-hard and has applications of evaluating the survivability or vulnerability of a network. In this paper, we consider the k-edge survivability problem restricted to an undirected ring network and develop an exact algorithm to solve it in polynomial time.

3 - Solving Two Facility Network Design Problem - A Polyhedral Approach

Faiz Hamid, Information Technology & Systems, Indian Institute of Management, Lucknow, India, FPM Office, IIM Lucknow, Prabandh Nagar, Off-Sitapur Road, 226013, Lucknow, Uttar Pradesh, India, faiz@iiml.ac.in, *Yogesh Agarwal*

The paper studies the problem of designing telecommunication networks using transmission facilities of two different capacities. A new family of facets is identified and also a new approach for computing the facets is introduced based on polarity theory. The approach has been tested on several randomly generated networks. Computational results show that 3-partition facets reduce the integrality gap, compared to that provided by 2-partition facets, by approximately 30-60%. Also there is a substantial reduction in the size of branch-and-bound tree.

4 - FIPP p-Cycles Based Resilient Network Design for MPLS

Richard Harris, School of Engineering and Adv Tech, Massey University, Private Bag 11 222, Manawatu Campus, 4474, Palmerston North, Manawatu, New Zealand, r.harris@massey.ac.nz, *Jing Zhang*

An extension of p-cycles, Failure-Independent Path-Protecting (FIPP) p-cycles are an efficient protection architecture for networks. They use properties of p-cycles: mesh-like efficiency, ring-like speed, and concurrently provide shared, failure independent end-to-end protection for working paths. We study FIPP p-cycle based resilient networking by two models for FIPP p-cycles: FIPP-SCP and FIPP-DRS. We consider joint capacity allocation design using the FIPP-SCP model for use with Multi Protocol Label Switching (MPLS) in Next Generation Networks. We discuss several comparative case studies.

■ TB-18

Tuesday, 11:00-12:30
Meeting Room 215

DEA- Keynote & Tutorial

Stream: Data Envelopment Analysis
Invited session

Chair: *Ali Emrouznejad*, Aston Business School, Aston University, B4 7ET, Birmingham, United Kingdom, a.emrouznejad@aston.ac.uk

1 - A Systematic Process for Measuring Efficiency of Decision Making Unites

Ali Emrouznejad, Aston Business School, Aston University, B4 7ET, Birmingham, United Kingdom, a.emrouznejad@aston.ac.uk

In large and complicated organisations, a standard process could facilitate performance assessment and help 1) to translate the aim of the performance measurement to a series of small tasks 2) to select homogeneous DMUs and suggest an appropriate input/output selection 3) to detect a suitable model 4) to provide means for evaluating the effectiveness of the results, and 5) to suggest a proper solution to improve the efficiency and productivity of entities. This paper proposes a systematic process for measuring efficiency of DMUs. The proposed framework helps to link different tools and different people with diverse skills and backgrounds, in order to work on an efficient and effective project.

2 - Tutorial on Data Envelopment Analysis

Ali Emrouznejad, Aston Business School, Aston University, B4 7ET, Birmingham, United Kingdom, a.emrouznejad@aston.ac.uk

Data Envelopment Analysis (DEA) was developed as a method for assessing the comparative efficiencies of organizational units such as the branches of a bank, schools, hospital departments or restaurants. The efficiencies assessed reflect the scope for resource conservation at the unit being assessed without detriment to its outputs, or alternatively, the scope for output augmentation without additional resources. In using DEA in practice we typically go far beyond the computation of a simple measure of the relative efficiency of a unit. We wish to know what operating practices, mix of resources, scale sizes, scope of activities and so on the operating units may adopt to improve their performance. The tutorial is specifically aimed at those who have had no prior exposure to DEA and wish to learn the essentials of how it works, what its key uses are and the mechanics of using it. The session will also involve demonstration of DEA software.

■ TB-19

Tuesday, 11:00-12:30
Meeting Room 216

Using Cases in OR Courses

Stream: Education and Operations Research
Invited session

Chair: *Mehmet Begen*, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond St. N., N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca

1 - Using Cases to Teach OR

Peter Bell, Richard Ivey School of Business, University of Western Ontario, N6A 3K7, London, Ontario, Canada, pbell@ivey.ca, *Mehmet Begen*

This workshop will discuss some of the issues surrounding the use of real-world cases in the OR course. Issues will include finding cases, preparing to teach a case, managing the case classroom, uses cases as projects, and addressing myths about case teaching.

■ TB-20

Tuesday, 11:00-12:30
Meeting Room 217

AHP I

Stream: Analytic Hierarchy/Network Process
Invited session

Chair: *Sheu-Hua Chen*, Distribution Management Dept., National Chin-Yi University of Technology, Taipin, 411, Taichung, Taiwan, shchen@ncut.edu.tw

1 - Characterizing Disagreement and Inconsistency in Experts' Judgments in the Analytic Hierarchy Process

Shi-Woei Lin, Yuan Ze University, 135 Yuan-Tung Rd., 32003, Chung-Li, Taiwan, shiwoei@saturn.yzu.edu.tw

Inconsistency arises due to intransitivity relationships in an individual expert's preference judgments. Disagreement arises due to the lack of consensus or differences in the value among different members in an expert panel. We propose a Bayesian modeling approach and a graphical representation to quantitatively characterize inconsistency and disagreement in the group decision making in the Analytic Hierarchy Process (AHP). This approach allows analysts to view the model results in a proper context, and pinpoint the uncertain component that affects model results most.

2 - A Classification Hierarchy for Ratio Scales

William Wedley, Faculty of Business Administration, Simon Fraser University, 8888 University Drive, V5A 1S6, Burnaby, BC, Canada, wedley@sfu.ca, *Eng Choo*

Since the choice of unit is arbitrary, a ratio scale can be expressed in many different ways. A similarity transform (multiplication by a positive constant) will change values of objects but not the ratios between them. This paper presents a hierarchical classification of ratio scales according the clarity of the unit of measure. The paper investigates how each scale type is used in the Analytic Hierarchy/Network processes. Various mechanisms are suggested to achieve commensurate aggregation.

3 - Hybrid MCDM Application for Performance Criteria in Customer Relation Management

Y. Esra Albayrak, Galatasaray University, 34357, Istanbul, Turkey, ealbayrak@gsu.edu.tr, *Tuncay Gürbüz*

CRM is one of the most important information systems providing feedback about the market to enterprises. You cannot manage the thing you cannot measure. Ergo for CRM performance to be measurable, quantitative attributes and methods are needed. In this study, the criteria affecting the CRM performance in construction sector (which is a highly competitive one) in Turkey, will be presented and evaluated in a model. First the relations between criteria will be handled with ANP and their relative weights will be determined. Then with an MCDM method, appropriate strategies for CRM will be ranked.

4 - Performance Evaluation Based on Managerial Practices and Associated Affect Factors

Hong Tau Lee, Industrial Engineering and Management, National Chin-Yi University of Technology, Taipin, Taichung County, 411, ROC, Taiwan, leeht@ncut.edu.tw, *Sheu-Hua Chen*

This research focuses on the performance of the people who manage projects based on those managerial practices with some essential affected factors. An analytic network process is employed to identify the interdependence between these two groups of elements. The relative importance of those leadership behaviors as well as the relative intensity of the factors that influence them is determined simultaneously. The relative importance of leadership behaviors and weights of their corresponding managerial practices will be involved to the model for evaluating the performance of project managers.

■ TB-21

Tuesday, 11:00-12:30
Meeting Room 218

Ground Operations

Stream: Airline Applications
Invited session

Chair: *Prem Kumar Viswanathan*, TRANSP-OR, ENAC, Ecole Polytechnique Federal de Lausanne, GC-B3-435, Batiment B3, Station 18, EPFL, 1015, Lausanne, VD, Switzerland, prem.viswanathan@epfl.ch

1 - Management of Airline Check-in Counter Queue: Static vs Dynamic Policies

Sharafali Moosa, LKC School of Business, Singapore Management University, 50 Stamford Road, 178899, Singapore, sharafalim@smu.edu.sg, *Mahmut Parlar*, *Brian Rodrigues*

In this paper, we analyse the problem of allocating a fixed number of counters dedicated to a single flight with the objective to minimize the total expected cost of waiting, counter operation, and of passenger delay. We demonstrate that the static policy proposed is very easy to determine unlike the difficult-to-evaluate dynamic policy proposed in the literature. Numerical comparison of the performance of the static and dynamic policies is also provided. An alternative formulation that includes a probabilistic service-level constraint helps estimate the imputed delay cost.

2 - Simulation of the Allocation of the Number of Counters in the Check-in Area of an International Airport

Wilmer Atoche, Ingeniería Industrial, Pontificia Universidad Católica del Perú, Av. Universitaria 1801 San Miguel, Lima, Peru, watoche@pucp.edu.pe, *Walter Silva*, *Miguel Mejia*

This research involves the simulation of the allocation of the number of counters for different airlines in the check-in area during daylight hours from the international airport Jorge Chavez in Lima, Peru. Measurements were made of two indicators: rates of passenger arrivals and service rates in the international and domestic terminals of check-in of the airport. Defines the model for every airline as a queuing system M / M / s / K and the article concludes with a simulation using ARENA software for application in the area of the airport check-in.

3 - Multi-Objective Airport Gate Assignment for a Large Airline

Prem Kumar Viswanathan, TRANSP-OR, ENAC, Ecole Polytechnique Federal de Lausanne, GC-B3-435, Batiment B3, Station 18, EPFL, 1015, Lausanne, VD, Switzerland, prem.viswanathan@epfl.ch

We consider the problem of assigning gates to a large airline at its hub airport in both planning and operations mode. The first objective in planning mode assigns airport gates for a given passenger flow data and pedestrian distances between the gates, such that maximum connection revenue is realized. The second objective aims to schedule flights to gates in as few manpower zones as possible to minimize operating costs. The third objective ensures that the time between a departure and next arrival at the same gate is maximized to ensure reasonable schedule robustness in the event of delays.

Tuesday, 15:00-16:30

■ TC-01

Tuesday, 15:00-16:30
Plenary Hall 3

OR Consultancy and Case Studies

Stream: OR Practice
Invited session

Chair: *John Ranyard*, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

1 - Identifying Your Niche—A Critical Step for an Independent OR Consultant

Liz Archibald, Cormack Consulting Limited, 3 St Lukes Terrace, BN2 9ZE, Brighton, East Sussex, United Kingdom, liz@cormackconsulting.co.uk

Marketing experts advise aspiring business consultants to identify and focus on a niche market. However, for OR consultants, narrowing the options too soon can seem overly restrictive. The presenter's evolution from generalist to niche consultant has taken 10 years and required being open to a possible specialism at the right moment. Discovering specific software for user-orientated optimisation gave Cormack Consulting an opportunity to distinguish itself within the Energy, Utilities & Regulated Industries (EURI) sector. Having located our niche, new technologies offer cost-effective options for communicating to customers in ways which are accessible even to very small consultancies.

2 - Changes in the Transport and Logistics Sector Create More Opportunities for Optimisation

Alan Dormer, Mathematics, Statistics & Informatics, CSIRO, Private Bag 33, 3169, Clayton South, VIC, Australia, alan.dormer@csiro.au

Freight transportation in Australia is facing a number of significant challenges: demand is increasing, regulation is becoming more stringent, customers are demanding efficiency improvements and the environmental impact is subject to greater scrutiny. CSIRO have been working in this area for over 10 years, applying operations research and statistical techniques to assist customers plan better and become more efficient. This presentation examines some applications of OR to rail and road freight and how changes in the industry are likely to accelerate the adoption of OR.

3 - Optimization of Usage of Water Tanks in Water Supply Systems

Corinna Dohle, DS&OR Lab, University Paderborn, Warburger Strasse 100, 33098, Paderborn, Nordrheinwestfalen, Germany, dohle@dsor.de, *Leena Suhl*

An application is presented which optimizes the usage of water tanks in municipal water networks. Optimal locations of new tanks are identified and the size of existing tanks is optimized. The optimal solution is found by a combination of optimization and simulation. After solving a coarse optimization model of the water network the solution is validated by a simulation tool with a finer model. If the solution is feasible an optimal solution has been found. Otherwise the optimization model is modified and solved again. The implementation of this approach is currently discussed with a client.

■ TC-02

Tuesday, 15:00-16:30
Meeting Room 101

Game Theory Applications in Economics II

Stream: Game Theory
Invited session

Chair: *Fouad El Ouardighi*, Operations Management, ESSEC Business School, Avenue Bernard hirsch, BP 105, 95021, Cergy Pontoise, France, elouardighi@essec.fr

1 - Strategic defence of networks under attack

Britta Hoyer, School of Economics, Utrecht University, Janskerkhof 12, 3512BL, Utrecht, Netherlands, b.hoyer@uu.nl, *Kris De Jaegher*

Networks are one of the essential building blocks of society. Social movements make use of networks to exchange information, but on the negative side so do criminal and terrorist networks. This paper investigates how players in a network can use additional links to optimally defend themselves against the impending attack on the links of the network by a network disruptor. We find that contrary to the intuition of the public-good nature of network protection underprotection is no problem. Instead, players will either go for "over-protection' or will remain in a minimally connected network.

2 - A Dynamic Game Analysis of Social Networking Services

Emiko Fukuda, Department of Computer Science, National Defense Academy of Japan, 2398686, Yokosuka, Kanagawa, Japan, emiko@nda.ac.jp

Social networking Services (SNS), such as MySpace or FaceBook, are one of the most popular websites. We model a diffusion process of users of a SNS as a dynamic game in which (1) each user can choose not to use the SNS in her/his turn, and (2) network effect of the SNS depends on a history of players' actions.Then we derive the necessary condition under which the state where every player is an active user is the unique Markov perfect equilibrium outcome. Moreover, we propose an incentive mechanism that enables the number of active users grows steadily.

3 - Pollution, Pigouvian Taxation and Cartel Stability

Luca Lambertini, Economics, University of Bologna, Strada Maggiore 45, 40125, Bologna, Italy, luca.lambertini@unibo.it, *Arsen Palestini*, *Andrea Mantovani*

We assess the effects of Pigouvian taxation on firms' ability to collude in a Cournot supergame where production pollutes the environment. It turns out that (i) if marginal production cost is constant, taxation enhances the intensity of collusion, creating a tradeoff between environmental regulation and antitrust policy; (ii) if instead marginal production cost is increasing, Pigouvian taxation has a definite pro-competitive effect.

4 - A Dynamic Game of Pollution and Environmental Absorption Capacity

Fouad El Ouardighi, Operations Management, ESSEC Business School, Avenue Bernard hirsch, BP 105, 95021, Cergy Pontoise, France, elouardighi@essec.fr

In this paper, we extend the model in El Ouardighi and Benchekroun (2010) with a dynamic environmental absorption capacity as a two-player dynamic game. We notably compare the open-loop Nash equilibrium with the cooperative solution. Also, the stability of both equilibria is analyzed.

■ TC-03

Tuesday, 15:00-16:30
Meeting Room 102

Metaheuristics

Stream: Meta-heuristics
Invited session

Chair: *Weiqi Li*, School of Management, University of Michigan-Flint, 303 East Kearsley Street, 48502, Flint, Michigan, United States, weli@umflint.edu

1 - Static Data Segment Location Problem in Information Networks

Goutam Sen, Industrial Engineering and Operations Research (IITB), Clayton School of Information Technology (Monash), IITB Monash Research Academy, C - 519, Hostel 12, Indian Institute of Technology, Powai, 400076, Mumbai, Maharashtra, India, goutam.sen@iitb.ac.in, *Mohan Krishnamoorthy*, *David Abramson*, *Vishnu Narayanan*, *Narayan Rangaraj*

We consider the problem of locating data mirrors in multiple locations in a communications network so as to provide fast access to data. Full replication of massively large databases, however, incurs large transmission and bandwidth/access costs. We propose a new data segment location model, and formulate it as a mixed integer linear program. We develop a simulated annealing algorithm for our problem and also provide results for an exact solution strategy based on a relaxation approach. We test our models on real data and also point to future research.

2 - Comparing the Performance of Different Metaheuristics for Solving a Location Problem

Javier Alcaraz, Dept. Estadística, Matemáticas e Informática, Universidad Miguel Hernández de Elche, Av. Universidad s/n, 03202, Elche, Alicante, Spain, jalcaraz@umh.es, *Mercedes Landete*, *Juan Francisco Monge*

In this work we present two new metaheuristics to solve a location problem. Both algorithms make use of the same solution encoding and some procedures based on the problem specific knowledge have been incorporated. To study the performance of the algorithms and to compare their efficiency, we have carried out an extensive computational experiment solving well known benchmark instances. We have also compared them with a genetic algorithm proposed to solve the P-median problem. The results show a similar behavior of the new methods, which are much more efficient than the genetic algorithm.

3 - Attractor-Based Approach To Dynamic Traveling Salesman Problem

Weiqi Li, School of Management, University of Michigan-Flint, 303 East Kearsley Street, 48502, Flint, Michigan, United States, weli@umflint.edu

The paper introduces the concept of solution attractor in local search for combinatorial optimization problems. A solution attractor drives local search trajectories to converge into a small region in the solution space that contains the most promising solutions. A method for constructing the solution attractor for the traveling salesman problem (TSP) is presented. Based on the attractor concept, this paper introduces an attractor-based procedure to tackle dynamic TSP. This procedure not only generates high quality solution, but also provides the flexibility and stability of the search system.

■ TC-04

Tuesday, 15:00-16:30
Meeting Room 103

Revenue Management 2

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Massoud Talebian*, University of Newcastle, NSW 2308, Callaghan, NSW, Australia, Masoud.Talebian@newcastle.edu.au

1 - Competitive Effects of Minimum Sales Volumes to Trigger Higher Commissions

Massoud Talebian, University of Newcastle, NSW 2308, Callaghan, NSW, Australia, Masoud.Talebian@newcastle.edu.au, *Guillermo Gallego*

We consider a game between two capacity providers that compete for customers through a broker. The broker works on commission margins and sells to both loyal and no-loyal customers. We study the effects of requiring minimum sales volumes, or thresholds, to trigger an increase in commissions. This setting is similar to quantity discount contracts, where suppliers require minimum purchase volumes to give discounts on the total purchase. We analyze two settings, when commission margins are endogenous and also when they are exogenous. We show that with endogenous margins the introduction of thresholds results in less revenue for the smaller provider and more revenue for the broker, with the revenue for the larger provider remaining unchanged. This is in sharp contrast to the case where margins are exogenous. In this case at least one provider has an incentive to impose minimum sales volumes to trigger commissions, usually at the expense of the broker. Consequently, the gains from the case of exogenous margins are a mirage in the full equilibrium, where commission margins are endogenous.

2 - Issues in Partitioned Revenue Management

Max Gerlach, Information Systems, Freie Universitaet Berlin, Garystr. 21, 14195, Berlin, Germany, max-gerlach@web.de, *Catherine Cleophas*, *Natalia Kliewer*

While maximum revenue may be achievable by optimization across the overall inventory, within the partitioned structure of conglomerates as well as in corporate alliances, this is often impossible due to legal, organizational and technical boundaries. We present an overview of constellations in which inventory can be split into sets of substituting or complementing products as well as alternative ways to implement revenue management in these constellations. We illustrate the effects of different strategies using stochastic simulations and provide applications in the airline industry.

3 - A Dynamic Pricing System for Guaranteed Online Display Advertising

Jian Yang, Yahoo!, United States, jianyang@yahoo-inc.com

One of the challenges to pricing guaranteed online display advertising is the high dimension and huge number of attribute combinations in inventory. This could make conventional pricing methods ineffective. We develop a dynamic pricing methodology and system composed of three main components: 1) base price that reflects business as usual, 2) price response that adjusts price for market condition changes and 3) opportunity cost that makes sure the price is no less than what the non-guaranteed spot market may offer. Both online and offline experiments show advantages of the new system.

■ TC-05

Tuesday, 15:00-16:30
Meeting Room 104

Marketing/Operations III

Stream: OR and Marketing
Invited session

Chair: *Felipe Caro*, UCLA Anderson School of Management, 110 Westwood Plaza, Suite B420, 90095, Los Angeles, CA, United States, fcaro@anderson.ucla.edu

1 - Estimating Primary Demand for Substitutable Products from Sales Transaction Data

Gustavo Vulcano, Leonard N. Stern School of Business, New York University, 44 West Fourth Street, Suite 8-76, 10012, New York, NY, United States, gvulcano@stern.nyu.edu, *Garret van Ryzin*, *Richard Ratliff*

We consider a method for estimating substitute and lost demand when only sales and product availability data are observable, not all products are available in all periods, and the seller knows its market share. The model combines a multinomial logit (MNL) choice model with a non-homogeneous Poisson model of arrivals over multiple periods. We propose an efficient, EM-based iterative procedure for estimating the parameters of the model, which provably converges to a stationary point of the incomplete data log-likelihood function.

2 - Retailers' Asymmetric Assortment Choices in the Presence of Uncertain Consumer Preferences

Haoying Sun, Department of Information, Risk and Operations Management, University of Texas at Austin, McCombs School of Business, 1 University Station, B6500, 78712, Austin, TX, United States, Haoying.Sun@phd.mccombs.utexas.edu, *Stephen Gilbert*

For many products, some (uninformed) consumers may need to experience the touch and feel in order to determine their valuation. In addition, consumers differ in their costs of searching for the ideal product. Under such circumstances, we show that heterogeneous product assortment breadth among two competing retailers can emerge as an equilibrium. Specifically, we consider a market with two products and two retailers, and show the conditions under which there exists an equilibrium in which one retailer carries a full-line and the other sells one product only, even though the demand structure for the two products is symmetric and the cost structures of the two retailers are the same. Under this equilibrium, the full line retailer expands the overall demand from uninformed consumers by reducing their search costs. Meanwhile, the single product retailer can sell to the informed consumers without added carrying costs. Furthermore, with this asymmetric assortment breadth, two retailers avoid the head-on price competition that could result from symmetric assortment breadth.

3 - Coordination of Inventory Distribution and Price Markdowns at Zara

Felipe Caro, UCLA Anderson School of Management, 110 Westwood Plaza, Suite B420, 90095, Los Angeles, CA, United States, fcaro@anderson.ucla.edu

Each year Zara sells inventory during clearance sales accounting for approximately thirteen percent of total revenues. One of the biggest challenges Zara faces in preparation for the clearance season is determining how to distribute 11,000 different fashion designs to over 1,200 stores worldwide. In this talk we describe an ongoing project to distribute merchandise to stores with the highest potential of sale in order to maximize revenues during the clearance period.

4 - Managing Supplier Product Adulteration Risks

Christopher Tang, UCLA Anderson School, 110 Westwood Plaza, 90095, Los Angeles, CA, United States, ctang@anderson.ucla.edu, *Vlad Babich*

We present two basic mechanisms to deterring suppliers from product adulteration. Specifically, we study: (a) the deferred payment mechanism — the buyer pays the supplier after the deferred payment period only if no adulteration has been discovered by the customers; (b) the inspection mechanism — the buyer pays the supplier is immediately, contingent on product passing the inspection. By analyzing the game between the buyer and supplier, we show that the inspection mechanism cannot completely deter the suppliers from product adulteration, while the deferred payment mechanism can.

■ TC-06

Tuesday, 15:00-16:30
Meeting Room 105

Models and Methods for City Logistics

Stream: Transportation
Invited session

Chair: *Teodor Gabriel Crainic*, Management and Technology, Univ. du Québec à Montréal, C.P. 8888, succ. Centre-Ville, H3C 3P8, Montréal, Québec, Canada, theo@crt.umontreal.ca

1 - Estimating the National Benefit of Introducing Performance Based Standard Vehicles into Australia

Kim Hassall, University of Melbourne, Civil and Environmental Engineering Dept., Parkville, 3010, Melbourne, Victoria, Australia, hassallk@unimelb.edu.au

In 1999 the National Road Transport Commission re-launched the Canadian concept of Performance Based Standards for Australian freight vehicles. A decade later permits are issued by States for these innovative vehicle combinations. In 2010 the NTC sought to evaluate the impact of a national framework. What does this mean to the economy by allowing new PBS vehicles to operate? The solution was achieved by simulation modelling of commodity networks, regression and Input-Output analysis. This OR and Econometric approach was accepted and is the framework for the national benefit cost analysis.

2 - City Logistics and the Physical Internet

Teodor Gabriel Crainic, Management and Technology, Univ. du Québec à Montréal, C.P. 8888, succ. Centre-Ville, H3C 3P8, Montréal, Québec, Canada, theo@crt.umontreal.ca, *Benoit Montreuil*

The Physical Internet is a new concept for freight logistics and transportation (www.physicalinternetinitiative.org). Similarly to the Internet, load movements are independent of the operations of the transportation infrastructure and services and proceed in a distributed, consolidated way through a series of relay facilities. This concept is close to the cooperation and consolidation ideas of City Logistics. We contrast these two systems and explore means and challenges of combining them into a smooth, efficient and sustainable freight logistics and transportation system.

■ TC-07

Tuesday, 15:00-16:30
Meeting Room 106

Topics in Combinatorial Optimization I

Stream: Combinatorial Optimization
Invited session

Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - Scheduling of Orders on a Variant of a Unidirectional Carousel System

Stephan Visagie, Department of Logistics, University of Stellenbosch, Posbus 3404, Matieland, 7602, Stellenbosch, South Africa, svisagie@sun.ac.za, *Jason Matthews*, *Anton de Villiers*

The scheduling of orders for multiple pickers on a picking line in a real life distribution centre (Pep Stores Ltd, South Africa) is considered. The picking line may be modelled as a variant of a unidirectional carousel system. The size and complexity of exact solution approaches, based on generalized TSPs, is highlighted and the need for heuristics discussed. Several heuristic approaches are presented and their performances compared base on real life data sets.

2 - A Column Generation Approach to Real World Two-Dimensional Cutting Problems

Enrico Malaguti, DEIS, University of Bologna, Viale Risorgimento, 2, 40136, Bologna, Italy, emalaguti@deis.unibo.it, *Rosa Medina Durán*, *Paolo Toth*

We consider a real-world generalization of the 2-Dimensional Guillotine Cutting Stock Problem arising in the wooden board cutting industry. A set of rectangular items has to be cut from rectangular stock boards, available in multiple formats. In addition to the classical objective of trim loss minimization, the problem also asks for the maximization of the cutting equipment productivity, which can be obtained by cutting several identical boards in parallel. We present an algorithm which produces high quality cutting patterns, and compare its performance with some commercial software tools.

3 - Routing Problems with Loading Constraints

Silvano Martello, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, smartello@deis.unibo.it, *Manuel Iori*

Difficult combinatorial optimization problems arise in transportation logistics when one is interested in optimizing both the routing of vehicles and the loading of goods into them. As the separate routing and loading problems are already NP-hard, and very difficult to solve in practice, a fortiori their combination is extremely challenging and stimulating. We review vehicle routing problems with two- and three-dimensional loading constraints, as well as other combinations of routing and special loading constraints arising from industrial applications.

■ TC-08

Tuesday, 15:00-16:30
Meeting Room 107

Bandit Processes and Resource Allocation

Stream: Dynamic Programming
Invited session

Chair: *Christopher Kirkbride*, The Management School, Lancaster University, Dept. of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, c.kirkbride@lancaster.ac.uk

1 - Index Policies for Some Families of Stochastic Machine Maintenance Problems

Diego Ruiz-Hernandez, Mathematics and Statistics Dept., CUNEF, c/ Serrano Anguita 9, 28004, Madrid, Spain, d.ruiz@cunef.edu

In Glazebrook, K., Ruiz-Hernandez, D. and Kirkbride, C. (2006) we established the indexability of a class of restless bandits designed to model machine maintenance problems in which maintenance interventions have to be scheduled to mitigate escalating costs as machines deteriorate, and to reduce the chances of a machine breakdown. In this paper we further develop the findings in our earlier work by offering new families of examples for which explicit formulae for the Whittle index can be derived. A numerical investigation demonstrates the very strong performance of Whittle's heuristic.

2 - Shelf Space Driven Assortment Planning for Seasonal Consumer Goods

Joern Meissner, Kuehne Logistics University, Hamburg, Germany, joe@meiss.com, *Kevin Glazebrook*, *Jochen Schurr*

We consider the operations of a "fast-fashion" retailer. Zara and others have developed and invested in merchandize procurement strategies that permit lead times as short as two weeks. Our research focuses on the use of the most valuable resource of such a retailer: shelf space. We investigate the use of multi-armed bandits to model the assortment decisions under demand learning. The learning aspect is captured by a Bayesian Gamma-Poisson model. We propose a knapsack based index heuristic that results in policies that are close to theoretically derived upper bounds.

3 - Monotone Policies and Indexability for Bi-directional Restless Bandits

Christopher Kirkbride, The Management School, Lancaster University, Dept. of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, c.kirkbride@lancaster.ac.uk

We consider a development of Whittles restless bandit model in which project activation requires a state-dependent amount of a key resource, assumed to be available at a constant rate, where as many projects may be activated at each decision epoch as resource availability allows. Projects are bi-directional such that the project state tends to move in a different direction when it is activated from that in which it moves when passive. We demonstrate the value of the ideas for the construction of policies for dynamic resource allocation in contexts which involve a large number of projects.

■ TC-09

Tuesday, 15:00-16:30
Meeting Room 108

VRP I

Stream: Vehicle Routing
Invited session

Chair: *Arne Lokketangen*, OIS, Molde College, Bitveien 2, 6411, Molde, Norway, Arne.Lokketangen@hiMolde.no

1 - The Driver Routing Problem

Johan Oppen, Molde University College, P O Box 2110, 6402, Molde, Norway, johan.oppen@hiMolde.no

A company offers a transportation service to bring both you and your vehicle from one location to another. Some of the transportation tasks are known in advance, others are called in while the plan is being executed. Several different transportation modes are used to bring drivers between tasks. The associated planning problem can be modelled as a dynamic and stochastic Vehicle Routing Problem with multiple transportation modes. We present a mathematical model and discuss solution methods for a simplified, deterministic version where all parameter values are assumed to be known in advance.

2 - Milk Collection in Western Norway Using Trucks and Trailers

Arild Hoff, Molde University College, P.O.Box 2110, 6425, Molde, Norway, arild.hoff@himolde.no, *Arne Løkketangen*

Milk collection is a problem which is well known in rural areas all around the world. This talk considers a real world problem for a Norwegian dairy company collecting raw milk from farmers. Most farms are inaccessible for a large truck carrying a trailer. Thus the routes are organized as a main tour between larger parking spots where the trailer is left behind, and the truck drives subtours from this spots to visit the actual farms. The talk will present heuristics for constructing such tours and computational results comparing our result with the current plan of the company.

3 - Metaheuristics with three search spaces for the vehicle routing problem

Christian Prins, ROSAS, University of Technology of Troyes, BP 2060 - 12 rue Marie Curie, 10010, Troyes, France, christian.prins@utt.fr

Some effective metaheuristics for the vehicle routing problem relax vehicle capacity and generate TSP tours, converted into VRP solutions using a splitting procedure. The results can be improved by a systematic alternation between the two search spaces, see the multi-start evolutionary local search of C. Prins in "Bio-inspired algorithms for the vehicle routing problem', Studies in Computational Intelligence 161, 35-53, Springer, 2009. The talk presents a metaheuristic with a third search space, defined by the partitions of customers into clusters compatible with vehicle capacity.

4 - Multiobjective VRP Decision Support

Arne Løkketangen, Molde University College, Britveien 2, 6411, Molde, Norway, arne.lokketangen@himolde.no, *Johan Oppen*, *Jorge Oyola*, *David Woodruff*

Due to the simplifications inherit in the modeling process, a Decision Maker (DM) often wants to see a set of good solution instead of just the optimal one. Also, the DM might often be interested in focusing on a set of solutions fulfilling certain conditions that are of specific importance that day, or in general, like avoiding a certain road due to road-works. We show how the use of a measure for the distance between solutions implemented in a Multi-Objective setting for the VRP problem, can be used for both of these purposes.

■ TC-10

Tuesday, 15:00-16:30
Meeting Room 111

Railway Applications II

Stream: Public Transit

Invited session

Chair: *Twan Dollevoet*, Econometric Institute, Erasmus University Rotterdam, 3000DR, Rotterdam, Netherlands, dollevoet@ese.eur.nl

1 - Knock, Knock, Knock-on on Railway Networks

Thijs Dewilde, Centre for Industrial Management/Traffic & Infrastructure, University of Leuven, Celestijnenlaan 300A, bus 2422, B-3001, Leuven, Belgium, Thijs.Dewilde@cib.kuleuven.be, *Peter Sels*, *Dirk Cattrysse*, *Pieter Vansteenwegen*

In our study about robust railway timetables, knock-on delays or delay propagation are of high importance. Interdependencies among trains and their paths cause delays, however small, to propagate in space and time. Identifying possible conflicts and accounting for the applied dispatching strategy, knock-on delays can be modeled. We created a delay propagation model for one of Europe's major railway bottlenecks, the Brussels area. This model enables us to improve the robustness of a timetable by avoiding knock-on delays as much as possible. We validated our results using real-time data.

2 - Scheduling in Rapid Transit Networks. Quality of Service vs Network Profitability

Eva Barrena, Applied Mathematics I, University of Sevilla, Avda. Reina Mercedes s/n, 41012, Sevilla, Spain, ebarrena@us.es, *Alejandro Zarzo*, *Encarnación Algaba*, *David Canca*

In the railway networks management context, set up of train schedules is a topic which affects both the level of satisfaction of the users and the network profitability. This double influence makes it a widely studied topic in the literature, where the main lines of research tend to improve the solving methods of the corresponding integer programming problems. However, literature about methods that take both user and service provider point of view jointly into account is sparse. The study of the trade-off between this two opposite aspects in rapid transit networks is the main aim of this work.

3 - Finding a Passenger-optimal Revised Schedule for a Rail Network

Todd Niven, Monash University, 3145, Caulfield East, Victoria, Australia, todd.niven@monash.edu, *Christopher Mears*, *Mark Wallace*, *Ian Evans*

In a suburban passenger railway network, a delay of a single train is likely to affect subsequent trains as well. When a delay has occurred, the delayed train and other nearby trains can be re-scheduled to minimise the effect on passengers' travel time. A simple single-track train network with a single delay is considered. We model and solve the problem using a constraint programming system, and are able to find optimal revised schedules, with respect to time spent waiting at the station and time aboard the train.

4 - Look-Ahead based Dynamic Ranking Heuristic as a Contingency measure to handle disruptions in a Railway Schedule.

Sundaravalli Narayanaswami, Information Technology Dept, Higher Colleges of Technology, PB No 58855, Madinat Zayed, 58855, Abu Dhabi, United Arab Emirates, sundaravalli@iitb.ac.in

Schedule disruptions occur due to deterministic and stochastic reasons. Many published rescheduling models are based on optimal, heuristic or meta-heuristic approaches that effectively dispatch conflicting trains to optimize rescheduling objective. A novel, dynamic, look-ahead based ranking heuristic is proposed as a contingency measure to resolve deterministic disruptions in this rescheduling model. The dispatch algorithm dynamically prioritizes conflict trains using momentary train parameters with an objective of total weighted delay of all trains at their respective destinations. Results are presented; significant feature of the heuristics is reduction of problem complexity by partitioning the problem space.

■ TC-11

Tuesday, 15:00-16:30
Meeting Room 112

Simulation for Operations Management

Stream: Simulation - Sponsored by I-SIM

Invited session

Chair: *Walter Silva*, Ingeniería Industrial, Pontificia Universidad Católica del Perú, Calle Fray Angélico 443. San Borja, Lima, Peru, walter.silva@pucp.edu.pe

1 - Dynamic Evaluation and Optimisation of an Urban Collective Taxis System by Discrete-Event Simulation

Jennie Lioris, CERMICS_IMARA, ENPC-INRIA, Domaine de Voluceau Rocquencourt, 78150, Le Chesnay, France, jennie.lioris@cermics.enpc.fr, *Guy Cohen*

Our aim is to provide optimal strategies for the performance management of an urban Collective-Taxis system, intelligently associating more than one passenger to each vehicle, controlling detours, waits, operating with/without reservations and door-to-door services, at low fares encouraging people its use. All controls governing the system (e.g. client acceptance, dynamically constructed vehicle itineraries, solutions for idle vehicles etc.) will be evaluated and system performances will be optimised by a made to measure discrete-event simulator, before any risky real-time application.

2 - Reducing Disturbance in Manufacturing System with Vehicle Tracking System and Discrete-event Simulation

Norhanom Awang, Technology Management, University Malaysia of Pahang, 26300, Kuantan, Pahang, Malaysia, anumjp@yahoo.com

This study aims to present a modelling of production flow in automotive manufacturing using discrete-event simulation (DES) model. The purpose of the study is to reduce disturbance using Vehicle Tracking System (VTS) and DES. The computer-based integrated approach successfully reduces the risk of inefficiency cause of these problems in operation. The study makes a business case that process improvement through reduction of disturbance can be effectively accomplished with the integrated approach of VTS with widely available inexpensive and user-friendly computer-based tools.

3 - A Simulation for Optimal Buffer Allocation in an In-line System

Eishi Chiba, Hosei University, 3-7-2, Kajino-cho, Koganei-shi, Tokyo 184-8584, Japan, e-chiba@hosei.ac.jp

A manufacturing system for Flat Panel Displays (FPDs) consists of series of equipments, each of which is usually equipped with enough number of buffers to avoid collision between glass substrates. However, they often contain redundant buffers which are not actually used. In order to reduce the production cost, the number of buffers should be minimized. In this paper, we try to find a buffer allocation that achieves the smallest total number of buffers under an arbitrarily specified collision probability. We also present some computational results.

4 - Application of Discrete Simulation in the Optimal Allocation of Ambulances Holding Points

Walter Silva, Ingeniería Industrial, Pontificia Universidad Católica del Perú, Calle Fray Angélico 443. San Borja, Lima, Peru, walter.silva@pucp.edu.pe, *Gonzalo Raffo*, *Wilmer Atoche*

The company operates 19 ambulances which are responsible for dealing with 190 calls per day. A valid assumption is that the waiting time is inversely proportional to the quality of service. It is therefore understood that a shorter waiting time, there would be a better quality of service. Given this situation, then there is the decision - making by management and by the operator: What are the sites of the stand by reducing waiting time? It is also important to answer the question, due to an emergency call, what should I allocate ambulance?

■ TC-12

Tuesday, 15:00-16:30
Meeting Room 205

Graph Problems

Stream: Contributed Talks

Contributed session

Chair: *Kai Helge Becker*, Mathematical Sciences, Faculty of Science & Technology, Queensland University of Technology, 2 George Street, GPO Box 2434, QLD 4001, Brisbane, Australia, kai.becker@qut.edu.au

1 - Rogo, a TSP-based Paper Puzzle: Optimization Approaches

Shane Dye, Department of Management, University of Canterbury, Private Bag 4800, 8140, Christchurch, New Zealand, shane.dye@canterbury.ac.nz, *Nicola Ward Petty*

Rogo(R) is a new type of mathematical puzzle, invented in 2009. Rogo is a prize-collecting subset-selection TSP on a grid. Grid squares can be blank, forbidden, or show a reward value. The object is to accumulate the biggest score using a given number of steps in a loop around the grid. This paper studies Rogo as a discrete optimisation problem. An mip formulation is given for the problem with two alternative sets of subtour elimination constraints. Enumeration-based algorithms are also proposed based on properties of solutions and Rogo instances. Some computational experiments are reported.

2 - Calculating the Probability of Occurrence of Any Given Score Sequence in a Tournament

Joris Pieters, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussel, Belgium, joris.pieters@vub.ac.be

A sequence of outdegrees of the nodes in a tournament is called a score sequence. The probability of occurrence of a certain score sequence can be obtained by generating all possible tournaments and counting which of them correspond with the sequence in question. As the number of nodes increases, this calculation becomes extremely time consuming. We provide a more efficient approach whereby only those graphs inherent to the sequence are being generated. Applications include exact probability calculation with regard to tests using pairwise comparisons and competitive balance in tournaments.

3 - Minimum Maximal Matching in some Classes of Graphs

Marc Demange, Romania Foundation, ESSEC Business School, Bucharest, Romania, demange@essec.edu, *Tinaz Ekim*, *Cerasela Tanasescu*

We consider the minimum maximal matching problem (MMM) in some classes of graphs, in particular in regular (bipartite) graphs. It is motivated by several applications including the theory of stable marriages. MMM is NP-hard in regular bipartite graphs. We focus on measuring the ratio between a minimum maximal matching and a maximum one, well-known to be bounded by 2. We first study the class of graphs for which this ratio is 1 and give a polynomial time algorithm testing it. We then analyze two natural greedy algorithms improving the usual approximation of 2 in regular (bipartite) graphs and in graphs with a perfect matching.

4 - Matching-based Alternating Hamiltonian Cycles

Kai Helge Becker, Mathematical Sciences, Faculty of Science & Technology, Queensland University of Technology, 2 George Street, GPO Box 2434, QLD 4001, Brisbane, Australia, kai.becker@qut.edu.au

For a given undirected graph G with an even node set, we define a new graph G' by adding to the edges of G ("red edges") the edges of an (arbitrary) perfect matching M of the nodes ("blue edges"). G is said to be matching-based alternating Hamiltonian with respect to M iff there exists a Hamiltonian cycle on G' such that blue and red edges alternate along the cycle. The paper presents some research on the complexity of the problem (as depending on the underlying graph G). The problem has an application in the paper industry.

■ TC-13

Tuesday, 15:00-16:30
Meeting Room 206

Optimization, Forecasting, Renewable Energy and Electricity Grid I

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Asef Nazari*, School of Mathematics and Statistics, University of South Australia, OC Building, Mawson Lakes Campus, 5095, Mawson Lakes, South Australia, Australia, asef.nazari@unisa.edu.au

Chair: *Jerzy Filar*, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au

Chair: *Manju Agrawal*, Mathematics and Statistics, University of South Australia, School of Mathematics and Statistics, Mawson Lakes, 5095, Adelaide, South Australia, Australia, manju.agrawal@unisa.edu.au

1 - Mechanisms of Market Power Reduction at Electricity Markets

Alexander Vasin, Operations Research, Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su, *Anton Gusev*

We consider a uniform price supply function auction (Klemperer and Meyer, 1989) and examine best reply dynamics for the repeated auction and a symmetric oligopoly A) with a linear marginal cost, B) with a fixed marginal cost and a limited capacity. For model A the dynamics converges to the equilibrium, but for model B it does not converge. Then we study a model of 2-stage market with Cournot competition and no arbitrage condition. We consider a random outcome at the spot market and consumers heterogeneous by their risk attitude. We compare the equilibrium outcome with the Cournot equilibrium.

2 - A Game Theoretical View of Price Volatility in the Australian Electricity Market

Ghazaleh Mohammadian, School of Mathematics and Statistics, University of South Australia, School of Mathematics and Statistics, Mawson Lakes Campus, 5095, Adelaide, South Australia, Australia, ghazalehmohammadian@yahoo.com

The Australian national electricity market has experienced high price volatility since deregulation in early 1990s. Considering variance as a measure of price risk, with some ordinary statistical tools, we can show that this risk is increasing dramatically in high demand periods. Closer examination demonstrate that bidding behavior of generators may, in fact, increase the risk of price volatility. In this talk we will consider the problem from game theory perspective.

3 - Forecasting Solar Radiation using Differencing Techniques

Jing Huang, School of Mathematics and Statistics, University of South Australia, OC1-64 Mawson Lakes campus, Mawson Lakes Boulevard, 5095, Mawson Lakes, South Australia, Australia, HUAJY017@mymail.unisa.edu.au

Forecasting solar energy uses different techniques to overcome some of the problems in traditional techniques, such as Box-Jenkins forecasting. I will present how I can use differencing techniques to better forecast solar energy time series and compare results of this approach with results from both standard ARMA models and an approach adapted from models of the electricity power market.

4 - Time Series Analysis of Climate Related Variables

John Boland, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd., 5095, Mawson Lakes, South Australia, Australia, john.boland@unisa.edu.au

Early efforts, including those of the author, to model climate variables such as solar radiation have depended on classical time series methods. With a rapidly expanding renewable energy industry, a higher degree of precision is required in order to satisfy "bankability' constraints of the financial backers. We are developing innovative methods to advance the forecasting of both level and variability of solar radiation series and wind farm output series.

■ TC-14

Tuesday, 15:00-16:30
Meeting Room 207

Continuous Optimization in Life and Human Sciences I

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Moshe Sniedovich*, Dept. of Mathematics and Statistics, University of Melbourne, Parkville, 3010, Melbourne, Victoria, Australia, m.sniedovich@ms.unimelb.edu.au

1 - Robust Regression Analysis for Complex Regulatory Networks in Finance, Computational Biology and Life Sciences

Erik Kropat, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de, *Gerhard-Wilhelm Weber*

Many complex regulatory systems in finance, computational biology and life sciences depend on functionally related groups or coalitions of variables. Target-environment networks under ellipsoidal and polyhedral uncertainty provide a conceptual framework for such dynamic systems with uncertain multivariate states. We introduce various robust regression models for an estimation of the unknown system parameters and an identification of the underlying network structure. We discuss the solvability by semidefinite programming and conclude with future research challenges.

2 - Optimization of Linear Models for Streamflow Prediction: Elements of Comparison Between Classical and Bio-inspired Methods

Hugo Siqueira, Department of Systems Engineering, State University of Campinas, College of Eletrical Engeneering, Cidade Universitária Zeferino Vaz, Barão Geraldo District, 13083-970, Campinas, São Paulo, Brazil, hugovaladares@hotmail.com, *Romis Attux*, *Christiano Lyra*

Seasonal streamflow series are essential in countries where the generation is done by hydroelectric plants. Linear techniques have been often proposed to address this problem. Although the optimization of linear feedforward models is straightforward, the same is not valid for models with feedback loops (like ARMA models), in view of the potential multimodality of the resulting cost function.We investigate the comparative performance of classical gradient-based optimization methods and of a bio-inspired algorithm (CLONALG), which is potentially capable of overcoming the aforementioned drawback.

3 - Optimization of Collective Boxes of Mobile Phones in a Factory Located in the Industrial Pole of Manaus in Amazon State, Northern Brazil

Fabricio Rodrigues Costa, Institute Nokia of Technology, +559232365418, +559282312810, Manaus, Amazon, Brazil, fabricio.costa@indt.org.br

We show the results of an optimization project applied in collective package of mobile phones. This industry is located in Manaus, capital of Amazon state, Brazil. The modal transportation used is the aerial, volume and weight of boxes shipped influence directly the freight costs. Have considered different dimensions constraints, such as pallet, forklift, high-rack and airplanes. The results of the development of new packagings were the reduction in freight costs, reduced the product damage in operation and transport steps and contributes to reduce the environment impacts.

4 - Fooled by Robustness: a Perspective from the Land of the Black Swan

Moshe Sniedovich, Dept. of Mathematics and Statistics, University of Melbourne, Parkville, 3010, Melbourne, Victoria, Australia, m.sniedovich@ms.unimelb.edu.au

The latest edition of the best selling book "The Black Swan" features a new section on "On Robustness and Fragility" and it is argued that "... It is much easier to deal with the Black Swan problem if we focus on robustness to errors rather than improving predictions ..." In this presentation I show/prove that it is (almost) as easy to be fooled by robustness as it is to be fooled by randomness. This rather gloomy conclusion is based on the research in connection with my campaign (launched at the end of 2006) to contain the spread of info-gap decision theory in the Land of the Black Swan.

■ TC-15

Tuesday, 15:00-16:30
Meeting Room 208

Mathematical Modeling, OR, and Decision Making in Military & Defense Analysis

Stream: Military, Defense and Security Applications

Invited session

Chair: *Gio Kao*, Sandia National Laboratories, PO Box 5800, MS 1188, 87185, Albuquerque, New Mexico, United States, gkkao@sandia.gov

1 - Behavior-based Modeling of U.S. Army Officer Attrition

Patrick Driscoll, Systems Engineering, U.S. Military Academy, Mahan Hall, Bldg 752, 10996, West Point, New York, United States, patrick.driscoll@usma.edu

We present a behavior-based approach that models officer attrition via job preference matching. This top-down approach leverages discrete choice theory and Monte Carlo simulation in a manner that unifies the conjectures: that satisfaction is either an environmental phenomenon or it is an inherent personal trait. The modeling results closely replicate the attrition pattern currently exhibited by officer cohort groups, which presents an interesting opportunity for scenario excursions to inform management policy.

2 - Multi-agents Based Protocols for the Supply Chain Management

Nesrine Zoghlami, LAGIS, ENIG/Ecole centrale Lille, France, nesrine.zoghlami@gmail.com

The management and optimization of the military supply chain is very complex and involves multiple concepts. we present in this paper a distributed logistics system in which flows of resources are hierarchically forwarded from one zone to another, taking into account the randomness of resources' consumption. Our industrial partner EADS handles a logistic flows demonstrator for crisis management that tries to optimize the routing of these flows as well as to satisfy the needs in every zone. In this paper we propose the multi-agent technology for modeling the different actors of the logistics chain.

3 - Managing Capital Assets: Lifecycle Planning Through Performance Optimization

Gio Kao, Sandia National Laboratories, PO Box 5800, MS 1188, 87185, Albuquerque, New Mexico, United States, gkkao@sandia.gov, *Liliana Andrade*, *Craig Lawton*, *Roy Rice*

Effective capital assets lifecyle management to sustain/maximize performance is essential for organizations with fast changing needs. Decisions such as technology upgrades, obsolescence, procurement, and divestiture can be very complex due to large number of performance parameters, variables, and objectives. This presentation describes a tool using a framework that incorporates MILP for capital asset lifecycle management. The MILP formulation and an example application will be presented to illustrate the complexity of the decision in examining tradeoffs among performance, budget, and schedule.

■ TC-16

Tuesday, 15:00-16:30
Meeting Room 209

Simulation Modelling for Healthcare

Stream: Health Care Applications

Invited session

Chair: *Leonid Churilov*, The University of Melbourne, Neurosciences Bld, 300 Waterdale Rd, Austin Health, Repat Campus, 3083, Heidelberg Heights, VIC, Australia, leonid.churilov@gmail.com

1 - Hybrid Simulation Models for Healthcare

Israel Vieira, School of Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, United Kingdom, itvieira@hotmail.com

Healthcare systems are embedded into the community they serve, they integrate a large network of service providers and exhibit dynamic, detailed and behavioural complexity. Effective and sustainable decision making in healthcare requires tools that can encompass complexity, handle variability and foresee the consequences of actions. In this talk we evaluated the extent to which hybrid models can capture the dynamics of complex healthcare systems, review existing tools supporting the development of multi-method models, and define best practice for combining methodologies into one model.

2 - The Case for Combining: Developing Designs for Integrating System Dynamics (SD) and Discrete Event Simulation (DES) in Healthcare

Jennifer Morgan, Management Science, University of Strathclyde, Graham Hills Building, 40 George St, G1 1QE, Glasgow, United Kingdom, jennifer.s.morgan@strath.ac.uk

SD and DES have been extensively applied to a range of situations in many ways, and can provide complementary insights into a system. This research considers the value of combining these approaches and presents proposals for their integration within healthcare. Designs for linking and a framework for undertaking mixed modelling interventions are proposed, providing a toolkit of interaction options. The impact of applying this framework and designs to facilitate integration in practice is considered. Models developed with an oncology unit are discussed and proposed practices are reflected upon.

3 - Assessing the Effectiveness of Infection Control Policies for MRSA in Different Hospital Settings using a Multiscale Modelling Framework

Rosemarie Sadsad, University of New South Wales, Centre for Health Informatics, 2052, Sydney, New South Wales, Australia, r.sadsad@student.unsw.edu.au

Infection control policies have mixed results for MRSA due to differences in context. A range of policies were simulated to study their impact on MRSA for different hospital settings. The model is based on a multiscale modelling framework and validated with two Australian hospitals. The incidence of MRSA was different across ward types and bed locations. The prevalence of MRSA responded to hand washing policies only. The incidence of MRSA responded to hand washing, staffing and cohorting policies. Models that consider context help identify appropriate hospital policies for particular settings.

4 - Decision Support in Pre-hospital Stroke Care Operations: Improving Eligibility of Acute Stroke Patients for Thrombolysis Treatment with Simulation

Leonid Churilov, The University of Melbourne, Neurosciences Bld, 300 Waterdale Rd, Austin Health, Repat Campus, 3083, Heidelberg Heights, VIC, Australia, leonid.churilov@gmail.com, *Andrew Flitman*, *Helen Dewey*

There is a need for a solution capable of simultaneous systemic evaluation of multi-factorial interventions in pre-hospital acute care systems aimed at increasing patients' eligibility for stroke thrombolysis. We propose an OR solution in the form of a simulation model that provides clear measure of the relative benefit of alternative potential interventions, thus demonstrating how OR modelling can be used for providing decision support in pre-hospital stroke care operations.

■ TC-17

Tuesday, 15:00-16:30
Meeting Room 214

Network Optimisation

Stream: Network Optimisation and Telecommunications

Invited session

Chair: *Francisco Saldanha-da-Gama*, CIO/DEIO, University of Lisbon, FCUL-DEIO, Bloco C6, Piso 4, 1749-016, Lisbon, Portugal, fsgama@fc.ul.pt

1 - A Flow-dependent Quadratic Steiner Tree Problem in the Euclidean Plane

Charl Ras, Department of Electrical and Electronic Engineering, University of Melbourne, Grattan Street, 3010, Parkville, Victoria, Australia, cjras@unimelb.edu.au, *Doreen Thomas*, *Marcus Brazil*

We introduce a flow-dependent version of the quadratic Steiner tree problem. An instance of the problem on a set of sources and a sink asks for a directed tree spanning these nodes and a bounded number of Steiner points, such that the sum of products of the edge-flows and the squares of the edge-lengths is a minimum. Our motivation for studying this problem is as a model for relay-augmentation of wireless sensor networks. We prove geometric results on the structure of optimal and locally optimal solution-trees and describe a geometric linear-time algorithm for fixed-topology construction.

2 - Dual Decomposition for Computational Optimization of Minimum-Power Shared Broadcast Tree in Wireless Networks

Di Yuan, Department of Science and Technology, Linköping University, SE 601 74, Norrköping, Sweden, diyua@itn.liu.se, *Dag Haugland*

We consider the problem of constructing a minimum-power shared broadcast tree (SBT) in wireless communication networks. We approach SBT using dual decomposition method applied to an integer linear programming formulation. As a feature of the formulation, the relation between some of the variables is preferably formulated implicitly. The decomposition scheme is coupled with a fast local search algorithm. We report computational results demonstrating the effectiveness of the proposed approach. In average, the optimality gap is less than three percent.

3 - Models and Algorithms for N-k Survivable Network Design

Richard Chen, Quantitative Modeling and Analysis, Sandia National Laboratories, P.O. Box 969 MS 9155, 3806 Picard Ave., 94551, Pleasanton, CA, United States, rlchen@sandia.gov

We present general bilevel and trilevel optimization models to identify vulnerabilities in a network and plan expansion and defensive measures. We describe a new decomposition-separation algorithm for finding an optimal solution to the trilevel model. We illustrate the applicability of trilevel optimization to the N-k problem in power system design. Given a power system represented by a network with equations governing power flow, power generation and consumption, how do you optimally enhance the system to survive the simultaneous failure of k or fewer components?

4 - Hub Location Problems with Multiple Flow Categories

Francisco Saldanha-da-Gama, CIO/DEIO, University of Lisbon, FCUL-DEIO, Bloco C6, Piso 4, 1749-016, Lisbon, Portugal, fsgama@fc.ul.pt, *Isabel Correia*, *Stefan Nickel*

In this paper, a unified modeling framework is proposed for capacitated hub location problems with multiple flow categories. At most one hub (dedicated or not) can be located in each node. The capacity constraints refer to the non-processed incoming flow to the hubs. The framework includes several situations of practical interest. A mixed-integer linear programming formulation enhanced with several sets of additional inequalities is proposed as well as a reformulation yielding tighter lower bounds. A computational analysis is presented using data derived from the well-known AP data set.

■ TC-18

Tuesday, 15:00-16:30
Meeting Room 215

Applications of DEA

Stream: Data Envelopment Analysis

Invited session

Chair: *Arash Aliakbari*, Parto Novin Modiriat Iranian (Penco Consulting Group), Flat 4, No 22 , Unit 22 Separ St, Africa Blvd., Tehran, Iran, Islamic Republic Of, arashaliakbari@yahoo.com

1 - DEA Applications of Human Capital Investment to Achieve Knowledge-Based Economy in ASEAN5

Elsadig Ahmed, Faculty of Business and Law, Multimedia University, 75450, Melaka, Malaysia, elsadigmusa@yahoo.com

In this paper, the nature and extent of productivity changes of ASEAN5 countries, namely, Malaysia, Indonesia, Philippines, Thailand, and Singapore, are analyzed over the period 1993 to 2006. The Malmquist TFP index calculated within the framework of DEA is next decomposed into three constituent elements accounting for different sources of productivity growth, which are technological progress, efficiency change, and the effects of economies of scale. The analysis is carried out for the sample with and without human capital variable to isolate the impact of human capital investment on TFP growth in these countries. Results indicate that when human capital is included in the model, Malaysia and Singapore reported an increase in TFP and this growth in productivity is derived from both technical efficiency gain and technological progress.

2 - Sustainable R&D Portfolio Management

Nico Vandaele, Operations Management Dept., Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, nico.vandaele@econ.kuleuven.be, *Catherine Decouttere*

Assessing and managing a R&D portfolio is a multi-dimensional decision problem with three clusters: • Technological: system aspects of flow (lead time) and resources (capacity), operational and technological factuals • Financial: monetary aspects of flow (expenses) and resources (investments), financial and monetary factuals • Human: value aspects of flows (sustainability) and resources (ethical employment), human and non-monetary factuals The static and dynamic decision support model manages the R&D portfolio and steers R&D activities, illustrated with empirical findings.

3 - Telecommunications Reform and Efficiency Performance: Do Good Institutions Matter?

Noorihsan Mohamad, Economics Department, Faculty of Economics & Management Sciences, International Islamic University Malaysia, P.O. Box 10, 50728, Kuala Lumpur, Wilayah Persekutuan, Malaysia, noorihsan@gmail.com

This study uses stochastic distance function approach to capture the role of institutions in explaining the efficiency differences in telecommunications across 70 countries. The empirical analysis reveals that policy stability in the form of substantive checks and balances on executive power is the most important aspect for successful reform. Independently, legal integrity improves telecommunications efficiency through privatization,while greater freedom from corruption influences the effectiveness of a regulatory body.

4 - Comparison of Urban Households Efficiency using Data Envelopment Analysis

Alireza Moghtadaei, CBI, 213 Ferdowsi Ave., 1135931496, Tehran, Iran, Islamic Republic Of, alimoghtadaie44@yahoo.com, *Arash Aliakbari*

The aim of this paper is to determine and compare the cost efficiency for households who are living in different provinces in Iran by Data Envelopment Analysis. Each household is considered as one DMU. We then compare several provinces in terms of their optimality use in each household.

■ TC-19

Tuesday, 15:00-16:30
Meeting Room 216

The Changing Skills Graduates Need To Be Successful In Applying Analytics

Stream: Education and Operations Research

Panel session

Chair: *Sandra Hogan*, Telstra, Melbourne, Australia, vsh010@gmail.com

Chair: *Evan Stubbs*, SAS, Lane Cove, Australia, Evan.Stubbs@sas.com

Chair: *James Cochran*, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu

Chair: *Peter O'Hanlon*, Australian Crime Commission, Canberra City, Australia, peter.ohanlon@crimecommission.gov.au

Chair: *Antony Ugoni*, National Australia Bank Ltd, Docklands, Australia, antony.m.ugoni@nab.com.au

1 - Changing Skills Graduates Need To Be Successful In Applying Analytics

James Cochran, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu, *Sandra Hogan*, *Peter O'Hanlon*, *Evan Stubbs*, *Antony Ugoni*

As analytics becomes increasingly entrenched within organizations, the skills needed to support innovation continue to grow. This panel will provide a variety of perspectives on what is needed for the next generation of analytics practitioners and involves representatives from industry associations, vendors, and the public/private sector.

■ TC-20

Tuesday, 15:00-16:30
Meeting Room 217

AHP II

Stream: Analytic Hierarchy/Network Process

Invited session

Chair: *Renaud Silva*, EBAPE, FGV-RJ, Praia Do Flamengo, Andar da Ebape, Botafogo, 20000, Rio de Janeiro, RJ, Brazil, renaud.barbosa@fgv.br

1 - Humanitarian Logistics: Location of an Intelligence and Support Facility for Natural Disasters or Complex Emergency Situations

Mirian Buss Goncalves, DEPS, UFSC, Rua Arlindo Penna, 27, 88037260, Florianopolis, Santa Catarina, Brazil, mirianbuss@gmail.com, *Christiane W. Nogueira*

Situations such as hurricanes, floods, earthquakes, terrorist attacks and other such events require specialized logistics, known as Humanitarian Logistics. In this context, we develop a model to determine the location of an intelligence and support unit for the storage, control and distribution of the resources needed in these emergency situations, using the Analytic Hierarchy Process (AHP). Also we show an application of the model to a natural disaster of floods and landslides that occurred in 2008, in the state of Santa Catarina, located in southern Brazil and the results obtained.

2 - AHP in a Multi Actor Setting: Experiences in the Transport and Mobility Sector

Cathy Macharis, MOSI-Transport and Logistics, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, Cathy.Macharis@vub.ac.be, *Klaas De Brucker*

Including stakeholders along the entire decision making process provides a better basis for the implementation of the ultimate decision. This is particularly important in the transport sector where often different stakeholders have conflicting points of view. The Multi Actor Multi Criteria Analysis (MAMCA) methodology in which AHP is often used, provides a good framework for including these points of view within the decision framework. Several applications within the transport and mobility sector will be shown.

3 - Evaluation of Supply Chain Performance in Fuzzy Environment with the AHP-TOPSIS Hybrid Method

Ergun Eraslan, Industrial Engineering, Baskent University, Baglica Campus Eskisehir Yolu 20 km, Etimesgut, 06810, Ankara, Turkey, eraslan@baskent.edu.tr

The competition in the dynamic market conditions has increased the importance of Supply Chain Management. The effectiveness of an organization on supply chain is needed to evaluate of suppliers' performance for both short and long term goals. This process is a multi-criteria decision analysis problem. In this study, a hybrid model is proposed for evaluation of the supplier performances of an electronic company. The fuzzy AHP Method is used for determination of the relative weights of the criteria and the performances of alternative companies are ranked by using Fuzzy TOPSIS method.

4 - GSM Operator Selection for a Call Center Investment by Using AHP

Özcan Çavusoglu, Industrial Engineering Ph.D. Programme, Istanbul Technical University, Institute of Science and Technology, Faculty of Management, 34367, Istanbul, MAÇKA,

Turkey, cavusogluo@itu.edu.tr, *Mustafa Canolca*, *Demet Bayraktar*

The aim of study is to propose a selection system, will provide a comprehensive approach for selecting the best GSM operator for Call Center, is selling GSM operator's prepaid minutes, investment. For this purpose, a literature review is performed about GSM. Then, interviews have been carried out with authorized experts; decision factors have been defined and evaluated by using AHP respectively. Finally, the best alternative GSM operator has been selected by using Goal Programming to consider cost, investment, profit etc. goals. The results and future work have been discussed in detail.

■ TC-21

Tuesday, 15:00-16:30
Meeting Room 218

Robustness and Recovery in Airline Operations

Stream: Airline Applications
Invited session

Chair: *Karla Hoffman*, Department of Systems Engineering and Operations Research, George Mason University, Mail Stop 4A6, 4400 University Drive, 22030, Fairfax, Virginia, United States, khoffman@gmu.edu

1 - Robust Airline Scheduling: Minimising Propagated Delay in an Integrated Routing and Crewing Framework

Michelle Dunbar, Mathematics and Statistics Dept., 18 Kalkada Avenue, Gymea Bay, 2227, Sydney, NSW, Australia, m.dunbar@unsw.edu.au, *Gary Froyland*

Traditionally, the airline scheduling problem has been sequentially decomposed into various stages, with earlier decisions imposed upon those of subsequent stages. Unfortunately, this fails to capture the dependencies between the stages of aircraft routing and crew pairing, and how these dependencies affect the propagation of delays through the flight network. To produce a jointly robust solution, routing and crewing decisions need to be made together. We outline a new approach to accurately calculate and minimise the cost of propagated delay, in an integrated routing and crewing framework.

2 - Recoverable Robustness Approach for the Tail Assignment Problem

Stephen Maher, Mathematics and Statistics, University of New South Wales, 2052, Sydney, NSW, Australia, stephen.maher@student.unsw.edu.au, *Gary Froyland*

Airlines are affected by disruptions daily and the recovery process can result in increased operational costs. To reduce the difference from planned to operational costs, redundancies are added using robust planning. In developing a less conservative robust planning, we introduce the concept of recoverable robustness for the tail assignment problem. We simultaneously solve the tail assignment planning and recovery problems to integrate recovery decisions into the original plan. As a result we develop a tail assignment that is recoverable with a minimal number of operational changes.

3 - A Disruption Neighbourhood Approach to the Airline Recovery Problem

Imran Ishrat, Engineering Science, The University of Auckland, 70 Symonds St, Level 3, Auckland, New Zealand, i.ishrat@auckland.ac.nz, *Matthias Ehrgott*, *David Ryan*

Airlines plan their crew schedules and aircraft routes ahead of time. However, on the day of operation schedules do not always proceed as planned due to unforeseen disruptions. In such situations schedule recovery is desired to get back to the originally planned schedule as soon as possible. In this work we propose the idea of an expanding disruption neighbourhood to solve a sequence of small crew rostering and aircraft routing problems (using set partitioning models) until a suitable recovery solution is obtained. The method is tested on various instances of disruptions on domestic operations of an airline.

4 - Cost of Delay to the Airline Industry

Karla Hoffman, Department of Systems Engineering and Operations Research, George Mason University, Mail Stop 4A6, 4400 University Drive, 22030, Fairfax, Virginia, United States, khoffman@gmu.edu

Establishing an accurate mechanism for estimating the cost of a delays for each portion of a flight (gate costs, taxiing in and out costs, and en-route costs) is useful for many aspects of modeling airline behavior and for better understanding the likely impact of regulations. This paper explains how we used a Euro Control paper (2004) and reversed engineer the components of their model to be able to explicitly identify each of the components of an airline's costs at each segment of an airline flight: gate costs, taxiing costs, and airborne costs.

Tuesday, 17:00-18:30

■ TD-01

Tuesday, 17:00-18:30
Plenary Hall 3

OR Consultancy and Case Studies 2

Stream: OR Practice
Invited session

Chair: *John Ranyard*, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, jranyard@cix.co.uk

1 - Modelling Human Services Networks At Centrelink

David Sier, Mathematics, Informatics and Statistics, CSIRO, Private Bag 33, Clayton South MDC, 3168, Melbourne, Victoria, Australia, David.sier@csiro.au, *Mark Horn*, *Warren Jin*, *Leorey Marquez*, *Ross Sparks*, *Stuart Woodman*, *Jane Athanasiadis*, *Donald Wolters*, *Lance Snowdon*, *Lisa Parker*

Abstract: Centrelink delivers a range of payments and services to the Australian public. It supports people in need and assists people to become self sufficient. This talk describes a network modelling approach to the evaluation of Centrelink customer pathways, which comprise sequences of activities that customers carry out while receiving support. Our aim is to identify particular paths in the network of customer interactions with Centrelink to inform best practice, identify service delivery gaps and improvement. We describe the results from simulation models and longitudinal parametric statistical models based on customer history records and their use to predict potentially efficient pathways for customers to follow.

2 - Artisanal Fisheries Analysis using the DPSIR Framework and System Dynamics: The Case of Dredge Fisheries in Portugal

Ana Camanho, Faculdade de Engenharia, Universidade do Porto, DEMEGI - GEIN, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, acamanho@fe.up.pt, *Joana Martins*, *Manuela Maria Oliveira*, *Miguel Gaspar*

This paper explores the application of the DPSIR framework to fisheries. A set of indicators that represent the key features of artisanal fisheries are applied to a case study of artisanal dredge fisheries in Portugal. This is followed by the development of a System Dynamics model to predict the behavior of the fisheries system under different assumptions concerning the evolution of the economic context. The study of dredge fisheries illustrates the potential of this approach to provide a multidisciplinary perspective of fisheries systems, including economic, social and ecologic dimensions.

3 - Delivery Fee Design for Logistics Partnerships

Harihara Natarajan, University of Miami, 33124, Coral Gables, FL, United States, hnataraj@exchange.sba.miami.edu, *Anant Balakrishnan*

As manufacturers and distributors increasingly develop close partnerships, they must properly negotiate the terms of collaboration and interaction with their partners. Compensation schemes play an important role in fostering such collaborations. Motivated by a problem facing a large building-products manufacturer, we propose an optimization model to determine delivery fees, using fee tables, for a manufacturer's distribution partners. Our industry partner developed fee tables using our model and achieved significant savings. In this talk, we will describe our model and application.

■ TD-02

Tuesday, 17:00-18:30
Meeting Room 101

Issues in Game Theory

Stream: Game Theory
Invited session

Chair: *Ryusuke Hohzaki*, Department of Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239-8686, Yokosuka, Kanagawa, Japan, hozaki@cc.nda.ac.jp

1 - Aggregate Monotonic Stable Single-valued Solutions for Cooperative

Pedro Calleja, Economical, Financial and Actuarial Mathematics, University of Barcelona, Facultat de CC. Economiques i Empresarials, Av. Diagonal 690, 08034, Barcelona, Spain, calleja@ub.edu, *Carles Rafels*, *Stef Tijs*

This paper considers single-valued solutions of transferable utility cooperative games that satisfy core selection and aggregate monotonicity. The main result is that for an arbitrary set of players, core selection and aggregate monotonicity are compatible with individual rationality, the dummy player property and symmetry for single-valued solutions defined either on the set of all games, or on the set of essential games (those with a non-empty imputation set). This result solves an open question in the literature noted by Selten and quoted in Young et al. (1982).

2 - An Axiomatization of Success in Voting Situations

Josune Albizuri, Applied Economics IV, UPV/EHU, Fac. Economics, Lehendakari Aguirre, 83, 48015, Bilbao, Spain, elpalirm@bs.ehu.es, *Annick Laruelle*

We provide an axiomatization of the measures of success in voting situation, defined by Laruelle and Valenciano (2005. These measures are associated with a probability distributions over the set of all possible vote configurations. A measure of the first type gives the probability for a voter of having the result he voted for. A measure of the second type gives the probability for a voter of having the result he voted for conditioned on voting yes. And the last ones give the probability for a voter of having the result he voted for conditioned on voting no.

3 - A Cooperative Model of Search Game

Ryusuke Hohzaki, Department of Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239-8686, Yokosuka, Kanagawa, Japan, hozaki@cc.nda.ac.jp

Most of search games have been studied in non-cooperative contexts. Here we deal with a cooperative search game, where multiple searchers behave cooperatively to detect a target. First we discuss the possibility of a coalition among the searchers and define a characteristic function. The function measures the randomness on whether the searchers can detect the target in the search operation. We complete the cooperative modeling by giving a methodology of distributing the obtained target value among the coalition members or a point in the core.

■ TD-03

Tuesday, 17:00-18:30
Meeting Room 102

Metaheuristics Applications to Production Planning with Deterioration and Perishability

Stream: Meta-heuristics
Invited session

Chair: *Julia Pahl*, IWI - Wirtschaftsinformatik, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, pahl@econ.uni-hamburg.de

1 - Tactical Production Planning with Load-dependent Lead Times and Depreciation Effects: Model Formulation and Solution Finding using Heuristic Methods

Julia Pahl, IWI - Wirtschaftsinformatik, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, pahl@econ.uni-hamburg.de

Lead times impact the performance of supply chains. Their consideration is essential, because long lead times impose high costs due to rising work in process, inventory levels and large safety stocks caused by increased uncertainty. Planning models typically treat lead times as input data, but often output of a planning model implies capacity utilization which, in turn, implies lead times. The situation gets inflated if product lifetimes are restricted and deterioration effects increase utilization. We give a model formulation propose heuristic methods to solve such complex problem.

2 - A Multi-objective Genetic Algorithm to Determine Accrue Provision Rates Achieving Smooth and Low Inventory Write-downs with Real Settings in a Semiconductor Memory Maker

Jei-Zheng Wu, Business Administration, Soochow University, 56 Kueiyang St., Sec. 1,, 100, Taipei, Taiwan, jzwu@scu.edu.tw

Most of semiconductor memory manufacturers have suffered from high inventory write-downs and subsequent negative impacts on stock market performance. This study aims to develop a multi-objective genetic algorithm to determine accrue provision rates that can generate a set of nondominated solutions of low inventory write-downs and low write-downs variation. A case study was conducted for validation. The proposed algorithm can help top managers compare and determine a number of write-down strategies by an interactive process to extract their preferences over write-downs levels and stability.

3 - Two-Warehouse Supply Chain Model with Power-form Stock Dependent Demand

Chaman Singh, Mathematics, Acharya Narendra Dev College, (University of Delhi), Chaman Singh, Dept. of Mathematics,, Acharya Narendra Dev College, (Unviersity of Delhi), Govindpuri, KalkaJi, 110019, New Delhi, Delhi, India, chamansingh07@gmail.com, *Shivraj Singh*

In realistic world, there usually exist various factors that induce the retailer to order more items than the capacity of his Own-warehouse (OW). Therefore, for the retailer, it is very practical to determine whether or not to rent other warehouse and what order policy to adopt if other warehouse is indeed needed. For the stock dependent demand pattern, retailer has his own warehouse to display the items and may hire another warehouse of the larger capacity, treated as rented warehouse (RW) to storage the excess inventory. In this paper, a supply chain model with power form stock-dependent demand rate is developed. The demand rate is assumed to be a polynomial form of current inventory level in Own-warehouse. It is considered that the deterioration rate per unit items in the RW and OW are different due to different preservation environments as a consequence the holding costs per unit item in RW and OW are also different. Proposed model is illustrated with some numerical example along with some sensitivity analysis of parameters.

■ TD-04

Tuesday, 17:00-18:30
Meeting Room 103

Revenue Management 1

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Joern Meissner*, Kuehne Logistics University, Hamburg, Germany, joe@meiss.com

1 - The Use of Design of Experiment in Strategic Decision Making

Emre Alptekin, Industrial Engineering Dept., Galatasaray University, Turkey, ealptekin@gsu.edu.tr, *Gülfem Isiklar Alptekin*

In todays' the economic world, the capacity and the existence of the companies become directly related to their market value. It is essential that the company or the organization addresses to its current and prospective customers; and the best way of carrying out this is marketing. As marketing become more and more important, a need for making strategic decisions in this field emerged. In this work, we have analyzed which factors influence the market share value of a globally known soft drink company.

2 - Challenges in Air Cargo Revenue Management

Joern Meissner, Kuehne Logistics University, Hamburg, Germany, joe@meiss.com, *Kevin Glazebrook*, *Emily Cookson*

The Air Cargo industry faces some unique challenges: Highly volatile demand, weight/volume uncertainty even for pre-booked allotments and very short booking cycles are some of the features. We propose a new dynamic programming formulation that an air cargo company can use to maximize its expected profit. Our formulation differs from previous ones in that capacity and demand uncertainty is incorporated into the model using probability distributions. We present first numerical results from an industry project with the cargo division of a major airline.

3 - Risk Minimizing Strategies for RM Problems with Target Values

Joern Meissner, Kuehne Logistics University, Hamburg, Germany, joe@meiss.com, *Matthias Koenig*

We consider a risk-averse decision maker in the setting of a single-leg dynamic revenue management problem with revenue controlled by limiting capacity for a fixed set of prices. Instead of focussing on maximizing the expected revenue, the decision maker has the objective of minimizing the risk of failing to achieve a given target revenue. Interpreting the problem in the framework of finite Markov decision processes, we augment the state space and change the objective to the probability of failing a specified target revenue. We present a numerical study and discuss advantages and limitations.

■ TD-05

Tuesday, 17:00-18:30
Meeting Room 104

Marketing/Operations IV

Stream: OR and Marketing
Invited session

Chair: *Wei Shi Lim*, NUS Business School, 12345, Singapore, Singapore, weishi@nus.edu.sg

1 - Optimal Dynamic Pricing Strategies in the Presence of Speculators and Forward Looking Consumers: Are Speculators Friends or Foes?

Wei Shi Lim, NUS Business School, 12345, Singapore, Singapore, weishi@nus.edu.sg, *Christopher Tang*

In a market with speculators whose sole objective is to arbitrage on the anticipated price differential to make a profit, we identify conditions under which the firm should deliberately price lower in Period 1 by selling to speculators so as to increase the number of arrivals in Period 2 in a downward market. We fruther show that speculators can help the firm to "price into the future' in a rising market if increased sales in Period 1 can boost the potential demand in Period 2. Finally, we examine whether a third-party should and could deter speculators' entry by imposing an entry barrier.

2 - Information Provision and Price Competition in a Duopoly Setting

Chung-Chi Hsieh, Department of Industrial and Information Management, National Cheng Kung University, 1, University Road, 701, Tainan, Taiwan, jcchsieh@mail.ncku.edu.tw, *Wei Shi Lim*

This paper studies the retailers' information provision and pricing strategies in a duopoly setting in the presence of heterogeneous consumers. By characterizing heterogeneity of consumers in terms of information possessed and loyalty, we develop an approximate yet analytical model of the retailers' equilibrium decisions. We then analyze how consumer heterogeneity and search cost shape the retailers' equilibrium decisions and profits.

3 - Optimal Pricing and Inventory Strategies With Stochastic Demands and The Option of Overselling

Wee Meng Yeo, Singapore Institute of Manufacturing Technology, 71 Nanyang Drive, 638075, Singapore, yeowm3@singnet.com.sg, *Wei Shi Lim*

We examine a two-period model in a duopoly where each seller may also adopt the overselling strategy, where goods sold earlier may be resold to late consumers as long as an appropriate compensation is provided to the early consumers. This work extends the majority of overbooking literature that do not consider price discrimination, much less pricing strategies. We provide exact conditions under which overselling and conventional selling are equilibrium selling strategies.

4 - Optimal Pricing of Customized Products

Brigitte Werners, Management and Economics, Ruhr-University Bochum, Universitätsstr, 44780, Bochum, Germany, or@rub.de, *Niels Becker*

Companies use modular systems for their products and allow customers to construct their products individually to meet their requirements. Usually, the final price of a customized product is the sum of the prices of the selected components. A new linear model is suggested to determine these prices for components optimally considering different customer segments. Using an illustrative example, results are compared to the outcomes of varying product line designs. Companies can increase their profit with optimal pricing customized products compared to offering a small product line.

■ TD-06

Tuesday, 17:00-18:30
Meeting Room 105

City Logistics

Stream: Transportation

Invited session

Chair: *Teodor Gabriel Crainic*, Management and Technology, Univ. du Québec à Montréal, C.P. 8888, succ. Centre-Ville, H3C 3P8, Montréal, Québec, Canada, theo@crt.umontreal.ca

1 - Incentives for Off-Hour Deliveries: A Business Friendly Way to Achieve Environmental and Economic Goals in Congested Urban Areas

Jose Holguin-Veras, Rensselaer Polytechnic Institute, United States, jhv@rpi.edu

In this talk, Professor Holguin-Veras will discuss the key findings of an important concept, based on the use of incentives to receivers in exchange for their commitment to accept off-hour deliveries. This project, pilot tested in New York City, has baen lauded by the freight industry as a path breaking effort to be emulated. The estimates produced indicate that, depending on the extent of the implementation, up to 20% of the total truck traffic could bw switched to the off-hours. The economic savings amount to $100-$200 million per year.

2 - Routing and Scheduling of Hazardous Material in Urban Areas

Rojee Pradhananga, Department of Urban Management, Kyoto University, C1-3, Katsura Campus, Kyoto, Japan, rojee@kiban.kuciv.kyoto-u.ac.jp

A meta-heuristics solution procedure based on Multi-Objective Ant Colony System (MOACS) has been presented to optimize Vehicle Routing and scheduling Problem with Time Windows (VRPTW) for hazardous material distribution in urban areas. The algorithm returns a set of routing solutions that approximate the frontier of the Pareto optimal solutions based on total scheduled travel time and total risk of whole transportation process. The algorithm works in a single-step fashion during the selection of vehicle routes utilizing non-dominated paths in terms of risk and travel time among customers.

3 - Addressing Demand Uncertainty in City Logistics

Teodor Gabriel Crainic, Management and Technology, Univ. du Québec à Montréal, C.P. 8888, succ. Centre-Ville, H3C 3P8, Montréal, Québec, Canada, theo@crt.umontreal.ca, *Fausto Errico*, *Walter Rei*, *Nicoletta Ricciardi*

We focus on tactical planning for two-tiered City Logistics systems. We review the main concepts and discuss types and sources of uncertainty. We then present a two-stage model to account for demand uncertainty while building the tactical plan. We discuss recourse options and related algorithmic challenges. Preliminary computational results will also be reviewed.

■ TD-07

Tuesday, 17:00-18:30
Meeting Room 106

Topics in Combinatorial Optimization II

Stream: Combinatorial Optimization

Invited session

Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - The Mathematics of Discrete Distance Geometry

Leo Liberti, LIX, Ecole Polytechnique, LIX, Ecole Polytechnique, 91128, Palaiseau, France, leoliberti@gmail.com, *Carlile Lavor*, *Nelson Maculan Filho*, *Antonio Mucherino*

The fundamental problem of distance geometry consists in determining whether a given weighted undirected graph G=(V,E,d) has an embedding x:V->RK feasible with d. Given an appropriate vertex order, it can be shown that the search is limited to a discrete set of embeddings. If each vertex with order rank greater than K has least K immediate and adjacent predecessors, we can prove that the number of non-congruent embeddings is a power of two, and that there are some interesting subclasses of instances (including protein backbones) that can be embedded in RK in polynomial time.

2 - The Bounded Cycle Cover

Irene Loiseau, Departamento de Computación-, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón I - Ciudad Universitaria, 1428, Buenos Aires, Argentina, irene@dc.uba.ar, *Nelson Maculan Filho*, *Guillermo Picardi*

The Bounded Cycle Cover Problem requires to determine a minimum cost cycle cover of a graph, with cycles bounded in length and number of edges. This problem arises in the design of fiber-optic telecommunications networks that employ multiple selfhealing rings to provide routing for communication traffic, even in the event of a fiber cut or other kinds of failures. We review algorithms for the BCCP appearing at the literature and we present results of new branch and price and heuristic algorithms we developed for this problem. We will compare our results with previous ones.

3 - Heuristic Algorithms for the Train-Unit Assignment Problem

Valentina Cacchiani, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, valentina.cacchiani@unibo.it, *Alberto Caprara*, *Paolo Toth*

We present fast heuristic algorithms for an important NP-hard problem, the Train-Unit Assignment Problem, arising in the planning of a railway passenger system, which calls for the definition of the train units to be assigned to a given set of timetabled trips, each with a given number of passenger seats requested. The proposed algorithms are tested on real-world instances of a regional Italian railway company. With respect to an already existing method, the proposed heuristic algorithms turn out to be much faster in practice and still providing solutions of good or even better quality.

■ TD-08

Tuesday, 17:00-18:30
Meeting Room 107

Supply Chain Management & Logistics

Stream: Dynamic Programming

Invited session

Chair: *Thomas Archibald*, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, T.Archibald@ed.ac.uk

1 - Inventory Decisions for Durable Goods with Volatile Demand

Vera Tilson, University of Rochester, 14627, Rochester, United States, vera.tilson@simon.rochester.edu

We consider an inventory problem faced by the manufacturer of durable goods who sells the goods on the retail market. There is an active second-hand market, and goods produced in the current period compete with the old goods previously sold to consumers. The demand model is based on modeling heterogeneous rational consumers maximizing their utility over an infinite horizon. We assume that the consumers' willingness to pay is subject to randomness due to economic conditions. We use the concept of Markov Perfect Equilibrium to characterize a profit-maximizing inventory policy.

2 - Dynamic Programming Based Algorithm for Supply Chain Coordinating Problem in Iron & Steel Production

Yang Yang, The Logistics Institute, Northeastern University, 110812, Shenyang, Liaoning, China, yangyang@ise.neu.edu.cn, *Lixin Tang*

Iron & steel production can be divided into multiple stages, it is important to coordinate the production in each stage in order to satisfy the material requirement for each production line and reduce the total production cost. Then the supply chain coordinating problem is proposed to determine the supply quantity and the destination production line for each production line in the preceding stage. To describe the problem, a mixed integral programming model is formulated. Then dynamic programming based algorithm is developed to solve the problem whose efficiency is verified by experiment.

3 - Modelling Unidirectional Transshipments from a Retail Network to Support a Virtual Store

Thomas Archibald, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, T.Archibald@ed.ac.uk, *Jiaqi Zhang*

We consider a multi-location inventory system in which demand at one of the locations can be met by local stock or by transshipment from any of the other locations. This situation arises, for example, in a retail company which has a branch network and a virtual store. Under the assumption of independent continuous review replenishment with fixed lead time at each location, we model the system as a semi-Markov decision process. Using decomposition, we develop an effective heuristic transshipment policy.

■ TD-09

Tuesday, 17:00-18:30
Meeting Room 108

VRP II

Stream: Vehicle Routing
Invited session

Chair: *Vinícius Armentano*, Faculdade de Engenharia Elétrica e de Computação, Universidade de Campinas, FEEC-UNICAMP, Av. Albert Einstein 400, 13083-852, Campinas, São Paulo, Brazil, vinicius@densis.fee.unicamp.br

1 - Estimation of an Activity-based Demand Model as a Class of Vehicle Routing Problems using Inverse Optimization

Joseph Chow, Institute of Transportation Studies, University of California, Irvine, 4000 Anteater Instruction and Research Bldg (AIRB), 92697, Irvine, CA, United States, joseph.chow@gmail.com, *Will Recker*

Inverse optimization is used to estimate unknown coefficients of the utility function of activity-based travel demand models formulated as vehicle routing problems that are based on a utility maximizing behavioral framework, as well as for estimating coefficients of multiple objectives based on observed patterns. The household activity pattern problem is presented as one such model. The inverse household activity pattern problem with soft time windows is estimated using a cutting plane algorithm and tested with the 2001 California Household Travel Survey.

2 - Routing with Multiple Deliverymen

Reinaldo Morabito, Dept. of Production Engineering, Federal University of São Carlos, CP 676, 13565-905, Sao Carlos, Sao Paulo, Brazil, morabito@ufscar.br, *Vitória Pureza*

In real life distribution of goods, relatively long service times may make it difficult to serve all requests during regular working hours, particularly when the beginning of the service in each site must occur within a time window, and violations of routing time restrictions are highly undesirable. We address this situation with a variant of the vehicle routing problem with time windows for which a number of extra deliverymen can be assigned to each route. We present a mathematical programming formulation for the problem and a tabu search heuristic for obtaining minimum cost routes.

3 - Fleet Deployment Optimization for Tramp Shipping

Vinícius Armentano, Faculdade de Engenharia Elétrica e de Computação, Universidade de Campinas, FEEC-UNICAMP, Av. Albert Einstein 400, 13083-852, Campinas, São Paulo, Brazil, vinicius@densis.fee.unicamp.br, *Rodrigo Branchini*

We address a tactical planning problem faced by many tramp shipping companies that have cargo contracts that they are committed to carry, while trying to serve optional spot cargoes to increase its revenue over medium-term horizon. The decisions include the number and type of vessels deployed, the assignment of vessels to contractual and spot voyages and the determination of vessel routes and schedules in order to maximize the profit. This problem is modeled as a mixed integer programming which is solved using COIN-OR open source platform. Computational results are reported.

■ TD-10

Tuesday, 17:00-18:30
Meeting Room 111

Planning Railway Rapid Transit

Stream: Public Transit
Invited session

Chair: *Juan A. Mesa*, University of Seville, 41092, Sevilla, Spain, jmesa@us.es

1 - Recovery of Disruptions in Rapid Transit Networks

Luis Cadarso, Matemática Aplicada y Estadística, Universidad Politécnica de Madrid, Pz. Cardenal Cisneros, 3, 28040, Madrid, Spain, luis.cadarso@upm.es, *Ángel Marín*, *Gabor Maroti*

This paper focuses on disruption management of Rapid Transit Rail Networks; such networks feature frequent train services and heavy passenger loads. In current practice, the timetable (TT) and the rolling stock (RS) are rescheduled sequentially. Here we propose an integrated multiobjective model for TT and RS recovery to minimize the recovery time, the passenger inconvenience and the incurred system costs. The model is validated by a simulation tool of the passenger flows during the disruption. The computations are based on realistic problem instances of the Spanish rail operator RENFE.

2 - A Path-relinking Algorithm for the Railway Network Design Problem

Federico Perea, Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, 46021, Valencia, Spain, perea@us.es, *Antonio J. Lozano*, *Juan A. Mesa*

Our railway network design problem in the presence of a competing transportation mode consists of choosing a set of stations and links so that the number of passengers that find the railway network more attractive than an already operating transportation mode is maximized. Due to the NP-hardness of this problem, heuristics are needed. In this presentation a path-relinking algorithm is proposed.

3 - A Review of Railway Rapid Transit Planning

Juan A. Mesa, University of Seville, 41092, Sevilla, Spain, jmesa@us.es, *Gilbert Laporte*, *Francisco A. Ortega*, *Federico Perea*

During last 30 years there has been an important increase in the number of metro and commuter systems all over the world. On the one hand, construction of such systems requires large investments and on the other hand the quality of the service is an important social issue thus motivating the application of scientific tools. Planning such systems gives rise to several mathematical problems such as network and line planning, timetable, scheduling, crew rostering and disruption management, among others. In this talk, the literature on analytical methods for solving these problems is reviewed.

4 - A Frequency Setting Model for Auxiliary Bus Lines on Disrupted Rapid Transit Networks

Esteve Codina, Statistics and Operational Research, UPC, Edifici C5, Desp 216 Campus Nord, 08034, Barcelona, Spain, esteve.codina@upc.edu, *Ángel Marín*, *Francisco Lopez*

A model is presented for dimensioning the number of services in bus lines intended for alleviating disruption situations of regular services in metro and Rapid Transit networks. The coordination between disrupted services and convoys of the auxiliary bus system is taken into account and the effects of congestion due to high levels of demand are also modeled. The model is formulated as an nonlinear mixed integer programming problem and results of ad hoc heuristics as well as classical methods are shown for medium size networks.

■ TD-11

Tuesday, 17:00-18:30
Meeting Room 112

Simulation for Supply Chain Management

Stream: Simulation - Sponsored by I-SIM

Invited session

Chair: *Preston White*, Systems and Information Engineering, University of Virginia, P.O. Box 400747, 151 Engineers' Way, 22904-4747, Charlottesville, VA, United States, kpwhite@virginia.edu

1 - Modelling and Simulation of a Palm Oil Mill towards Effective Supply Chain Management

Fazeeda Mohamad, Technology Management, Universiti Malaysia Pahang, H-95 Jalan Karyawan 11, Taman Guru, 25150, Kuantan, Pahang, Malaysia, adeezaf@yahoo.com

This paper evaluated the capacity of the palm oil mill. The under utilized of capacity effect the capacity of the mill due to shortage of materials. Data were collected from a palm oil mill as our case study. Modelling and simulation were used in designing and accessing the mill operation using Arena simulation.The result will help the management to do better capacity planning towards effective supply chain.

2 - Time Depending Network Node Modelling and Effectcause Vehicle Modelling for Sustainable Public Transportation Systems

Joeri Van Mierlo, MOBI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, jvmierlo@vub.ac.be

This article describes a multi-train mathematical model for rail networks capable of estimating the energy consumption of different tram and metro networks. The simulations determine the vehicles and substations power and the energy exchange among simultaneously running vehicles. Energy consumption reduction that can be achieved by introducing energy storage technologies in sustainable transportation systems is evaluated

3 - Empirical Tests of Variables Acceptance Sampling Plans

Preston White, Systems and Information Engineering, University of Virginia, P.O. Box 400747, 151 Engineers' Way, 22904-4747, Charlottesville, VA, United States, kpwhite@virginia.edu

Acceptance sampling, originally developed as an approach to determining the quality of procured items, can be adapted to verifying design requirements using Monte Carlo methods (White, et al., 2009). Extending this research, we implemented variables acceptance sampling plans for six standard output distributions reported in the literature. In this paper, we present the results of tests which provide an independent assessment of the validity and accuracy of these plans.

■ TD-12

Tuesday, 17:00-18:30
Meeting Room 205

Networks

Stream: Contributed Talks

Contributed session

Chair: *Shunji Umetani*, Osaka University, 2-1 Yamadaoka, Suita, 560-0871, Osaka, Japan, umetani@se.uec.ac.jp

1 - A Model of Adding Relation between the Top and a Member in a Linking Pin Organization Structure

Kiyoshi Sawada, Department of Information and Management Science, University of Marketing and Distribution Sciences, 3-1, Gakuen-nishi-machi, Nishi-ku, 651-2188, Kobe, Japan, Kiyoshi_Sawada@red.umds.ac.jp

The purpose of our study is to obtain an optimal set of additional relations to the linking pin organization such that the communication of information between every member becomes the most efficient. This study proposes a model of adding relation between the top and a member in a linking pin organization where every pair of siblings in a complete K-ary tree of height H is adjacent. When a new edge between the root and a node with a depth N is added, an optimal depth N* is obtained by minimizing the total distance which is the sum of lengths of shortest paths between every pair of all nodes.

2 - Conjecture of Aouchiche and Hansen about the Randic Index

Ljiljana Pavlovic, Department of Mathematics, Faculty of Natural Sciences nd Mathematics, Radoja Domanovica 14, 34000, Kragujevac, Serbia, pavlovic@kg.ac.rs, *Marina Stojanovic*

Let G(k,n) be the set of connected simple graphs which have n vertices and the minimum degree of vertices is k. The Randic index of a graph G is defined as sum of d(u)d(v) raised to the power of -1/2 , where d(u) is the degree of vertex u and the summation extends over all edges uv of G. We prove the conjecture given by Aouchiche and Hansen on the graphs for which the Randic index attains its minimum value when k is greater or equal to n/2. We show that the extremal graphs have only degree k and degree n-1, and the number of vertices of degree k is as close to n/2 as possible.

3 - Shortest Path Approach to Find Critical Path in a Network Model.

Shruthi S Kumar, Telecommunication, PES Institute of Technology, 100 Ft Ring Road BSK III Stage, 560085, Bangalore, Karnataka, India, shruthulisha@gmail.com, *Guruprasad Nagaraj*

Networks provide a natural way of graphically displaying the flow of activities in a major project. The critical path of a project network is the longest path and the main purpose is to identify those activities whose crashing may reduce the overall duration of the project. Dijkstra's algorithm solves the shortest path problem on a weighted directed graph. In this paper, we have made an attempt to find out how the shortest path algorithm can be slightly modified to find the critical path of a network. We have compared this approach with the regular method and found to be more efficient.

4 - Two-probe Routing Model and Algorithm for Multi-chip Module Substrates

Shunji Umetani, Osaka University, Japan, umetani@ist.osaka-u.ac.jp, *Keisuke Murakami*, *Hiroshi Morita*

The testing faults on multi-chip module (MCM) substrates is essential but quite time consuming task in assembling circuit boards. We formulate the problem of routing a pair of testing probes on MCM substrates as a constrained shortest path problem, and propose an exact algorithm and an approximate algorithm using labeling method.

■ TD-13

Tuesday, 17:00-18:30
Meeting Room 206

Optimization, Forecasting, Renewable Energy and Electricity Grid II

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Asef Nazari*, School of Mathematics and Statistics, University of South Australia, OC Building, Mawson Lakes Campus, 5095, Mawson Lakes, South Australia, Australia, asef.nazari@unisa.edu.au

Chair: *Jerzy Filar*, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au

Chair: *Manju Agrawal*, Mathematics and Statistics, University of South Australia, School of Mathematics and Statistics, Mawson Lakes, 5095, Adelaide, South Australia, Australia, manju.agrawal@unisa.edu.au

1 - Optimal Transmission Expansion Planning for Increasing Wind Power Penetration

Asef Nazari, School of Mathematics and Statistics, University of South Australia, OC Building, Mawson Lakes Campus, 5095,

Mawson Lakes, South Australia, Australia,
asef.nazari@unisa.edu.au

The increasing utilization of electricity generated by wind farms in a power system requires a careful expansion policy for the existing grid. The transmission expansion planning incorporating uncertainties in load and wind generation leads to a complex stochastic mixed integer programming problem. The Cross Entropy method shows promise in solving global optimization problems regardless of continuity or other assumptions. In this adaptation of the method to stochastic cases, we sample integer variables using the CE mechanism, and solve stochastic LPs to obtain matching continuous variables.

2 - Cointegration of Wind Energy from South Australian Windfarms

Manju Agrawal, Mathematics and Statistics, University of South Australia, School of Mathematics and Statistics, Mawson Lakes, 5095, Adelaide, South Australia, Australia, manju.agrawal@unisa.edu.au, *John Boland*

Volatility of wind energy is a challenge to effecient operation of an electricity grid. We analyse concurrent data of South Australian wind-farms' output. Engle and Granger (1987) demonstrate the importance of cointegration in general and we apply this concept in the context of Australian windfarms, in particular.

3 - The Ecological Factor in Optimization Models

Marija Cileg, Quantitative Methods in Economy, Faculty of Economics, Segedinski put 9-11, 24000, Subotica, Serbia, macileg@yahoo.com, *Tibor Kis*

The main objective of this paper is to investigate modes of quantifying and optimizing ecological factors, analyzing this problem from the standpoint of companies. In the paper we propose a particular method of comparing additional costs for environment protection and repayments received by companies that has high importance for the overall profitability. To investigate and solve the described problem we apply a programming model with fractional objective function along with appropriate sensitivity analysis. Separate analysis is devoted to system of limits and to objective function.

4 - Lebesgue Integral Inspired Estimation of 5 Minute Wind Energy Output

Barbara Ridley, Barbara Hardy Institute, University of South Australia, School of Mathematics and Statistics, Mawson Lakes, 5095, Adelaide, South Australia, Australia, barbara.ridley@unisa.edu.au, *Jerzy Filar*, *John Boland*

We are investigating the behaviour of total energy output from wind farms using a Lebesgue integral inspired aggregation of contributions from different energy bands. This procedure will identify the length of duration of events and also the waiting time between those events. Our goal is to mathematically model these processes to forecast the energy from wind farms so that their output can be reliably estimated in order to enter fully into the competitive electricity market. Our research is utilising 5 minute data which is the most important time interval for the Australian electricity market.

■ TD-14

Tuesday, 17:00-18:30
Meeting Room 207

Optimization Methods and Stochastic Calculus in the Financial Sector I

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Miroslav Culik*, Finance, VSB-TUO, Sokolska tr. 33, 70121, Ostrava, Czech Republic, miroslav.culik@vsb.cz

Chair: *Leonidas Sakalauskas*, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt

1 - Option Pricing via Monte Carlo Simulation with Fuzzy Parameters

Tomás Tichý, Department of Finance, Faculty of Economics, VSB-Technical University Ostrava, Sokolská 33, 701 21, Ostrava, Czech Republic, tomas.tichy@vsb.cz, *Michal Holcapek*

During last decades the stochastic simulation approach, both via MC and QMC has been vastly applied and subsequently analyzed in almost all branches of science. Since financial quantities, opposed to natural processes, depends on human activity, their modeling is often very challenging. Many scholars therefore suggest to specify some parts of financial models by means of fuzzy set theory. In this contribution the recent knowledge of fuzzy numbers and their approximation is utilized in order to suggest fuzzy-MC simulation to option price modeling in terms of fuzzy-random variables.

2 - On the Number of Explanatory Variables of Corporate Rating Method with Artificial Neural Network

Katsuaki Tanaka, Faculty of Business Administration, Setsunan University, 17-8 Ikedanakamachi, 572-8508, Neyagawa, Osaka, Japan, k-tanaka@kjo.setsunan.ac.jp, *Hideki Katsuda*

Our research objective is to simulate the corporate ratings by rating agency only with quantitative data using artificial neural networks. The details of rating agency's procedure are not disclosed. In rating process, they use not only quantitative variables in financial statements but also qualitative information about the company. When we simulate ratings, we have used 12 variables. In this paper, we delete some variables with low contribution and decide the number of enough variables based on five years data.Our contribution is to show the way of reducing a cost burden to get data.

3 - The Stability Investigation of the Three Large Czech Banks within Z - Metrics Methodology

Petr Gurný, Department of Finance, VSB -TU Ostrava, Sokolska tr. 33, 70121, Ostrava, Czech Republic, petr.gurny@vsb.cz

The paper is devoted to the investigation of the Czech banks health, which we can regard as one of the most important tasks in the time of the financial crisis. The main goal of the paper is an estimation of the future probability of default (PD) for three key Czech banks. At first the model (built on the basis of the Z-metrics methodology) for prediction of bank failure will be presented. Afterwards the relevant financial indicators needed for estimation of the future PD will be simulated via Lévy processes and their dependencies will be captured via gaussian copula function.

4 - Cash Management by Two-stage Stochastic Programming

Leonidas Sakalauskas, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt

Problems of cash management are analyzed, that often arise in public, non-profit-making or business institutions. Stochastic linear programming formulation of a firm's short term financial planning problem is presented using two-stage stochastic model. Two-stage stochastic problems are solved by series of Monte-Carlo estimators ensuring the solution with admissible accuracy. The method developed is realized in C++ programming language. Several cases of application of financial options are investigated.

■ TD-15

Tuesday, 17:00-18:30
Meeting Room 208

Holistic Approaches to Military and Security Modeling

Stream: Military, Defense and Security Applications

Invited session

Chair: *Justin Millikan*, DSTO Australia, Australia, justin.millikan@dsto.defence.gov.au

1 - A Study of Issues Involved in using an Explicit Cognitive Model within an Agent-Based-Model Crowd Scenario

Wayne Johnson, Land Operations Division, Defence Science & Technology Organisation, 5111, Edinburgh, SA, Australia, wayne.johnson@dsto.defence.gov.au, *Philip Jacques*, *Martin Wong*

We investigate the feasibility of including simple rule based cognitive models within Agent-Based-Models (ABMs) in general and the Societal-centric Interactions Model (ScIMs) project in particular. It will extend an existing published sociological crowd riot scenario of Jager et al. (2001), in which agents currently only have a single dimension, aggression-motivation, as a cognitive representation. The extended cognitive model includes other emotional dimensions to create a richer emotion, motivation model.

2 - Social Models of Terrorist Radicalisation

Margaret Egudo, LOD, DSTO, PO Box 1500, 5111, Edinburgh, SA, Australia, Margaret.egudo@dsto.defence.gov.au

Most studies on terrorist radicalisation suggest only a few religiously radicalised individuals become terrorists. There is consensus it requires a transformative process of persuasion and idea intensification. Propagation and diffusion of militant ideology, are explained in the literature using agent-based social models drawing on rational choice, network and contagion theories. Working from established critiques, I propose a synthesis of several existing models to produce a social model of extremist behavior, based on integration of individuals, society and government.

3 - An Exploration of Australia's Future Threat Environments using Scenario-Based Planning

Wayne Hobbs, Defence Dept., DSTO, PO Box 1500, 5111, Edinburgh, South Australia, Australia, wayne.hobbs@dsto.defence.gov.au

This paper explores the application of scenario based planning for the investigation of Australia's future regional threat environment. Evolution of both state and non-state based threats is considered. Using nuclear proliferation as a case study a Faustian tree is developed that describes multiple decision points and pathways to a number of plausible futures. The Faustian tree facilitates discussion of strategies focussed on the regional security architecture and Australia as a middle power. The scenario based planning approach is enhanced through use of concepts from systems analysis.

4 - From Conceptual to Holistic Modelling: Societal Responses of Populations in Crisis using an Opinion Dynamics Model

Justin Millikan, DSTO Australia, Australia, justin.millikan@dsto.defence.gov.au, *Dion Grieger*, *Willaim Chau*

In this paper we demonstrate how a conceptual model can be integrated into a holistic model of peace-keepers interacting with urban populations in crisis. In particular we expand the scope of the Relative Agreement model [Deffuant, 2002)] to yield an organisational alignment representation within the simulated society using the Societal Centric Interactions Model (SCIMS). This allows us to investigate informational feedback loops in the simulated environment.

■ TD-16

Tuesday, 17:00-18:30
Meeting Room 209

System Dynamics Modelling for Health Care

Stream: Health Care Applications

Invited session

Chair: *Brian Dangerfield*, Centre for Operations Management, Management Science & Statistics, University of Salford, Salford Business School, Maxwell Building, The Crescent, M5 4WT, Manchester, United Kingdom, b.c.dangerfield@salford.ac.uk

1 - Reversing Trends in Childhood Obesity: Are Changes in Energy Intake More Important than Changes in Energy Expenditure?

Brian Dangerfield, Centre for Operations Management, Management Science & Statistics, University of Salford, Salford Business School, Maxwell Building, The Crescent, M5 4WT, Manchester, United Kingdom, b.c.dangerfield@salford.ac.uk, *Norhaslinda Zainal Abidin*

This study explains how system dynamics simulation modeling can be used to evaluate interventions aimed at reversing current trends in childhood obesity. In contrast to the usual methodology employed for research in public health (randomized controlled trials) our approach allows for evaluation ahead of an intervention, rather than as an ex post activity. Results show that an increase in energy intake from food consumption is the main reason behind the increases in weight. Reducing the amount of energy derived from food consumption is a high leverage solution to the obesity problem.

2 - National Aged Care Workforce Planning Dynamics

Geoff McDonnell, CHI, UNSW, 382 Bronte Rd, 2024, Bronte, NSW, Australia, gmcdonne@bigpond.net.au, *David Rees*

A system dynamics model based on general health care demand and supply framework was used to plan national workforce requirements and their sensitivity to changes in population expectations, technologies and service configurations. This work can be generalised to understand how different stakeholders interact in managing competing gaps in need for functional assistance, gaps in service provision and gaps in resources.

3 - A Systematic Dynamic Model of Health Workforce Planning Training and Deployment

Keith Masnick, Medicine, UNSW, 1 Roslyndale Ave, 2025, Woollahra, NSW, Australia, keith.masnick@unsw.edu.au, *Geoff McDonnell*

All aspects of the provision of personnel are invariably under-managed in a health system. Personnel are defined by its quantity (numbers, distribution, productivity) and its quality (outcomes) and value. We have developed a competency based multi entry and exit training model where each entry/exit point is tied to the needs of the health service, accounting for delays and accumulations, to address the quantity and quality of personnel. The model was calibrated using data provided by stakeholders. Better outcomes were possible by concentrating on mid to low level staff rather than on doctors.

4 - Predicting the System Dynamics of Specialist Health Service Utilisation by People with Intellectual Disability

Lynette Lee, Sydney University, 2000, Sydney, NSW, Australia, lyn-lee@bigpond.net.au, *Geoff McDonnell*

National survey data and service recipient administrative information was collated to estimate the NSW prevalence of people with Intellectual Disability in four age groups in 2003. These were used to calibrate a computational stock-flow model of the population and disability dynamics to predict overall prevalence in 2043. Epidemiological data on rates of complex within-disability disorders and health service utilization, in a representative region, were incorporated into the model as parameters which could be adjusted for scenario settings, for use in strategic service planning.

■ TD-17

Tuesday, 17:00-18:30
Meeting Room 214

OR in Finance 1

Stream: Finance

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Rita Decclesia*, Economic and Social Analysis, Sapienza University of Rome, Piazza Aldo Morto 5, 00185, Rome, Italy, rita.decclesia@uniroma1.it

Chair: *Alexander Schaefer*, Goethe-University, Germany, schaefer@finance.uni-frankfurt.de

1 - A Study of Bank Efficiency under Financial Holding Companies in Taiwan

Chun Liu, International Business, Chang Jung Christian University, 396 Chang Jung Rd., Sec.1,Kway Jen, 71101, Tainan, Taiwan, lcc@mail.cjcu.edu.tw, *Huang Chien-Min*

In order to adjust the impacts of joining WTO to the financial industry, Taiwan government had approved "The Passage of the Financial Institutions Merge Act' and "The Financial Holding Company Act' in the year 2000 and 2001. With these two laws, the financial companies in Taiwan, via internal controls and mergers, could become large financial holding companies to increase the competitiveness of the financial industry in Taiwan. This study, evaluates the operational efficiency and productivity growth of the FHCs in Taiwan from 2003 to 2007 by using DEA and Malmquist Productivity Index.

2 - Dynamic Portfolio Selection with Absolute Deviation Model

Mei Yu, University of International Business and Economics, China, yumei@amss.ac.cn

In this paper, a new dynamic portfolio selection model is established. Different from original consideration that risk is defined as the variance of terminal wealth, the total risk is defined as the average of the sum of maximum absolute deviation of all assets in all periods. At the same time, noticing that the risk during the period is so high that the investor may go bankrupt, a maximum risk level is given to control risk in every period. By introducing an auxiliary problem, the optimal strategy is deduced via the dynamic programming method.

3 - Portfolio-selection Models for Small Investors

Philipp Baumann, Department of Business Administration, University of Bern, IFM, AP Quantitative Methoden, Schützenmattstrasse 14, 3012, Bern, Switzerland, philipp.baumann@pqm.unibe.ch, *Norbert Trautmann*

We study the problem of investing capital in stocks such that the risk is minimized, a certain rate of return is guaranteed and some small-investors specific constraints are met. We extend four portfolio selection models from the literature in order to consider transaction-costs, minimum transaction units, and dividends. In an experimental analysis, we apply each model using historical data of 239 Swiss stocks. All models generate portfolios which yield higher mean returns than the Swiss Performance Index. However, the return of the Swiss Performance Index has a considerably lower variance.

4 - Cost Efficiency of German Mutual Fund Complexes

Alexander Schaefer, Goethe-University, Germany, schaefer@finance.uni-frankfurt.de

German mutual fund complexes are far from being cost efficient. This result is derived by applying the nonparametric linear programming method known as data envelopment analysis. We use the sum of operating and commission expenses as input and the assets under management differentiated into retail and institutional funds as outputs. Furthermore, we choose an input-orientation and allow for variable returns to scale. Finally, we run multiple second-stage regressions to assess the impact of explanatory variables on cost efficiency, but the results are ambiguous.

■ TD-18

Tuesday, 17:00-18:30
Meeting Room 215

Applications of DEA

Stream: Data Envelopment Analysis
Invited session

Chair: *Jenq-Hann Chung*, Department of Business Administration, National Central University, 300, Jhongda Rd., 320, Jhongli, Taoyuan County, Taiwan, frmcfaactuary@gmail.com

1 - Risk Ranking of GPT Service Failures Resulting in Third-Party Complaints

Jenq-Hann Chung, Department of Business Administration, National Central University, 300, Jhongda Rd., 320, Jhongli, Taoyuan County, Taiwan, frmcfaactuary@gmail.com, *Dong Shang Chang*

Third-party complaints of service failures are a higher-order action of customers. For reducing these complaints and protecting long-term profits of service firms, FMEA can be employed to identify the major potential risk and to take preventive actions at design stage. There is little information in literature on third-party complaints of group package tours(GPT). The purpose of this study is to evaluate the risk prioritization of twenty service failure modes for Taiwanese outbound GPT. A novel approach,based on DEA and FMEA,is applied for risk ranking.

2 - Efficiency of Israeli Local Municipalities in Preventing Road Accidents via DEA

Zilla Sinuany-Stern, Industrial Engineering and Management, Ben Gurion University, Beer-Sheva, 84105, Israel, zilla@bgu.ac.il, *Doron Alper*

The purpose of this study is to estimate the relative efficiency of 197 local municipalities in traffic safety in Israel via DEA. We used here 2 inputs, 6 main outputs, and 8 intermediate variables. Several DEA versions were used on subsets of the variables, including a two stage procedure. Further analyses utilizing multiple regression and factor analysis were preformed to verify the effect of various environmental parameters on the efficiency. The environmental parameters, tested for each local municipality, were related to the size, the age, and socio-economic level of the population.

3 - Efficiency and Malmquist Index of Chinese Financial Companies

Debin Tan, School of Business Administration, Southwestern University of Finance and Economics, China, 55 Guanghuacun, Chengdu 610074, China, zhunan2001@yahoo.com.cn, *Nan Zhu*, *Xingchen Zhu*

This paper applies the data envelopment analysis and Malmquist index method to measure the productive efficiency and total factor productivity of Chinese Financial Companies over the period between 2006 and 2009. The results and conclusion are provided.

4 - Towards More Sophisticated Identification of Efficiency Drivers in Business Processes

Anne Dohmen, ProcessLab, Frankfurt School of Finance & Management, Sonnemannstr. 9-11, 60314 , Frankfurt am Main, Germany, a.dohmen@fs.de

This paper presents a new three-stage approach for identifying drivers of efficiency in business processes by combining Data Envelopment Analysis with data mining. Compared to commonly used one-stage and two-stage DEA-models, the presented approach does not need a priori knowledge about potential drivers of efficiency, but identifies structural associations between process instances' characteristics and their efficiency scores. The paper further shows a real-life application of this approach to the derivatives settlement and clearing process of a major European bank.

■ TD-19

Tuesday, 17:00-18:30
Meeting Room 216

Issues in OR Education in Developing Nations

Stream: Education and Operations Research
Invited session

Chair: *Javier Faulin*, Department of Statistics and OR, Public University of Navarre, Los Magnolios Builing. First floor, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, javier.faulin@unavarra.es

1 - Factors that may Account for Delayed Graduation at the University of Limpopo in South Africa

Negussie Yibas, Statistics and Operations Researc, University of Limpopo, Turfloop Campus, 0727, Polokwane, Limpopo, South Africa, negussieyibas@gmail.com

University of Limpopo admits its students from overseas and different parts of South Africa. Not all students complete their studies and graduate on the record time. Some students need one or more academic years over and above the record time to complete and graduate. This paper attempts to identify the main factors that may account for the delay using logit analysis. In the process of identification of the factors, the average delay time in approximate number years and the proportion of students completing on the record time will be estimated.

2 - Application of Operations Research Tools to Aid Performance Growth of Small Scale Industry in National Development in Sub-saharan Africa

Joshua Magbagbeola, Dept. of Actuarial Science and Insurance, Joseph Ayo Babalola University, P.M.B. 5006, Ilesha, 234, Ikeji-Arakeji, Osun State, Nigeria, kunle_magbagbeola@yahoo.com, *Jonathan Adetoso*

Most entrepreneurs in sub-saharan africa are even undecided about the type of business to set up and lack necessary business ideas. Some Small scale operators are undecided on how to finanace their business and where to source for the funds. Lack of entrepreneurship culture and education. Rudimentary introduction to tools in Operations Research (O.R.) need be encouraged, in other to assist the young business owners in the art and science of decision making which will help in overcoming challenges.

3 - Teaching Operations Research Online: Experiences and Challenges using Virtual Campuses

Javier Faulin, Department of Statistics and OR, Public University of Navarre, Los Magnolios Builing. First floor, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, javier.faulin@unavarra.es, *Angel A. Juan*, *LluisM Pla*

We describe here some benefits and challenges related to teaching operations research (OR) in online environments related to virtual campuses. Information technologies (IT) offer new ways to teach and learn OR: on the one hand, they have driven the growth of distance learning opportunities; on the other hand, 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.

■ TD-20

Tuesday, 17:00-18:30
Meeting Room 217

AHP III

Stream: Analytic Hierarchy/Network Process
Invited session

Chair: *Luiz F. Autran M. Gomes*, Management, Ibmec/RJ, Av. Presidente Wilson, No. 118, Room 1110, 20030020, Rio de Janeiro, RJ, Brazil, autran@ibmecrj.br

1 - Research on Current and Potential Creative Ability Assessment Analysis for Innovative Enterprise

Xiaoya Li, Institute of Applied Mathematics, Academy of Mathematics and Systems Science, CAS, China, xyli@amss.ac.cn, *Jinchuan Cui*

Focused on innovative enterprise management, we investigate assessment analysis method for evaluating current and potential creative ability. Since traditional methods focus on analytic hierarchy process frame or other qualitative research method, which can not well explain the relationship between indicators and potential innovative ability. In our work, data envelopment analysis methods are employed, combined with analytic hierarchy process method for assessing the current innovative ability, and elasticity analysis method based on DEA for evaluating the potential innovative ability.

2 - A Decision Support System for Financial and Social Investment

Begoña Gutiérrez-Nieto, Universidad de Zaragoza, Spain, bgn@unizar.es, *Carlos Serrano*

The paper proposes a decision-making model to assess the aspects associated to Social Venture Capital (SVC) investment decisions. SVC companies value financial and social aspects of investee companies. The model includes three factors: the previous experience with the company (the past); its financial information and intangible assets (the present); and the proposed project, with financial and social criteria (the future). The model has 26 criteria and 160 indicators, prioritized by means of Analytic Hierarchy Process (AHP). The model is tested in a given SVC company.

3 - A Decision Support System for a Production Plant Investment

Özcan Çavusoglu, Industrial Engineering Ph.D. Programme, Istanbul Technical University, Institute of Science and Technology, Faculty of Management, 34367, Istanbul, MAÇKA, Turkey, cavusogluo@itu.edu.tr, *Demet Bayraktar*, *Mustafa Canolca*

The aim of this study is to propose a decision support system which will provide a comprehensive and a scientific approach for solving an investment problem of a production firm. A literature review and also interviews have been carried out with experts. Qualitative and quantitative factors have been defined for alternative countries, which have been evaluated by using AHP. Finally, the best alternative country has been selected by goal programming taking into consideration investment, raw material and labor cost, profit, and market share goal. The results and future work have been discussed.

4 - Selecting the Best Mutual Funds Portfolio for the Brazilian Investment Market with the AHP

Luiz F. Autran M. Gomes, Management, Ibmec/RJ, Av. Presidente Wilson, No. 118, Room 1110, 20030020, Rio de Janeiro, RJ, Brazil, autran@ibmecrj.br, *Gisele dos Santos*

The objective of this study was to identify investors suitability to assets' classes and provide diversification in mutual funds portfolio for the Brazilian investment market. The model used was the Analytic Hierarchy Process, via the use of the Super Decisions software. This study identified the need for financial institutions to evaluate mutual funds offered more rigorously before offering third party funds to their clients. It also demonstrated the validity of a suitable and detailed process and for analysis on the part of the investors when designing their portfolios.

■ TD-21

Tuesday, 17:00-18:30
Meeting Room 218

Location, Simulation, Cargo

Stream: Airline Applications
Invited session

Chair: *Ulrich Derigs*, Information Systems and Operations Research, University of Cologne, Pohligstr. 1, 50969, Cologne, Germany, derigs@informatik.uni-koeln.de

1 - A Time-space Network Flow Model to Simulate the Trips on International Regular Airlines

Ririka Takahashi, Information and System Engineering, Chuo University, Japan, rtakahas@educ.ise.chuo-u.ac.jp, *Shigeki Toriumi*, *Azuma Taguchi*

The aim of this study is to simulate the trips in the international aviation network. In order to treat time dependent air traffic demand, we construct a time-space network which expresses the timetable of flights. The flow of passengers on a flight can be determined based on ICAO data. However, ICAO data do not cover all flights. We first make up for ICAO data by regression analysis, and then express the passengers' flow in the time-space network by network flow algorithms. The use of the time-space network enables to represent passengers' time dependent trips in a static manner.

2 - Decision Support for Centralizing Cargo at a Moroccan Airport Hub using Stochastic Multicriteria Acceptability Analysis

Abdellah Menou, Mohammed VI International Academy of Civil Aviation, National Airports Authority of Morocco, ONDA, Nouaceur, 65, BVD de la résistance, Lot Ennour, Berrchid, B.P.52, Casablanca, Morocco, a.menou@onda.ma, *Risto Lahdelam*, *Pekka Salminen*

The geographical position of Morocco places it at the heart of important sea, air, rail and motorway transportation routes between four continents. In this study we evaluate different alternatives to centralize multimodal cargo at a Moroccan airport hub. The choice depends on different socio-economical criteria, the geographical location, and the environmental impacts. Some of the criteria can be measured quantitatively, while for others only qualitative assessment is feasible. Furthermore, significant uncertainty is present both the criteria measurements and the preferences. Due to this problem setting, we analyze the problem using Stochastic Multicriteria Acceptability Analysis (SMAA). SMAA allows representing a mixture of different kinds of uncertain, imprecise and partially missing information in a consistent way. The results of the analysis describe the conditions that make each alternative the most preferred one, or give it a particular rank.

3 - Air Cargo Scheduling - Planning Paradigms, Integrated Models and Methods

Ulrich Derigs, Information Systems and Operations Research, University of Cologne, Pohligstr. 1, 50969, Cologne, Germany, derigs@informatik.uni-koeln.de, *Stefan Friederichs*

Designing a profitable flight schedule is a highly complex planning problem. Both passenger and cargo airlines usually follow a decomposition approach and break this problem into several sub problems which are then solved consecutively and iteratively using specific but isolated models. At cargo airlines, the four major interdependent decision problems are flight selection, fleet assignment, rotation planning, and cargo routing. In our research we have developed a planning approach which differs from other OR-based planning approaches in two aspects. The approach is based on integrated models and it is based on the pragmatic planning paradigm to optimally modify an existing schedule. For this purpose, the planner has to identify mandatory and optional flights. Then the planning goal is to identify the best combination of optional flights to be included into the schedule. Our integrated planning models comprise several additional important planning aspects for cargo airlines such as available capacities on external flights (e.g. belly capacities from passenger flights or road-feeder services), cargo handling costs and constraints, and aircraft maintenance regulations.
In this talk we describe the planning problem and the specific planning paradigm, develop a set of complex mixed integer programs representing the different sub problems as well as an integrated problem formulation. We outline a branch&price&cut approach for solving the mathematical programs and present computational results obtained for a set of generated yet highly practical problem instances for different types of carriers.

Thursday, 9:00-10:30

■ HA-01

Thursday, 9:00-10:30
Plenary Hall 3

OR Applications in the Design and Operation of Electricity Markets

Stream: OR Applications in Energy
Invited session

Chair: *Ilhan Or*, Industrial Engineering Department, Bogazici University, Bebek, 34342, Istanbul, Turkey, or@boun.edu.tr

1 - Genersys — a Simulation Tool for Australia's National Electricity and Gas Market

George Grozev, Ecosystem Sciences, CSIRO, Box 56, 3190, Highett, Victoria, Australia, george.grozev@csiro.au, *Melissa James*, *John Page*, *Kwok Yum*

This paper presents Genersys, an agent-based simulation tool for Australia's Electricity Market developed by CSIRO Energy in collaboration with Core Energy. Genersys is a scenario development tool that allows building and analysing gas and electricity energy futures for periods over 30 years. Simulation agents are used to model bidding and investment decisions of power companies. Renewable generation, electricity, gas demand models are linked to climate variables and allow comparing results in the context of climate change. Examples of simulation studies based on Genersys will be described.

2 - Optimal Generation Mix and Weak Regulation in Competitive Electricity Markets

Irena Milstein, Faculty of Management of Technology, Holon Institute of Technology, 52 Golomb St., 58102, Holon, Israel, irenam@hit.ac.il, *Asher Tishler*

This paper presents a two-stage decision model of endogenous investments and operations in a competitive (oligopoly) electricity market with two generating technologies and uncertain demand. The analytical solutions are obtained for two different market structures: (i) each producer can construct and operate only one type of generation technology, and (ii) producers are free to construct and operate any type of generation technologies. The theoretical result predicts that an upper bound on the industry's overall capacity is identical whether the producers can employ both technologies or only one. The empirical results suggest that though each market structure may lead to high optimal capacity, capacity mix differs tremendously in these markets.

3 - Co-optimization Model for Choosing the Optimal Plan for Simultaneously Expanding Both Power Transmission and Power Generation

Enzo Sauma, Industrial and Systems Engineering Department, Pontificia Universidad Catolica de Chile, Vicuña Mackenna 4860, Macul, 00001, Santiago, Chile, esauma@ing.puc.cl, *David Pozo*, *Javier Contreras*

We formulate a mixed integer linear programming co-optimization model for choosing the optimal plan for simultaneously expanding both power transmission and power generation that helps decision makers to incorporate transmission issues when evaluating the development of renewable resources. The model characterizes the competitive interaction among generation firms whose decisions in generation capacity investments and production are affected by both the transmission investments and the market operation. We illustrate our results using simple network examples.

4 - Investigation of Bid Pricing and Load Assignment Policies in an Electricity Market Through an Integrated Optimization-Simulation Model

Ilhan Or, Industrial Engineering Department, Bogazici University, Bebek, 34342, Istanbul, Turkey, or@boun.edu.tr

An integrated simulation-optimization model is developed for modeling and analysis of a decentralized electricity market. It is aimed to investigate the impact of bid pricing decisions (of electricity suppliers), load assignment policies (of the regulatory authority), generator characteristics (of the generators in the system) on electricity prices, load assignments, generator profits and the supply-demand balance. The model is designed such that it can be used for market design as well as investment planning, being capable to identify advantages of production technology and capacity choices.

■ HA-02

Thursday, 9:00-10:30
Meeting Room 101

Innovative Applications in Game Theory

Stream: Game Theory

Invited session

Chair: *Krishna Chaitanya Vanam*, Industrial Engineering and Operations Research, Indian Institute of Technology - Bombay, Room No.519, B-wing, Hostel 13, Powai, 400076, Mumbai, Maharashtra, India, krishhhv@gmail.com

1 - Integration of Data Mining, Game Theory and Optimization for Tackling Crime

Carolina Segovia, Monash University, Australia, Caro.Segovia@monash.edu, *Kate Smith-Miles*

Classical Data Mining models for crime prediction give only a partial solution to the problem, because they do not consider the game between the police and the criminals. By incorporating Game Theory into the models it is possible to consider this adversarial behavior, through modeling the problem as a Bayesian Stackelberg game. We propose a methodology to predict crime, by integrating dynamic crime prediction Data Mining models with a game theoretical approach that enables police resources to be optimally allocated.

2 - Sharing Costs in Highways: A Game Theoretical Approach

José Manuel Zarzuelo, Applied Economics IV, Basque Country University, F. CC. Económicas, Lehendakari Aguirre, 83, 48015, Bilbao, Spain, josemanuel.zarzuelo@ehu.es, *Jeroen Kuipers*, *Manuel Alfredo Mosquera Rodríguez*

In this paper we introduce a new class of games, called highway games, which arise from situations where there is a common resource that agents will jointly use. That resource is an ordered combination of several indivisible sections and each agent needs some consecutive sections. We present easy formulas to calculate the Shapley value and the compromise value. Finally, we propose an algorithm to calculate the nucleolus for this new class of games.

3 - A New Excess-based Solution Concept for Cooperative TU Games

Krishna Chaitanya Vanam, Industrial Engineering and Operations Research, Indian Institute of Technology - Bombay, Room No.519, B-wing, Hostel 13, Powai, 400076, Mumbai, Maharashtra, India, krishhhv@gmail.com, *Nandyala Hemachandra*

We propose a new solution concept for cooperative games. Excess of a coalition in the context of nucleolus captures dissatisfaction of a coalition of players. We define excess-sum, a measure of the dissatisfaction of a player, as the sum of excesses of all possible coalitions involving the player. Our proposed solution is the imputation that minimizes the maximum excess-sum of all players. First, we show that this satisfies axioms like covariant, etc. Next, we show that in an N player cooperative game, this can be computed by at most N LPs and thus easily computable (unlike nucleolus, etc.)

■ HA-03

Thursday, 9:00-10:30
Meeting Room 102

Intelligent Optimisation

Stream: Intelligent Optimisation

Invited session

Chair: *Kate Smith-Miles*, Monash University, Melbourne, Australia, kate.smith-miles@sci.monash.edu.au

1 - Learning to Predict the Performance of Graph Colouring Heuristics Based on Properties of the Graph

Kate Smith-Miles, Monash University, Melbourne, Australia, kate.smith-miles@sci.monash.edu.au, *Leo Lopes*, *Brendan Wreford*

The performance of a graph colouring method depends upon critical properties of the graph. This presentation describes a set of mathematical properties of a graph and shows how data mining methods can be used to learn the relationship between these properties and the performance of graph colouring heuristics. Data visualisation techniques are used to define the "algorithm footprint" showing the boundaries of good performance for each heuristic.

2 - An Algorithm Portfolio for Nurse Rostering

Patrick De Causmaecker, Computerscience/CODeS, Katholieke Universiteit Leuven, Campus Kortrijk, Etienne Sabbelaan 53, BE-8500, Kortrijk, Flanders, Belgium, Patrick.DeCausmaecker@kuleuven-kortrijk.be, *Tommy Messelis*

Based on the success of algorithm portfolio's in other domains, we have applied these ideas in a real world setting. Recently, our research group co-organised the First International Nurse Rostering Competition. This is an ideal testbed for the creation and validation of an algorithm portfolio for this real-world problem. The portfolio predicts the performance of a set of competitive algorithms based on characteristics of the problem instance, and decides which algorithm to run. Doing so, the portfolio is expected to outperform any of its individual components.

3 - Generalized Meta-optimization in Continuous Domain

Vladimir Bicik, Department of Theoretical Computer Science, Czech Technical University in Prague, Faculty of Information Technology, Kolejni 550/2, 160 00, Prague 6, Hl. m. Praha, Czech Republic, bicikvla@fit.cvut.cz

Meta-optimization has been used for distinct tasks; however attributes of the given task other than the fundamentals were used too. Instead we explored basis of such a task and studied unconstrained continuous optimization without a link to the goal. We inspected the optimized function by landmarking; a local optimization method executed few times. Convergence, success rate and other statistics were used as meta-features. We present preliminary results obtained after linking this data to several global optimization methods and to values of their inputs, which led to the best solutions.

4 - On the Suitability of Graph Coloring Formulations

Nur Insani, Mathematics, Monash University, 3168, Clayton, Victoria, Australia, nur.insani@monash.edu, *Kate Smith-Miles*, *Leo Lopes*

The innate difficulty of the Graph Coloring Problem (GCP) induced researchers to devise efficient algorithms based on graph coloring formulations. Selecting the best formulation of GCP on average across all instances does not help us pick the best one for particular graph instances. In this paper, we explores the classical Integer Linear Programming of the graph coloring formulations. We then compare the performances of these formulations to determine what makes one formulation works well from another for particular graph instances. Computational experiments are also reported in this paper.

■ HA-04

Thursday, 9:00-10:30
Meeting Room 103

SCM - Topics Of General Interest

Stream: Supply Chain Management

Invited session

Chair: *Valery Pavlov*, ISOM, University of Auckland, OGGB, 12 Grafton Road, 1142, Auckland, New Zealand, v.pavlov@auckland.ac.nz

1 - Efficiency of Optimal Long-term Contracts under a Dynamic Principal-Agent Model

Hao Zhang, Information and Operations Management, University of Southern California, 3670 Trousdale Pkwy, BRI 401F, 90089, Los Angeles, CA, United States, zhanghao@usc.edu

Many interesting problems in supply chain management can be cast as a dynamic principal-agent problem in which the principal offers a long-term contract to an agent who has private information on the underlying system, e.g., production costs, consumer types, and inventory levels. We identify a condition under which the principal's optimal long-term contracts converge to first-best contracts and achieve first-best efficiency eventually. This structural result generalizes the existing results in the dynamic adverse-selection literature and has many potential applications.

2 - A Robust Distribution-free Approximation for Setting Service Levels when Inventory is Subject to a Production Constraint

John Betts, Faculty of IT, Monash University, Wellington Road, 3800, Clayton, VIC, Australia, john.betts@monash.edu

A model is developed to calculate the target level required to provide a given service level in a single-item inventory when production is constrained. The model is a reliable alternative to exact methods when these become intractable or unreliable due to high demand variability, and an efficient alternative to simulation-based optimization. The model requires no user estimate of demand distribution and is easily used by inventory practitioners. The model is reliable and robust as verified by tests under common demand distributions. Accuracy is only affected to a small degree by sample size.

3 - Distribution Channel Structure for Chain-to-Chain Competition with Price and Lead-Time Sensitive Demand

Lucy Gongtao Chen, NUS Business School, National University of Singapore, 15 Kent Ridge Drive, 119245, Singapore, Singapore, bizcg@nus.edu.sg, *Zhengping Wu*, *Jihong Ou*

This paper studies distribution channel structure strategies for two competing manufacturers that sell substitutable products with price and lead-time sensitive demand. Given that the manufacturers can choose either a centralized distribution structure in which they sell directly to the demand, or a decentralized one in which they sell through an independent retailer, we study three channel structure combinations in the chain-to-chain competition. We develop equilibrium channel structure and investigate the impact of price and lead-time competition on the selection of distribution channel.

4 - On the Optimal Return Policies Allowing for Resale

Valery Pavlov, ISOM, University of Auckland, OGGB, 12 Grafton Road, 1142, Auckland, New Zealand, v.pavlov@auckland.ac.nz, *Kate Li*

In practice, return policies feature a great variety. The existing literatures mainly suggest that although full refund can be better than no refund at all, the optimal refund is partial and equals the salvage value of the product in the end of the sales period. We argue that in product categories such as apparel, returned products can be re-sold as new at full price. We show that allowing for this possibility increases the value of the optimal refund so that it can be almost as high as the selling price, so that in practice the difference can be ignored and full refund offered.

■ HA-05

Thursday, 9:00-10:30
Meeting Room 104

Consumer-Driven OM Models

Stream: Marketing and OM Interface

Invited session

Chair: *Yanchong (Karen) Zheng*, Stanford University, Huang Engineering Center 338C, 475 Via Ortega, 94305, Stanford, CA, United States, yczheng@stanford.edu

1 - Dynamic Pricing of Limited Inventories under Co-Existence of Multi-Generation Products

Kwei-Long Huang, Institute of Industrial Engineering, National Taiwan University, Taiwan, craighuang@ntu.edu.tw, *Chia-Wei Kuo*

The co-existence of multi-generation products is a prevailing phenomenon in retail. The retailer may only display goods from one specific generation, but may sell an alternative from another generation. In pricing, retailers might allow customers to bargain on products of one generation but stick with take-it-or-leave-it pricing on the other. In this research, we consider a retailer selling products from two different generations, both with limited inventory over a predetermined selling horizon. We analyze two models – Posted-Pricing-First model and Negotiation-First model. The former considers negotiation as being allowed on the second product only and in the latter, only the first product is negotiable. Our results show that the retailer can adopt both models effectively depending on the relative inventory levels of the products. In addition, the retailer is better off compared to the take-it-or-leave-it pricing when the inventory level of the negotiable product is high.

2 - Maximizing Price Returns under constraints of Perishability and Time Windows

Varimna Singh, Decision Sciences, Birla Institute of Management Technology, Plot No 5, Knowledge Park II, 201306, Greater Noida, Uttar Pradesh, India, varimna_singh@yahoo.com, *Amarnath Bose*

This paper attempts to solve a generic transportation problem. Vehicles are assigned to transport perishable goods over a network of delivery points and a fixed number of supply points. The routes are defined on the basis of demand and a variable product-specific time window. The price realizable on delivery is fuzzy and starts diminishing linearly till it becomes zero after a fixed transit time. We assume that the rate of deterioration increases significantly during transit and the product is unusable beyond a particular time point. The problem is to optimize returns subject to various constraints of perishability, vehicle availability, time-windows, stock-in-hand and variable demand. Key word: Vehicle routing, perishability, fuzzy time window

3 - Marketing and Operations Management Interface: How Customer Relationship Management can Facilitate Reverse Logistics in the Pharmaceutical Supply Chain

Ying Xie, Dept of System Management and Strategy, University of Greenwich, Business School, Park Row, SE10 9LS, London, United Kingdom, Y.Xie@gre.ac.uk

Improper disposal of drugs is costly and harmful to the environment. The aim of this study is to propose a Customer Relationship Management(CRM) strategy to facilitate the reverse logistics in the community pharmaceutical supply chain, mainly to increase customer compliance in reducing and recycling drug waste. In the meantime, the research shows how marketing interfaces with operations management in the health care system. A survey is conducted to investigate the existing disposal habits, and to propose a CRM strategy in the dimensions of knowledge, processes, and information technology.

4 - Strategic Purchase with Counterfactual Payoffs and Misperception of Availability

Yanchong (Karen) Zheng, Stanford University, Huang Engineering Center 338C, 475 Via Ortega, 94305, Stanford, CA, United States, yczheng@stanford.edu, *Ozalp Ozer*

We study a firm's inventory decision when it sells to strategic consumers over two periods. Consumers' purchase decisions are impacted by counterfactual payoffs and misperceived product availability. We show that both counterfactual payoff of late purchase and misperception in availability make it less necessary for the firm to adopt inventory rationing, whereas counterfactual payoff of early purchase encourages rationing. In addition, the firm can gain a substantial profit if it correctly anticipates these behavioral issues on the consumer side when making its operational decisions.

■ HA-06

Thursday, 9:00-10:30
Meeting Room 105

Industrial Applications of Scheduling and Routing I

Stream: Transportation

Invited session

Chair: *Geir Hasle*, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, geir.hasle@sintef.no

1 - Locating Cross-docking Centers with Two-level Routing Considerations under Demand Uncertainty

Jenn-rong Lin, Department of Transportation Science, National Taiwan Ocean University, 2, Pei-Ning Road, 20224, Keelung, Taiwan, jrlin@mail.ntou.edu.tw, *Ta-hui Yang*, *Wei-ming Wu*, *Kuo-chung Shang*

We formulate and analyze a strategic design model for locating cross-docking centers with two-level routing considerations under demand uncertainty. The key decisions are: the number and locations of cross-docking centers (CDC's), which big clients should be included in the first level routing , the first-level routing between plants, CDC's and big clients, and the second-level routing between CDC's and other clients not included in the first-level routing. At last, the model is applied to design a national finished goods distribution system for a Taiwan label-stock manufacturer.

2 - Counter Allocation for Copenhagen Airport

Jonas Jeppesen, Technical University of Denmark, 2800, Kgs. Lyngby, Denmark, s042403@student.dtu.dk, *Jesper Larsen*, *Tor Justesen*

Allocating counters for check-in is a central task for airport authorities. With the increasing number of airline travellers and the subsequent increased demand of check-in counters efficient planning is crucial. Based on the estimated data the problem of generating a daily counter allocation can be modelled as a Mixed Integer Linear programme. The problem is closely connected to the NP-hard Adjacent Resource Allocation problem. Our formulation seeks to spread out queuing, baggage in-take and usage of CUSS (Common Use Self check-in) as much as possible throughout the airport.

3 - Integer Linear Programming Models for a Cement Delivery Problem

Marino Widmer, Département d'Informatique, Université de Fribourg, Boulevard de Pérolles 90, 1700, Fribourg, Switzerland, marino.widmer@unifr.ch, *Marc Uldry*, *Alain Hertz*

We consider a delivery problem with an heterogeneous fleet of vehicles and several depots. The demands of the customers are larger than the capacity of the vehicles; in consequence most customers are visited several times. This is a split delivery vehicle routing problem with additional constraints. We first propose a two phase solution method assigning deliveries to the vehicles, and then building vehicle routes. Both subproblems are formulated as ILP problems. We then show how to combine the two phases in a single ILP. Experiments on real life instances are also provided.

■ HA-07

Thursday, 9:00-10:30

Meeting Room 106

Integer Programming and Combinatorial Optimization

Stream: Combinatorial Optimization

Invited session

Chair: *Monique Guignard-Spielberg*, OPIM, University of Pennsylvania, 5th floor, JMHH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr

1 - Lagrangian Decomposition and Convex Relaxations for a Class of Cardinality Constrained Portfolio Selection Problems

Xueting Cui, School of Management, Fudan University, 670 Guoshun Road, 200433, Shanghai, China, xtcui@fudan.edu.cn, *Xiaoling Sun*, *Xiaojin Zheng*

In this talk, we consider a class of cardinality constrained quadratic program problems arising from risk management and portfolio selection. The problem can be reforumulated as a mixed integer quadratically constrained quadratic program (MIQCQP). We show that the convex relaxation via Lagrangian decomposition and diagonal decomposition of the objective function can be reduced to an SDP problem or a second-order cone program. A new MIQCQP reformulation of the orginal problem is also derived. Computational results on several cardinality constrained portfolio selection models are reported.

2 - Some Observations on the Bi-objective 01 Bi-dimensional Knapsack Problem

Xavier Gandibleux, LINA - UMR CNRS 6241, The University of Nantes, Faculty of Sciences, 2, rue de la Houssiniere BP 92208 - Cedex 03, F-44322 , Nantes, France, xavier.gandibleux@univ-nantes.fr, *Olga Perederieieva*

Knapsack problems are often used as benchmark in multi-objective optimization to discuss on the efficiency of a new proposed algorithm. However this problem is often central within real complex situations. Then this family of multi-objective problems deserves to be carefully studied. Ehrgott and Gandibleux have introduced in 2000 the notion of bound sets. A first part of this work investigates this notion for the bi-objective 01 bi-dimensional knapsack problem. A tentative link between feasible and non-feasible solutions is discussed. A discussion about relevant numerical instances is reported.

3 - On the Use of Quadratic Convex Reformulations Coupled with Convex Hull Relaxation for Solving Pure Quadratic 0-1 Programming Problems

Monique Guignard-Spielberg, OPIM, University of Pennsylvania, 5th floor, JMHH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr, *Aykut Ahlatcioglu*, *Michael Bussieck*, *Jiaxing Pi*

We will discuss the use of Quadratic Convex Reformulations in the context of Convex Hull Relaxation for obtaining bounds and feasible solutions for several quadratic 0-1 optimization problems, including GQAP and quadratic knapsack problems with or without cardinality constraints.

■ HA-08

Thursday, 9:00-10:30

Meeting Room 107

Dynamic Programming Applications I

Stream: Dynamic Programming

Invited session

Chair: *David Brown*, Duke University, United States, dbbrown@duke.edu

1 - A Dynamic Programming Algorithm for Single Crane Scheduling in Steel Coil Warehouse

Jiyin Liu, School of Business and Economics, Loughborough University, Ashby Road, LE11 3TU, Loughborough, Leicestershire, United Kingdom, j.y.liu@lboro.ac.uk, *Lixin Tang*, *Xie Xie*

We study the problem of scheduling a single crane to retrieve a set of steel coils from a warehouse. The coils are stacked in two levels. Each coil at the upper level is supported by two coils below it. So one or two other coils may need to be shuffled when retrieving a coil. The problem is to determine the sequence of retrieving the required coils and to decide the new positions for the shuffled coils, so that the retrieval of all the required coils can be completed as soon as possible. We propose a dynamic programming algorithm to solve a restricted version in which a blocking coil is shuffled only when a required coil it blocks is retrieved, and it will not block another required coil after shuffling.

2 - When to Morph Websites

Gui Liberali, Marketing, Erasmus University and MIT, Ramlehstraat 10, 30161 JT, Rotterdam, Netherlands, liberali@mit.edu, *John Hauser*, *Glen Urban*

Websites increase sales if they adapt to customers' cognitive styles. We earlier developed a method that infers cognitive styles from clickstream data with Bayesian updating, and then optimally balances exploration (learning how morphing affects purchase probabilities) with exploitation (maximizing short-term sales) using expected Gittins indices. We now introduce a dynamic program to solve the trade-off between information about user style and exposure to the optimal morph. In a BT group application the basic model increased revenue by almost 20% ($80 million). The extended model adds approximately $5.7 million. We also report a field test of the model in Suruga Bank's card loan website.

3 - Combining Resolution Search and Dynamic Programming for the 0-1 Multidimensional Knapsack Problem

Michel Vasquez, LGI2P, Ecole des Mines d'Alès, Parc scientifique Georges Besse, 30035 cedex 1, Nîmes, France, Michel.Vasquez@ema.fr, *Sylvain Boussier*, *Saïd Hanafi*, *Yannick Vimont*, *Christophe Wilbaut*

We propose an exact method which combines resolution search, branch and bound, and dynamic programming algorithm for solving the 0-1 Multidimensional Knapsack Problem. Our method is a multi-level search strategy where the top level branches of the search tree are enumerated using Resolution Search, the middle level branches are enumerated using Branch & Bound and the lower level branches are solved with dynamic programming. The proposed algorithm is competitive with the existing heuristics in terms of convergence and is able to prove large-scale strong correlated instances of the OR-Library.

4 - Approximate Sequential Exploration

David Brown, Duke University, United States, dbbrown@duke.edu, *James Smith*, *Jo Eidsvik*, *Gabriele Martinelli*

We consider the problem of sequential exploration of a large oil field. The dependence among drilling sites is described by a Bayesian network: the results during exploration lead to revisions of probabilities for the remaining (unexplored) sites. In principle, an optimal exploration strategy could be computed using dynamic programming; in practice, the problem is often far too large to solve exactly. We develop tractable heuristics by decomposing the field into clusters of sites and show how to compute, using information relaxations, upper bounds on the expected reward of an optimal strategy.

■ HA-09

Thursday, 9:00-10:30
Meeting Room 108

Network Behavior under Disruption

Stream: Emergency Evacuation and Response
Invited session

Chair: *Joyanto Mukerjee*, Defence Science and Technology Organisation, Australia, joyanto.mukerjee@dsto.defence.gov.au

1 - Predicting Disrupted Network Behavior

S. Travis Waller, University of Texas at Austin, TX, United States, s.travis.waller@gmail.com, *Renee Alsup*, *Bradley Love*

While complex stochastic transport network modeling is a highly active research area, models often represent network behavior through idealized approaches regarding equilibrium, familiarity, rationality, and single-criterion cost dominance. Although equilibrium may remain suitable for "typical" conditions, the proposed multi-stage framework models perceived stochastic distributions, develops transforms of those distributions based on varying degrees of information pertaining to a disruption, and explores adaptive behavior as well as multi-criteria considerations and travel constraints.

2 - Modeling Evacuation Vulnerability: A Research Framework

Micah Brachman, Geography, UCSB, 1832 Ellison Hall, UC Santa Barbara, 93106-4060, Santa Barbara, CA, United States, brachman@geog.ucsb.edu

Evacuation vulnerability is the inability or unwillingness to safely evacuate from a hazard affected area. Those who do not evacuate are most vulnerable to hazards. Those who do evacuate may choose routes that make them more vulnerable than necessary. We present a research framework that incorporates survey data from the 2009 Jesusita Fire with discrete choice, network flow, and microsimulation models to assess evacuation vulnerability in Santa Barbara. Cognitive, socioeconomic, and transportation factors are integrated into a platform to test evacuation vulnerability mitigation strategies.

3 - A Quantitative Measure to Estimate and Characterise the Resilience of Guided Transport Networks exposed to Disruptive Events

Joyanto Mukerjee, Defence Science and Technology Organisation, Australia, joyanto.mukerjee@dsto.defence.gov.au, *William Malcolm*

We propose a quantitative measure to analyse the resilience of guided transportation networks subjected to disruptive events. The measure is a functional whose domain is simulated or real QoS data and is computed as the product of the temporal extent of the disruption, the maximum degradation from steady state QoS and an integration term. The objective is to quantify resilience of a transport network as a function of disruption parameters. We consider the effects of symmetric & asymmetric disruptions using a DES model.

■ HA-10

Thursday, 9:00-10:30
Meeting Room 111

Public Transport Planning

Stream: Public Transit
Invited session

Chair: *Dennis Huisman*, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl

1 - K Shortest Paths in Public Transport Time / Space Networks

Owen Griffiths, Jepppesen, 4001, Brisbane, Qld, Australia, Owen.Griffiths@jeppesen.com

Commercial journey planners have been marketed for over 10 years, finding shortest paths through public transport networks. An important extension is finding the K shortest paths through these networks. Use of K shortest paths journey planning guarantees that we can always find the best possible journey for any quantifiable definition of "best'. This paper describes an algorithm for finding K Shortest paths using a branch and bound procedure. It requires no network modifications, which is a valuable property for running many queries in succession, or even in parallel.

2 - An Optimization Model for Synchronizing Last Trains in a Metro Network

Pablo A. Rey, Industrial Engineering, Universidad Diego Portales, Vergara 432, Santiago, Chile, pablo.rey@udp.cl, *Cristián Cortés*

Some public transit systems face the problem of transporting passengers arriving at stations near the closing time of access. The Metro of Santiago (Chile) operates most part of the day with fixed stop times at stations using headways as the main flow control variable. In the final hours of daily operation, they also modify dwell times at stations. We present an integer programming model to determine the departure times of trains from the terminals and dwell times at transfer stations to ensure that all passengers can reach their destinations in the last part of the daily period of operation.

3 - Computer-aided Bus Transit Scheduling with Flexible Parameters for Guangzhou of China

Yindong Shen, Control Science and Engineering, Huazhong University of Science and Technology, 1037 Luoyu Road, 430074, Wuhan, Hubei, China, shen.yindong@gmail.com, *Yudong Ni*

The paper presents an applied study of scheduling buses and drivers for Guangzhou of China. This is pioneering research in China for making computer-aided bus transit scheduling approaches be applied in practice. The paper focuses on reporting the solution methods for Guangzhou, especially those developed to solve the specific problems such as scheduling buses with flexible parameters and built-in meal periods. Meanwhile, interactions between different operational planning processes are devised in order to build practically applicable schedules. Finally, application performances are reported.

4 - Locating Stations for Bicycle-Sharing Schemes

Tori Wyatt, Mathematics and Statistics, University of Melbourne, 23 Austin St, Balwyn, 3103, Balwyn, VIC, Australia, toriwyatt@hotmail.com, *Heng-Soon Gan*

One of the key drivers for success (increased usage) of Bicycle-sharing schemes is how well the scheme is "integrated' into existing public transport systems and the level at which it enhances the connectivity to major locations in the region of interest. We consider here the problem of locating bicycle-sharing stations with the aim to enhance connectivity to major locations in the region of interest. We present a mathematical programming formulation of this problem and several heuristics, and their performances evaluated on actual data.

■ HA-11

Thursday, 9:00-10:30
Meeting Room 112

ILP and Clustering Algorithms

Stream: Integer Programming
Invited session

Chair: *Sonia Cafieri*, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Av. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr

1 - An Exterior Point Method for ILP

Yanqun Liu, School of Mathematics and Geospatial Sciences, RMIT University, School of Mathematics and Geospatial Sciences, GPO Box 2476, 3001, Melbourne, Vic, Australia, yanqun.liu@rmit.edu.au

In this talk, we introduce the so called inclusive cone method which applies to optimization problems of either disctere or continuous nature such as linear and convex programms including linear and convex SIPs. We will focus on its extension to integer/mixed integer linear programm that leads naturally to a class of branch-climb algorithm. We also provide numerical examples.

2 - Exact Normalized Cut Clustering by Column Generation

Sylvain Perron, Management Science, GERAD and HEC Montreal, Montreal, QC, Canada, sylvain.perron@hec.ca, *Gilles Caporossi*, *Pierre Hansen*

Clustering addresses the following problem: given a set of entities, find subsets, or clusters, which are homogeneous and/or well separated. Many criteria have been proposed to express homogeneity and/or separation of the clusters. We focus on the normalized cut criterion proposed Shi and Malik (IEEE Trans. Pattern Anal. Mach. Intell., 2000). We present an exact solution method based on the column generation techniques of linear programming applied to a set partitioning formulation of the problem containing an exponential number of columns. Numerical results are presented.

3 - Hierarchical Network Clustering

Sonia Cafieri, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Av. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr, *Pierre Hansen*, *Leo Liberti*

Complex systems in a variety of fields can be represented as networks, where the vertices are given by the entities under study and the edges represent relations holding for pairs of vertices. The identification of clusters in networks is of particular interest. Many heuristics and a few exact algorithms have been proposed . Hierarchical heuristics are in principle devised for finding a hierarchy of partitions implicit in the network. We present recent advances, proposing a new hierarchical divisive heuristic which is locally optimal, in the sense that each bipartition is done in an optimal way. The bipartition subproblem is expressed as a quadratic mixed-integer program with a convex relaxation.

■ HA-12

Thursday, 9:00-10:30

Meeting Room 205

Traffic Flows and ITS

Stream: Contributed Talks

Contributed session

Chair: *Yasushi Masuda*, Faculty of Science and Tech, Keio University, 3-14-1, Hiyoshi, Kohoku, 2238522, Yokohama, Japan, masuda@ae.keio.ac.jp

1 - Dynamic Routing in Stochastic Time-Dependent Networks under ITS

Ratna Babu Chinnam, Industrial & Systems Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu, *Ali Guner*, *Alper Murat*, *Alper Murat*

We consider dynamic vehicle routing under milk-run tours with time windows in congested transportation networks for JIT production. JIT requires frequent and reliable pick-ups and deliveries within specified time windows. However, growing congestion on road networks is increasing variability in travel times, making it difficult to achieve efficient and reliable deliveries. Our dynamic routing algorithm handles milk-run tours under a TSP framework, while modeling congestion on arcs as stochastic and time-dependent congestion states. We tested our algorithms with real-time ITS information.

2 - Dynamic Origin-destination Trip Matrices Estimation in Urban Networks Based on a Kalman Filtering Approach and New ICT Sensor Data

Lidia Montero, EIO, UPC, C/Jordi Girona, 31, Campus Nord, Edifici C5 Despatx 217, 08034, Barcelona, Catalonia, Spain, lidia.montero@upc.edu, *Jaume Barcelo*

We present a new formulation of Kalman Filtering to solve the dynamic OD estimation that exploits traffic data available from ICT technologies, i.e. those capturing electronic or magnetic signatures, providing accurate measures of travel times. The formulation is an extension to urban networks of the formulations in Barcelo et al. (TRR, 2010). The extension accounts for alternative OD paths, assumes travel times are affected by congestion and models time dependencies between measures replacing estimates by sampling experiments. Results for small and medium networks are presented and discussed.

3 - An Estimate of Total Traffic Flow by Distance Distribution Method

Takeshi Koshizuka, Information Sciences and Engineering, Nanzan University, 27 Seirei-cho, 489-0863, Seto, Aichi, Japan, koshizuk@nanzan-u.ac.jp

In Japan, traffic flows are counted at many sample points by Traffic Census. Baseed on the census data we estimate the total traffic flow in every prefecture. But the census points are restricted to national and prefectural roads. In other words the traffic in local area roads is ignored. Therefore we revise the estimates of total traffic flows using the distance distributions in local area and the length of national roads, preffectural roads and other local area roads. Finally we analyze the number of killed persons in traffic accidents by the revised estimates.

4 - Second-Best Congestion Pricing: Interpretation and User Heterogeneity

Yasushi Masuda, Faculty of Science and Tech, Keio University, 3-14-1, Hiyoshi, Kohoku, 2238522, Yokohama, Japan, masuda@ae.keio.ac.jp, *Toyokazu Kido*

We explore the second-best pricing problem of congested transportation networks with elastic demand where only a subset of links is charged. We derive a simple expression of the second-best pricing rule under some technical condition and provide a clear interpretation of congestion externalities. Also examined is the issue of heterogeneity and anonymity of users. We extend the analysis of the second-best price to the case with heterogeneous user population, and study the impact of type-dependent/independent pricing schemes on social welfare.

■ HA-13

Thursday, 9:00-10:30

Meeting Room 206

Continuous Optimization in Life and Human Sciences II

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Shunsuke Hayashi*, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Catherine Decouttere*, Katholieke Universiteit Leuven Campus Kortrijk, Flanders InShape, E. Sabbelaan 51, B-8500, Kortrijk, Belgium, catherine.decouttere@kuleuven-kortrijk.be

1 - A Bi Objective Graph Coloring Approach for the Bus Driver's Timetables: A Real Case Study of the Public Transport of Sfax (TUNISIA)

Youssef Masmoudi, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef_m_tn@yahoo.fr, *Mouna Gargouri*, *Habib Chabchoub*

This work proposed an approach for timetabling problem for a public transport company. The goal is to affect all the travel services into groups. Each group represents the daily work for a driver. The first objective is that all services must have a balanced working time (to be minimized). The second objective is to maximize the break time between tow travels for one driver. This break time will guarantee the absorption of the loosed time during travels. A graph coloring approach based heuristic was applied. The obtained results indicate that our approach solve efficiently the problem.

2 - Experience and Results of OR Disciplines Introduction in a Programme of Summer School

Kateryna Pereverza, Students Science Association, National Technical University of Ukraine, Kyiv, Revutskogo, 19/1, app. 282, 02091, Kyiv, Ukraine, pereverza.kate@gmail.com, *Ielyzaveta Korotchenko*, *Alexis Pasichny*

Six year experience and results of introduction OR disciplines in Summer School AACIMP (http://summerschool.ssa.org.ua/) will be in the scope of this talk. Each year courses on optimization and other OR branches in form of interactive lectures, workshops are conducted. Besides, they are accompanied by presentations of current IFORS, EURO events. Collaboration between Ukrainian scientific community and international one, growing interest to the OR education, increasing number of Ukrainian participants in OR events are among the positive effects for the Ukrainian OR-community.

3 - The User-centered Aspect of R&D

Catherine Decouttere, Katholieke Universiteit Leuven Campus Kortrijk, Flanders InShape, E. Sabbelaan 51, B-8500, Kortrijk, Belgium, catherine.decouttere@kuleuven-kortrijk.be, *Nico Vandaele*

Research and development portfolio management is traditionally technologically and financially dominated, with little or no attention for value based performance. The latter is mainly due to the lack of quantified and reliable data on the human aspects of product/service development: sustainability, usability, ecology, ethics, product experience, perceived quality etc. We show results from an industry review that these issues really matter, not in the least if it comes to radical innovations (compared to incremental innovations). Using real life examples we show that this seemingly impossible assessment is practically possible to include sustainable, social and human centered issues.

4 - Shell Power: Managing the Giant Earthworms (Pheretima elongata) With Melanoides Granifera to Save the Ifugao Rice Terraces (IRT)

Nancy Ann Gonzales, Research & Health Sciences, Ifugao State University, Ifugao State University, 3605, IFUGAO, Philippines, napgonzales@yahoo.com

The Ifugao Rice Terraces, a World Heritage Site is in danger because of the giant earthworm (Pheretima elongata). This study aims to test the effectiveness of Melanoides granifera shell lime in controlling the giant earthworms. Field evaluation and pilot testing were applied in the study. The two-factor — factorial within a Randomized Complete Block Design (RCBD) was used. The data were treated using Analysis of Variance and the Duncan Multiple Range Test (DMRT). Mixtures of 50g shell lime:6L water and 100g shell lime:6L water were found to controll giant earthworms.

■ HA-14

Thursday, 9:00-10:30
Meeting Room 207

Continuous Optimization, Modelling and Dynamics in Biology and Medicine I

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id

1 - Modeling Coordination Relationship in School Communities using Markov-based Dynamic Influence Diagram

Azizah Hanim Nasution, Graduate School of Natural Resources and Environment Management, University of Sumatera Utara, Indonesia, nazizahhanim@yahoo.com, *Retno Widhiastuti*, *Herman Mawengkang*, *Hidayati Hidayati*

Most of the environmental problems might be caused by human behavior.The effective way to enhance environmental behavior is through education. The communities involved in a school can be regarded as a multi agent system. One approach to manage such relationships consists of using an explicit representation of them, allowing each agent to choose its actions based on them. In this paper we address an approach to represent coordination relationships assuming that agents inhabit an uncertain condition. We use Markov-based dynamic influence diagram to model the coordination relationships.

2 - A Projected Lagrangian Approach for a Class of Multi-stage Stochastic Nonlinear Programs

Ihda Hasbiyati, Mathematics, Universitas Riau/Graduate School of Mathematics, University of Sumatera Utara, Pekanbaru-Indonesia, Medan-Indonesia, Indonesia, ihasbiyati@yahoo.com

Multi-stage stochastic programming problems arise in many practical situations. By using scenario analysis technique, a decomposition strategy a for solving a class of multi-stage stochastic nonlinear programs is proposed, which generates the search direction by solving parallelly a set of quadratic programming sub-problems with size much less than the original problem at each iteration. Generalized reduced gradient methods can be introduced to derive the estimates of the dual multiplier associated with the nonanticipativity constraints.

3 - On Solving Mixed-integer Non Linear Programming Problems using Active Cinstraint Strategy

Hardi Tambunan, Universitas Quality/Graduate School of Mathematics, University of Sumatera Utara, Indonesia, harditambunan22@yahoo.com, *Herman Mawengkang*

The special nonlinear mathematical programming problem addressed in this paper has a structure characterized by a subset of variables restricted to assume discrete values, which are linear and seperable from the continuous variables. The strategy of releasing nonbasic variables from their bounds, combined with the "active constraint' method, has been developed. This strategy is used to force the appropriate non-integer basic variables to move to their neighborhood integer points. Successful implementation of these algorithms was achieved on various test problems.

4 - Modeling of Epidemic Transmission and Predicting the Spread of Pathogenic Avian Flu Between Farms

Tertia Delia Nova, Environment Management, University of Sumatera Utara, Jl. Ampera, Jl. Dr. Mansur, 20155, Medan, Indonesia, nt.delia@yahoo.com, *Herman Mawengkang*

Avian flu is an epidemic caused by H5N1 viruses. The infuenza viruses occur naturally among birds. The transmission mode of avian flu can occur due to the spread from one farm to other farm of chickens. This paper addresses a transmission model of avian flu taking into account the factors that affect the epidemic transmission such as source of infection, social and natural factors.We estimate key parameters determining the spread of highly transmissible animal diseases between farms. We implement the model aimed at controlling such transmission between chicken farms at Padang city, Indonesia.

■ HA-15

Thursday, 9:00-10:30
Meeting Room 208

OR for Irregular Warfare

Stream: Military, Defense and Security Applications
Invited session

Chair: *Marc West*, DSTO, 13 Garden St, 2015, Sydney, Australia, marc.west@dsto.defence.gov.au

1 - Analysis in Support of Counter Piracy Operations

Marc West, DSTO, 13 Garden St, 2015, Sydney, Australia, marc.west@dsto.defence.gov.au, *Bernard Kachoyan*, *Les Hamilton*

Somali piracy has increased dramatically in recent years. This paper describes an analysis technique that could be used with Automatic Identification System (AIS) data to help characterise merchant shipping traffic and traffic flows, and spot anomalies. This paper also describes the use of simulated annealing to allocate patrolling assets in a region where piracy may occur. This technique allows for the incorporation of piracy risk in certain areas and the movement of vessels. This style of data analysis is useful when planning future counter-piracy operations.

2 - An Application of Morphological Analysis for Bioterrorism Preparedness Scenario Planning

Tony Lau, Human Protection and Performance Division, DSTO, 506, Lorimer Street, 3207, Fishermans Bend, Victoria, Australia, tony.lau@dsto.defence.gov.au, *Wayne Hobbs*

The 2001 Amerithrax incident highlighted the potential impact of biological agents employed as weapons of terror. An issue in planning to meet the threat of biological terrorism is the large range of potential actors, motives, agents and delivery methods that could be considered. Scenario based planning has been demonstrated as a useful tool in support of planning under uncertain conditions. Using Morphological Analysis a problem space can be defined from which a hierarchy of plausible scenarios and vignettes is identified. This provides a basis for exploration of future strategies.

3 - DSTO Threat Anticipation Framework

Simon Crase, JOD, Defence Science and Technology Organisation, PO Box 1500, 5111, Edinburgh, South Australia, Australia, simon.crase@dsto.defence.gov.au

Improvised explosive devices (IEDs) account for the majority of casualties incurred in current Australian Defence Force (ADF) operations. Insurgent IED technology is continually evolving and predicting this evolution allows for early development of ADF countermeasures. A novel framework has been developed which uses OR methods to provide structure and rigour in assessing potential threats. This framework is used to determine the most likely paths of IED evolution, given common operational scenarios. This paper introduces the framework along with examples of its potential utility.

4 - Building a Flexible and Extensible Improvised Explosive Device Data Model

Mark Bottger, DSTO, Australia, mark.bottger@dsto.defence.gov.au

Improvised Explosive Devices (IEDs) are a significant threat present in military operations. To deal with this complex threat requires well structured data on the IED construction and the events so that the IED system can be understood. A data model has been developed using traditional database concepts combined with object oriented design principles to allow for a flexible construct of complex data. The model allows for the representation of actual IED devices and can be extended to incorporate new components and configurations. This will enable more detailed OR studies of the IED threat.

■ HA-16

Thursday, 9:00-10:30
Meeting Room 209

OR for Ambulance Services and Emergency Departments

Stream: Health Care Applications

Invited session

Chair: *Mark Fackrell*, Mathematics and Statistics, The University of Melbourne, 3010, Melbourne, Victoria, Australia, fackrell@unimelb.edu.au

1 - Predicting Emergency Medical Service Demand in Wales using Singular Spectrum Analysis

Julie Williams, Mathematics, Cardiff University, Senghennydd Road, Cardiff, Wales, United Kingdom, WilliamsJL5@cardiff.ac.uk, *Paul Harper*, *Jonathan Gillard*, *Vincent Knight*

Our work is concerned with considering a novel time-series approach to predicting demand exerted upon the Welsh Ambulance Service using the technique of Singular Spectrum Analysis (SSA), and show that the predictions generated using this technique compare favourably to forecasts obtained from conventional forecasting methods. We proportion the daily predictions by shift period and priority levels, to optimise the number of response vehicles to be deployed at a regional level. Ultimately we aim to develop a time-dependent and priority queueing model to generate rosters for crew members.

2 - Optimisation of Ambulance Move-up

Lei Zhang, Engineering Science Dept., The University of Auckland, 70 Symonds St., Auckland, New Zealand, lzha174@aucklanduni.ac.nz, *Andrew J Mason*, *Andy Philpott*

In this presentation, we will first present a single-ambulance move-up model that redeploys the ambulance that just becomes available either at scene or at a hospital in order to maximise the percentage of calls reached within a target response time. We use simulation optimisation with local search to find a static look-up table that creates rankings for ambulance bases. The highest vacant entry of the table is chosen to be the destination for the newly freed ambulance. We then will show that we can formulate a two-stage integer programming (IP) model which is a generalised version of the single-ambulance move-up model. It allows us to redeploy multiple ambulances under the same framework—using a static look-up table. We use randomly generated call data and the Auckland road network for computational experiments. We will analyse the simulation results consisting of performance measures such as the calls reached on time, operational costs induced by driving and crew's 'discomfort' caused by move-ups. Insights will be obtained from these results and guide us towards developing improved models.

3 - The Impact of Whiteboard System on Dynamics of an Emergency Department

Farrukh Rasheed, Information & Industrial Engineering Dept., Yonsei University, Seoul, Korea, Republic Of, farrukhaccount@gmail.com, *Young Hoon Lee*

Information management in health care operation research paradigm is one of the most crucial issues requiring utmost attention from professionals/senior executives interested in design, management and implementation of related information systems. Information management system deals with the collection of information from all relevant sources and distributing that information to target locations provided that the subject system has also a complete control over the structure, processing and delivery of information with secure real-time data management and access. Whiteboard system is an appropriate and proven means of health care information management because of its highly intuitive nature and architecture. This research study deals with the development of a whiteboard system for an emergency department and quantifying the benefits in numerical terms.

4 - Predicting Overflow in an Emergency Department

Mark Fackrell, Mathematics and Statistics, The University of Melbourne, 3010, Melbourne, Victoria, Australia, fackrell@unimelb.edu.au

The main cause for an emergency department to reach capacity is access block, that is, the inability to move patients into hospital beds quickly enough. We model the bed waiting process as a C-server queue with exponentially distributed arrival and service times, and find the probability that the emergency department reaches capacity given the current number of patients waiting. We also discuss the validation of the model, and give some details as to how the parameters governing the arrival and departure processes were estimated.

■ HA-17

Thursday, 9:00-10:30
Meeting Room 214

OR in Finance 2

Stream: Finance

Invited session

Chair: *Rita Decclesia*, Economic and Social Analysis, Sapienza University of Rome, Piazza Aldo Morto 5, 00185, Rome, Italy, rita.decclesia@uniroma1.it

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Cristinca Fulga*, Department of Mathematics, Academy of Economic Studies, Piata Romana 6, Sector 1, 010374, Bucharest, Romania, fulga@csie.ase.ro

1 - Evaluation of the Governance Performance of Chinese Local Government from its Financial Expenditures on Rural Compulsory Education

Yongsheng Chen, Social-Ecomic Division, Institute of International Relations, NO.64, Wan Shou Road, Wenshan, 116, Taipei, Taiwan, yschenfu@nccu.edu.tw

In recent years, China set up the protection mechanism of financial transit payment for rural compulsory education. In the point of financial expenditure, this study assesses the performances of China's local government. By employing the Location Quotient and Data Envelopment Analysis, this study will evaluate that the efforts of the local government willing to put the policy into action; consider the renovation of dilapidated buildings, increase of school library equipment and special facilities, the increase on the amounts of graduates and full-time teachers, etc.

2 - Changes in the Structure of Economic Activities of Developed and Developing Countries - Case of Serbia

Tibor Kis, Quantitative Methods in Economy, Faculty of Economics, Segedinski put 9-11, 24000, Subotica, Serbia, tbkis@yahoo.com, *Marija Cileg*

Structural changes of an economy can occur as outcome of technological advance, shocks and they can be traced along its development. Growth induces social, political, financial system and sector and distribution structure changes, and these contribute to further growth. In this paper preposition is that there is a possibility to apply formal analytical models to follow structural changes on sector level and there are patterns of developed countries expected to be followed by developing ones. Particular attention will be paid to economy of Serbia as a transitional country.

3 - Understanding Black Box: Knowledge Induction from Mathematical Models

Jinhwa Kim, Business, Sogang University, 1 Shinsoo-Dong, Mapo-Gu, Seoul, Korea, Republic Of, jinhwakim@sogang.ac.kr

This study explores approaches figuring what is inside black boxes such as mathematical models. The experiment compares the performance of the random dataset, RAA, elimination of redundant rules (ERR), and GA-RRA. In order to verify the feasibility and effectiveness of the proposed algorithms, personal credit rating dataset provided by a local bank in Seoul, Republic of Korea is used in this study. The performance of these algorithms is compared to that of the other algorithms.

4 - Single Period Mean-risk Portfolio Rebalancing Model with a Hybrid Approach of the Stock Selection Phase

Cristinca Fulga, Department of Mathematics, Academy of Economic Studies, Piata Romana 6, Sector 1, 010374, Bucharest, Romania, fulga@csie.ase.ro

In this paper we are concerned with the portfolio optimization problem in the mean-risk framework. We develop a portfolio selection method which takes into consideration the recent positive evolution of the risky assets that are not comprised in the portfolio available at the moment of the decision by combining the Principal Component Analysis and the Analytical Hierarchy Process with four key criteria: return, risk, liquidity and suitability. In our model, we rely on a new quantile based risk measure and on a utility function which captures the decision maker's attitude towards risk.

■ HA-18

Thursday, 9:00-10:30
Meeting Room 215

Applications of DEA in Banking and Financial Institutions

Stream: Data Envelopment Analysis
Invited session

Chair: *Jun Li*, Southwestern University of Finance and Economics, 610074, Chengdu, China, sodoll@163.com

1 - Measuring Total Performance Score for Iranian Bank Sector

Arash Aliakbari, Parto Novin Modiriat Iranian (Penco Consulting Group), Flat 4, No 22 , Unit 22 Separ St, Africa Blvd., Tehran, Iran, Islamic Republic Of, arashaliakbari@yahoo.com, *Evangelia Pappa*

Performance benchmarking is gradually taken to be fundamental for enhancing productivity.Data Envelopment Analysis is a useful non-parametric technique in evaluating efficiency performance of a sample of Iranian Banks, with multiple inputs and outputs and monitor the gap between actual and targeted performance.In our analysis, we will also incorporate Balance Scorecard approach,a management tool which is structured along financial,marketing,operational and strategic dimensions.

2 - Efficiency and Effectiveness of Australian Banks using a Two-Stage Data Envelopment Analysis

Amir Moradi-Motlagh, Engineering and Industrial Sciences, Swinburne University, 10 Henry Street, Sandringham, 3191, Melbourne, VIC, Australia, moradimotlagh@yahoo.com, *Amir Abdekhodaee*, *Ali Salman Saleh*, *Mehran Motamed Ektesabi*

This paper measures and analyses two aspects of the Australian banks performance which are efficiency and effectiveness using a two-stage Data Envelopment Analysis (DEA). Results indicate there is no apparent correlation between the efficiency and effectiveness of the Australian banks. While large banks generally perform better on the effectiveness, they have lower efficiency scores in comparison with the medium sized banks. Therefore, this study could be a basis for discovering strengths and weaknesses of the Australian banks in terms of efficiency and effectiveness.

3 - Efficiency and Malmquist Index of Banks in A Developing Economy: The Case of China

Jun Li, Southwestern University of Finance and Economics, 610074, Chengdu, China, sodoll@163.com, *Nan Zhu*, *Qing Wu*, *Wenli Cheng*

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■ HA-19

Thursday, 9:00-10:30
Meeting Room 216

Innovation in OR Education

Stream: Education and Operations Research
Invited session

Chair: *Kellie Keeling*, Business Information & Analytics, University of Denver, Daniels College of Business, 2101 S. University Blvd, 80208-8952, Denver, CO, United States, Kellie.Keeling@du.edu

1 - OpenSolver - An Open Source Linear Optimizer for Excel

Andrew J Mason, Dept Engineering Science, University of Auckland, Private Bag 92019, 1020, Auckland, New Zealand, a.mason@auckland.ac.nz

We have developed OpenSolver as an open-source alternative to Excel's inbuilt Solver. OpenSolver works with Solver models, but uses the COIN-OR CBC engine to solve much larger linear and integer programming problems, making Excel's optimization capabilities more accessible to OR practitioners. OpenSolver also provides additional benefits including easy viewing of the underlying formulation, and direct construction of the optimization model using information provided on the spreadsheet. OpenSolver is available for download at http://opensolver.org

2 - Linear Programming and Network Problems in Mathematics Education: Middle and High School Experiences

Susana Colaco, Departamento de Ciências Matemáticas e Naturais, Escola Suerior de Educação- Instituto politécnico de Santarém, Compexo Andaluz, Apartado 131, 2000, Santarem, Portugal, susana.colaco@ese.ipsantarem.pt, *Margarida Pato*, *Cecilia Rebelo*

This talk is devoted to the implementation of mathematical tasks for the elementary, middle and high school levels using linear programming and network problems. Experiments comparing the same tasks in the middle and high schools have been undertaken and the results will be analyzed on the basis of the students representation, reasoning, and problem solving.

3 - Creating a Data Visualization Course

Kellie Keeling, Business Information & Analytics, University of Denver, Daniels College of Business, 2101 S. University Blvd, 80208-8952, Denver, CO, United States, Kellie.Keeling@du.edu

With the large amount of data that is available, analysts continue to be challenged to understand what is going on in our data. Advances in Business Analytics software such as Tableau are allowing analysts to quickly and easily use Data Visualization techniques to organize and highlight their data so that they can determine what is happening and what might be causing it to happen. This presentation will focus on Data Visualization as a course presented to undergraduate and graduate students in a business school. A syllabus, course outline, and suggestions for implementation will be shared.

■ HA-20

Thursday, 9:00-10:30
Meeting Room 217

Managing Knowledge and Innovation

Stream: Knowledge and Knowledge Organizations
Invited session

Chair: *Uttarayan Bagchi*, Information, Risk and Operations Management, University of Texas, 78712, Austin, TX, United States, Uttarayan.Bagchi@mccombs.utexas.edu

Chair: *A. D. Amar*, Management Department, Seton Hall University, School of Business, 400 South Orange Ave., 07079, South Orange, NJ, United States, amaramar@shu.edu

1 - Rating Customers According to their Promptness to Adopt New Products

Erick Moreno-Centeno, Industrial & Systems Engineering, Texas A&M University, 3131 Tamu, 77843, College Station, TX, United States, e.moreno@tamu.edu, *Dorit Hochbaum*, *Phillip Yelland*, *Rodolfo Catena*

We use the separation-deviation model (SD-model) to processes commercial data of Sun Microsystems in order to rate Sun's customers according to their promptness for adopting new products. We provide a novel interpretation of the SD-model as an unidimensional scaling technique and show that it outperforms several dimension-reduction and scaling techniques. We analyze the results with respect to various dimensions of the customer base and report on the generated insights.

2 - Knowledge Leadership: Why, What and How?

Uttarayan Bagchi, Information, Risk and Operations Management, University of Texas, 78712, Austin, TX, United States, Uttarayan.Bagchi@mccombs.utexas.edu

It has been said that when it comes to successful exploitation of knowledge, it is leadership rather than management that is more to the point. In this talk, we start by trying to establish the why of knowledge leadership. We discuss both the distinctive characteristics of knowledge as an organizational resource and the characteristics that distinguish leadership from management, to argue that knowledge and leadership are truly compatible and commensurable constructs. We then proceed to articulate the what and the how of knowledge leadership.

3 - Super-Flexibility for Real-Time Adaptation: Insights from Silicon Valley

Stuart Evans, Silicon Valley Campus, Carnegie Mellon University, CA 94035, Moffett Field, CA, United States, stuart.evans@sv.cmu.edu

Real-time adaptation is crucial for enterprises in today's unpredictable world. The hallmark of Silicon Valley firms, super-flexibility provides capacity to pivot in accordance with advances in knowledge. Super-flexibility is the capacity to withstand turbulence while being able to transform. Based on research in Silicon Valley, this presentation describes the conceptual foundations and five action principles of super-flexibility for knowledge enterprises.

4 - Knowledge Work Organization: The Symbiotic Approach

A. D. Amar, Management Department, Seton Hall University, School of Business, 400 South Orange Ave., 07079, South Orange, NJ, United States, amaramar@shu.edu

Condemning the traditional methods of work organization, this paper first defines the goals of knowledge work, comparing them against the traditional work, and, then, drafts organization design principles that will not asphyxiate human creativity and innovation in organizations. Guided by the themes observed from symbiotic systems in nature, the paper describes models of work sectorization, integration, work assignment, scheduling and loading. Also covered in here are the principles for teaming knowledge workers. Some examples illustrating the concepts from real world are also given.

■ HA-21

Thursday, 9:00-10:30
Meeting Room 218

Maritime Inventory Routing Problems in the Asia-Pacific Region

Stream: Maritime Transportation and Logistics
Invited session

Chair: *Heng-Soon Gan*, University of Melbourne, Department of Mathematics and Statistics, 3010, Parkville, VIC, Australia, hsg@unimelb.edu.au

1 - Heuristics for a Multi-Product Maritime Inventory Routing Problem with Varying Consumption Rates

Tuong Vi Vu, Department of Mathematics and Statistics, University of Melbourne, 3010, Parkville, VIC, Australia, v.vu2@pgrad.unimelb.edu.au, *Heng-Soon Gan*

The multi-product maritime inventory routing problem with varying consumption rates is considered here. Multiple time periods for each port and each product are considered, where in each time period the consumption rate is constant. The objective is to minimize total route, load/discharge and inventory surplus costs. We propose several multi-stage heuristics, which could be used for the purpose of warm-starting arc-based and path-based mixed-integer programming formulations for this problem. The performances of these heuristics were tested on datasets derived from an industrial application.

2 - Scheduling Ship Annual Surveys and Deliveries for Tramp Service Owners

Hua-An Lu, Department of Shipping and Transportation Management, National Taiwan Ocean University, #2, Pei-Ning Road, 202, Keelung, Taiwan, halu@mail.ntou.edu.tw

For seaworthiness certificates, all ships must implement annual surveys since their deliveries. Owners can flexibly plan all ships to follow a buffer regulation and to cope with operational requirements. Besides an assignment model is formulated when all dates of delivery are fixed, the uncertainty of deliveries for order ships is further considered in this study. A genetic algorithm is applied to generate the possible delivery schedule for assessing the annual survey arrangement. A tramp service case is discussed for the practical application.

3 - Maritime inventory routing problem with spot cargoes: Automotive maritime logistics application

Saurabh Chandra, Operations Management, Indian Institute of Management Lucknow, Off Sitapur Road, Prabandh Nagar, 226013, Lucknow, UP, India, saurabh.c.pathak@iiml.org, *Rajiv Srivastava*

The problem is an extension to "maritime inventory routing' problem, with the proposed inclusion of inventory costs at ports, spot cargoes etc. The problem has been developed in the scenario of global export/import of "finished automobiles', in which a LSP has to plan the simultaneous maritime transportation along with stock management at ports.

4 - A Column Generation Approach for a Multi-Product Maritime Inventory Routing Problem with Varying Consumption Rates

Heng-Soon Gan, University of Melbourne, Department of Mathematics and Statistics, 3010, Parkville, VIC, Australia, hsg@unimelb.edu.au, *Tuong Vi Vu*, *Henrik Andersson*, *Marielle Christiansen*

The multi-product maritime inventory routing problem with varying consumption rates is considered here. Multiple time periods for each port and each product are considered. In each time period the consumption rate is constant. The objective is to minimize total route, load/discharge and inventory surplus costs. A path-based mixed-integer programming formulation for this problem is proposed for this problem. A column generation approach is developed for this formulation and its performance is tested at the root node on datasets derived from an industrial application.

Thursday, 11:00-12:30

■ HB-01

Thursday, 11:00-12:30
Plenary Hall 3

OR Applications in Electricity Transmission & Distribution

Stream: OR Applications in Energy
Invited session
Chair: *Young-Jun Son*, Systems and Industrial Engineering, The University of Arizona, Engineering Building #20, Room 111, 85721, Tucson, AZ, United States, son@sie.arizona.edu

1 - Optimization of Alternative Energy Generator Placement in Electrical Power Distribution Networks using Mixed-integer Programming

James Foster, School of Mathematical and Physical Sciences, University of Newcastle, University Drive, Callaghan, 2308, Newcastle, NSW, Australia, james.foster@uon.edu.au, *Natashia Boland*, *Hamish Waterer*

One barrier to the wide-spread uptake of alternative energy generators in electrical power distribution networks is the creation of unplanned system instability. This talk outlines a methodology for placing generators in an existing network so as to minimize imported power subject to demand and budget constraints. The problem is modelled as a mixed-integer non-convex quadratic program and as an approximate mixed-integer linear program. Computational results using state-of-the-art mixed-integer programming solvers are compared to those found by a widely-used industry accepted genetic algorithm.

2 - Thermo-accumulation: An Algorithm for Identifying Potential Customers of Electricity Utilities

Reinaldo Souza, Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro, Rua Marquês de São Vicente, 24020-140, Rio de Janeiro, RJ, Afghanistan, reinaldo@ele.puc-rio.br, *Patricia Queiroz*, *Mauricio Frota*, *Aguinaldo Pinho*, *Antenor Davila*, *Fernanda Particelli*

An statistical-based algorithm capable to build real-time load curves of clients in the high voltage category was developed to identify potential customers to make use of thermo-accumulation. The algorithm, based on real-time measurement of the electric energy consumed, includes a "missing data' treatment. The use of thermo-accumulation allows to the displacement of the curve peak from peak to off-peak hours while ensuring economy savings as high as 40% in the electricity bill.

3 - Multicriteria Capacitated Districting Problem: Study Case on Power Distribution Companies

Laura Assis, DENSIS, Universidade Estadual de Campinas, Avenida Albert Einstein n 400 - Cidade Universitária Zeferino Vaz - Barão Geraldo - Campinas - São Paulo - Brasil, 13081-970, Campinas, SP, Brazil, laura.assis@gmail.com, *Paulo Morelato França*, *Fábio Usberti*

The capacitated districting problem (CDP) consists of partitioning a geographical region constituted by a set of small territorial units in a set of capacitated contiguous and non-overlapped districts with optimization of some criteria. We present the CDP inserted in reassignment of urban clusters of clients where readings of electric energy measurement must be performed. The criteria considered are compactness, workload homogeneity and conformity. A GRASP heuristic is proposed to solve the CDP; results are discussed for 240 instances more a large scale network from city of São Paulo, Brazil.

4 - A Hierarchical Modeling Framework for Electrical Power Operational Decision Making and Quality Monitoring

Young-Jun Son, Systems and Industrial Engineering, The University of Arizona, Engineering Building #20, Room 111, 85721, Tucson, AZ, United States, son@sie.arizona.edu, *Esfand Mazhari*

A hierarchical modeling framework is proposed for electric networks. The high level concerns operational decision making and defining regulations for customers for a maximum revenue and enhanced reliability. The lower level concerns changes in power quality factors and demand behavior caused by customers' response to operational decisions and regulations. The higher level is based on system dynamics (SD) and agent-based modeling (ABS) while the lower level is based on ABS and circuit-level continuous modeling. The proposed framework is demonstrated with a case with a utility company.

■ HB-02

Thursday, 11:00-12:30
Meeting Room 101

Project Scheduling

Stream: Scheduling
Contributed session
Chair: *Stefan Creemers*, IESEG School of Management, 59000, Lille, France, s.creemers@ieseg.fr

1 - Project Scheduling with Modular Project Completion on a Bottleneck Resource

Kris Coolen, Decision Sciences and Information Management, KULeuven - FBE, Ond.gr. Operat.Res. & Bus.Stat.(ORSTAT), Naamsestraat 69 - bus 3555, 3000, Leuven, Belgium, Kris.Coolen@econ.kuleuven.be, *Wenchao Wei*, *Roel Leus*

In this paper, we model a research-and-development project as consisting of several modules, with each module containing one or more activities. We examine how to schedule the activities of such a project in order to maximize the expected profit when the activities have a probability of failure and when an activity's failure can cause its module and thereby the overall project to fail. A module succeeds when at least one of its constituent activities is successfully executed. All activities are scheduled on a scarce resource that is modeled as a single machine.

2 - A Heuristic Procedure for Resource-constrained Project Scheduling within Microsoft Project

Norbert Trautmann, Department of Business Administration, University of Bern, IFM, AP Quantitative Methoden, Schützenmattstrasse 14, 3012, Bern, BE, Switzerland, norbert.trautmann@pqm.unibe.ch, *Philipp Baumann*, *Gianluca Brandinu*, *Tobias Schaefer*

The resource-allocation procedure of Microsoft Project applies a specific schedule-generation scheme. Compared against other software or state-of-the-art methods, this procedure performs relatively poor. In Microsoft Project 2010, it is possible to work with schedules that are infeasible w.r.t. the precedence or the resource constraints. We propose a novel schedule-generation scheme that uses this possibility; the scheme takes into account all calendar constraints defined within Microsoft Project. We report on computational results for the PSPLIB and several real-world projects.

3 - Information System Outsourcing Risk Factors Analysis

Otilija Sedlak, Business Informatics and Quantitative Methods, Faculty of Economics Subotica, Ivana Sarica 14, 24000, Subotica, Vojvodina, Serbia, otilijas@ef.uns.ac.rs, *Zoran Ciric*

A firm needs to determine its outsourcing need, make a sound outsourcing plan and strategy, and then work on vendor selection process. A comprehensive understanding to outsourcing risks allows the firm to monitor these risky areas. An outsourcing firm must survey its market situation and also identify its outsourcing success factors and risk factors. Project risk is a measurement of the probability of adverse or anomalous effect toward a working project. Appropriate work on project management and risk management will increase the likelihood of outsourcing success. In this paper risk uncertainty will be used to identify the accuracy of the outsourcing risk estimation.

4 - Project Scheduling with Alternative Technologies: Incorporating Varying Activity Duration Variability

Stefan Creemers, IESEG School of Management, 59000, Lille, France, s.creemers@ieseg.fr, *Roel Leus*, *Bert De Reyck*

We look into project scheduling with expected-NPV objective and stochastic activity durations. Individual activities carry a risk of failure, and an activity's failure can cause the overall project to fail. We determine the optimal solution to the scheduling problem by means of stochastic dynamic programming. We examine the impact of the variability of activity durations on the project's value. We also illustrate that higher operational variability does not always lead to lower project values, meaning that (sometimes costly) variance-reduction strategies are not always advisable.

■ HB-03

Thursday, 11:00-12:30
Meeting Room 102

Green Supply Chain Management

Stream: Contributed Talks
Contributed session
Chair: *Gopal Agarwal*, Dept of Mechanical Engineering, MNIT, J.L.N. Marg, 302033, Jaipur, Rajasthan, India, agarwal.drg@gmail.com

1 - Green Supply Chain Management: Comparative study of Indian, Japanese and China's Industry

Lokesh Vijayvargy, Operations Management, Jaipuria Insitiute of Management, Jaipur, 1, Bambala Institutional Area, Pratap Nagar, Sanganer, 302033, Jaipur, Rajasthan, India, lokeshvijay79@gmail.com, *Gopal Agarwal*

This paper aims to introduce and compare the environmental issues, green supply chain management (GSCM), and experiences of large Industries of India, Japan and China. The present study examines Indian Organizations for their involvement in GSCM using structured questionnaire. Along with this, performance improvement in GSCM is studied and thereafter the analysis of Zhu (2010) research based on the Japan and China's Industry has been referred and hence comparison between three counties is analyzed. Indian Organizations are performing consistently well in GSCM.

2 - A Closed-loop Supply Chain Coordination Model Considering the Effect of Regulation Alternatives

Youngwoo Kim, Dept. of Industrial Engineering, Seoul National University, Korea, Republic Of, remediless@gmail.com, *Sumin Han*, *Jinwoo Park*

A closed-loop supply chain(CLSC) manages forward process as well as reverse flow of end of life product returns. And many products are produced under modular design. Thus we can take advantage of the modular products in the recycling process from the end-of-life goods to manufacture new ones. In this paper, we propose a 4 echelon model for closed-loop supply chain under differing regulation scenarios and analyze the model to develop an implementable CLSC system. By analyzing the model we were able to identify the behaviors of entities, and came up with well-coordinated CLSC policy.

■ HB-04

Thursday, 11:00-12:30
Meeting Room 103

Advances in Inventory Theory

Stream: Supply Chain Management
Invited session
Chair: *Emre Berk*, Department of Management, Faculty of Business Administration, Bilkent University, 6800, Ankara, Turkey, eberk@bilkent.edu.tr

1 - Hedging Demand and Supply Risks in the Newsvendor Model

Suleyman Ozekici, Department of Industrial Engineering, Koç University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, sozekici@ku.edu.tr, *Fikri Karaesmen*, *Kaan Okyay*

We consider the newsvendor model where there are risks associated with the uncertainty in demand as well as supply. The randomness in demand and supply is correlated with the financial markets. The inventory manager exploits this correlation and manages his risks by investing in a portfolio of financial instruments. The decision problem therefore includes the determination of the optimal quantity as well as the selection of the optimal. We analyze this problem in detail and provide a risk-sensitive approach to inventory management using the mean and the variance of the cash flow.

2 - Coordinated Logistics: Joint Replenishment with Limited Fleet In-House Transportation for a Supply Chain

Ulku Gurler, Department of Industrial Engineering, Bilkent University, 6800, Ankara, Turkey, ulku@bilkent.edu.tr, *Osman Alp*, *N. Cagdas Büyükkaramikli*

We jointly consider inventory replenishment and transportation operations in a two echelon supply chain with multiple retailers and an in-house fleet of limited size. Retailers use a quantity based (Q; S) joint replenishment policy and warehouse uses one-for-one replenishment policy.Operating characteristics and expected cost rate of the model are derived. Extensive numerical study is conducted to assess performance and sensitivity of the model with interesting managerial findings.

3 - A Multi-echelon (S-1,S) Inventory System with Partial Lost Sales

Ozgur Toy, Industrial Engineering, Turkish Naval Academy, Deniz Harp Okulu Dekanlığı, Endüstri Müh.Bl.Bşk.lığı Tuzla, 34942, Istanbul, Turkey, aotoy@bilkent.edu.tr, *Ismail Kirci*

We consider a serial inventory system comprising of one warehouse and one retailer. Both locations implement (S-1, S) inventory policy. Demand during the stockout period is partially lost at the retailer level and backordered at the warehouse level. We assume that the demand follows a poisson process, there is a constant leadtime for replenishment at each levels. We provide the operating characteristics of the system and propose an approximation for obtaining optimal inventory levels of the echelons. We report our numerical study results along with comparisons with a simulation study.

4 - The (S-1,1) Perishable Inventory System with Leadtime Dependent Backordering

Emre Berk, Department of Management, Faculty of Business Administration, Bilkent University, 6800, Ankara, Turkey, eberk@bilkent.edu.tr

We consider a perishable inventory system under (S-1,S) control policy facing unit demands and arbitrary lead times. The items have random lifetimes on the shelf. During stockouts, backordering is allowed but contingent upon waiting time tolerances of customers. Continuous and discrete time versions of the system are modeled and discussed.

■ HB-05

Thursday, 11:00-12:30
Meeting Room 104

Interface between OM and Marketing

Stream: Marketing and OM Interface
Invited session
Chair: *Kathryn E. Stecke*, University of Texas at Dallas, United States, KStecke@utdallas.edu

1 - Advance Selling when Consumers Regret

Javad Nasiry, ISOM, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, nasiry@ust.hk, *Ioana Popescu*

We characterize the effect of anticipated regret on consumer decisions, firm profits and policies, in an advance selling context where buyers have uncertain valuations. Advance purchases trigger action regret if valuations turn out to be lower than the price paid, whereas delaying purchase may cause inaction regret from missing a discount or facing a stock-out. We show how regret can explain certian types of customer inertia and buying frenzies. We propose tools to either mitigate or induce regret in customers depending on how it affects the firm profits.

2 - Exact Analysis of Divergent Systems with Time-Based Shipment Consolidation and Compound Poisson Demand

Olof Stenius, Industrial Management & Logistics, Lund University - Faculty of Engineering, Ole Römers väg 1, Box 118, SE-221 00, Lund, Sweden, olle.stenius@iml.lth.se, *Gönül Karaarslan*, *Johan Marklund*, *Ton de Kok*, *Gudrun Kiesmüller*

Sustainable management of VMI systems require integration of transportation and inventory planning. In this context, a one warehouse multi-retailer system with point-of-sales data, time-based shipment consolidation and compound Poisson demand is studied. Exact costs for single- and multi-item systems are derived, and optimization of shipment interval and reorder points is provided both for systems with shortage cost and fill-rate constraints. This is done by examining the warehouse backorder distribution for each retailer.

3 - Effect of Lead Time Information Sharing on the Performance of Retailer in a Supply Chain: A Simulation Study

Padmapriya Pugazhendhi, Department of Management Studies, IIT Madras, Room no.453, Sarayu Hostel, IIT Madras, 600036, Chennai, TamilNadu, India, priyap.cool@gmail.com, *Arshinder Kaur*

Supply chain risks refer to the supply and demand uncertainty which results in poor supply chain performance. An attempt has been made in this paper to model the supply side risk that arises due to supplier's lead time uncertainty in the presence of uncertain customer demand in a single-supplier-single-retailer supply chain. A MILP model has been proposed and through simulation exercise the present work evaluates the benefit of sharing information on supplier lead time in the form of improved fill rate and reduced total cost for the retailer.

4 - Innovative Dynamic Pricing Strategies under Strategic Consumer Behavior

Yossi Aviv, Olin Business School, Washington University in Saint Louis, Campus Box 1133, 1 Brookings Drive, 63130, Saint Louis, MO, United States, aviv@wustl.edu

When implementing dynamic pricing, retailers must account for the fact that, often, strategic customers may time their purchases in anticipation of future discounts. Such strategic consumer behavior might lead to severe consequences on the retailers' revenues and profitability. In this talk, we will discuss some ways in which sellers can adopt creative dynamic pricing schemes to optimally price products in the face of strategic consumer behavior.

■ HB-06

Thursday, 11:00-12:30
Meeting Room 105

Industrial Applications of Scheduling and Routing II

Stream: Transportation

Invited session

Chair: *Geir Hasle*, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, geir.hasle@sintef.no

1 - Optimising Line-Haul Distribution Networks Using a Vehicle Routing Algorithm

Philip Kilby, NICTA, Australian National University, RSISE Building 115, North Rd ANU, 0200, Canberra, ACT, Australia, Philip.Kilby@nicta.com.au, *Andrew Verden*

In the usual formulation of the Vehicle Routing Problem, a set of routes is calculated for a fleet of vehicles to deliver goods from depot(s) to a set of customers at minimum cost. However, in distribution systems, goods are first taken from a port or manufacturing centre, and delivered to the depots. This bulk transport phase is called "line-haul". While the line-haul problem share some common ground with the VRP, it is not usually solved using VRP solvers. In this talk, we will describe how a VRP solver was used to solve a line-haul distribution problem for an Australian food manufacturer.

2 - A Multi-trip Routing Problem with Time Window and Meal Break

Suk Fung Ng, Institute of Transport and Logistics Studies, University of Sydney, ITLS, C37, Faculty of Economics and Business, 2006, Sydney, NSW, Australia, suk.ng@sydney.edu.au, *Daniel Oron*, *San Nah Sze*

A multi-trip routing problem with time window and meal break consideration, motivated by a real life application in in-flight catering, is studied. Loading teams delivers packaged meals to aircraft within their transit time windows. Due to limited truck capacity, loading teams have to serve aircraft in multiple trips. An insertion and a two-stage heuristics are developed for the cases without and with workforce synchronisation, respectively. The solutions provided by the algorithms are shown to be effective and efficient compare with the one provided by the company's professional planner.

3 - Operation Control Strategies to Improve Transfers Between High-Frequency Urban Rail Lines

Felipe Delgado, Transport and Logistics, Pontificia Universidad Católica de Chile, 1, Chile, fadelgab@gmail.com, *Juan Carlos Muñoz*, *Nigel H.M. Wilson*, *Corey Wong*

In high frequency transit systems that lack coordinated transfers, groups of passengers could benefit from faster connections if selected departing vehicles were held for short periods. To solve this problem, we propose a real-time mathematical programming model for transfer's coordination. The decision is whether or not to hold a departing vehicle at the transfer station in order to allow some, or all of the transferring passengers on an arriving vehicle to board this one. An application from the single highest-volume transfer station in the Boston subway network, Park Street, is presented.

4 - A Capacitated Clustering-based Method for Newspaper Delivery Routing

Geir Hasle, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, geir.hasle@sintef.no, *Oddvar Kloster*, *Morten Smedsrud*

We present an efficient solver that produces clustered, balanced, and cost effective routes for distribution in a given geographical area. Through cloud computing, the optimization functionality is used by some 30 Norwegian, Swedish, and Finnish newspaper distribution companies for solving Large-scale Node Edge Arc Routing Problems (NEARP) with route duration, route balancing, and route compactness constraints. First, we solve a capacitated clustering problem. The corresponding NEARP solution is further optimized through a combination of ILS and VND.

■ HB-07

Thursday, 11:00-12:30
Meeting Room 106

Topics in Combinatorial Optimization III

Stream: Combinatorial Optimization

Invited session

Chair: *Juan José Salazar González*, Estadística e Investigación Operativa, Universidad de La Laguna (Tenerife), Av. Astrofísico Francisco Sánchez, s/n, Facultad de Matemáticas, 38271, La Laguna, Tenerife, Spain, jjsalaza@ull.es

1 - Decomposition and Sensitivity Analysis Study for the Multiple Scenario Max-min Knapsack Problem: the Profit Variations

Abdelkader Sbihi, Information & Finance, Euromed Management, Marseille, France, Domaine de Luminy, BP 921, 13288, Marseille cedex 9, France, Abdelkader.Sbihi@euromed-management.com

We study a decomposition and profit variations sensitivity analysis for the Multiple Scenario Max-Min Knapsack Problem which is a max-min combinatorial optimization. The aim is to select the better scenario leading to the best outcome. We present a decomposition strategy by considering a sequence of knapsack problems, each related to a scenario and with a specific capacity. We study the sensitivity analysis of the optimal solution to the profits variations by building robust intervals bounding the variations. The obtained experiment results demonstrated a high efficiency of our approach.

2 - Determining Clusters for Existence of Solutions for the Optimal Stars Clustering Tree Problem

Michal Stern, Academic College of Tel-Aviv Yaffo, Rabenu Yeruham St., 61083, Tel-Aviv, Israel, stern@mta.ac.il, *Ron*

Ben-Ishay, *Rosanna Grassi*, *Sagi Hilleli*, *Ephraim Korach*, *Silvana Stefani*, *Anna Torriero*

The OS problem is given hypergraph (V,S) where V set of elements, S collection of subsets (clusters) of V and given complete weighted graph G=(V,E), find clustering spanning tree T with minimum weight where each cluster in S induces star in T. We use the known polynomial algorithm for the OS as tool for determining the centralities of nodes. As first step to test whether various instances have feasible solutions. We developed probabilistic lower bound for inexistence of feasible solution. The OS problem can be applied successfully to the analysis of the board director's network.

3 - A Parallel Branch & Bound for the Capacitated Centred Clustering Problem

Marcos José Negreiros, MESTRADO PROFISSIONAL EM COMPUTAÇÃO, UNIVERSIDADE ESTADUAL DO CEARÁ, Av Paranjana, 1700 - Campus do Itaperi, 60740-000, Fortaleza, CEARÁ, Brazil, negreiro@graphvs.com.br, *Augusto Palhano*, *Pablo Luis Fernandes*

The Capacitated Centred Clustering Problem is a problem that considers a number of customers with their location and demand attributes, and a fixed cost to open a cluster of customers. The problem wants to minimize both fixed and variable cost of opening and assingning customers to clusters with minimum internal variance in the clusters. This work shows a new parallel branch and bound strategy, which is non recursive, that uses new lower bounds and upper-bounds for the CCCP that can solve and prove optimality to some moderate sized instances selected from the pertinent literature.

4 - Cut-and-branch versus Branch-and-cut for protecting sensitive cells when publishing statistical tables

Juan José Salazar González, Estadística e Investigación Operativa, Universidad de La Laguna (Tenerife), Av. Astrofísico Francisco Sánchez, s/n, Facultad de Matemáticas, 38271, La Laguna, Tenerife, Spain, jjsalaza@ull.es

This paper discusses several techniques to apply Cell Suppression Methodology to protect private information when publishing tabular data. All techniques are exact algorithms to find optimal suppression patterns, but they can also be used as heuristic approaches to find good suppression patterns. We show advantages and disadvantages of a cut-and-branch algorithm when compared to a branch-and-cut algorithm, and shows computational results on a set of real world instances. The computer implementation has been done using only free and open-source libraries.

■ HB-08

Thursday, 11:00-12:30
Meeting Room 107

Dynamic Programming Applications II

Stream: Dynamic Programming
Invited session

Chair: *Thomas Archibald*, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, T.Archibald@ed.ac.uk

1 - Mitigating Inequities in Organ Allocation via Revised Health Reporting Frequencies

Lisa Maillart, University of Pittsburgh, United States, maillart@pitt.edu

In the US, the minimum frequency with which patients awaiting liver transplantation must report their current health (i.e., MELD score) depends on their last reported score. Hence, patients can conceal changes in their MELD scores and "game' the system. Using a Markov decision process model parameterized by clinical data, we examine the degree to which an individual patient can benefit from this flexibility, and investigate revised updating frequency requirements. Our results suggest that the current updating requirements are too stringent (lenient) for the healthier (sicker) patients.

2 - Dynamic Programming for Hot Rolling Operational Optimization

Li Chen, The Logistics Institute, Northeastern University, Shenyang, Liaoning province, China, chenlisky2000@126.com, *Lixin Tang*

In this paper the hot rolling operational optimization problem is formalized as a nonlinear mathematical model. It takes getting good shape as the objective function. But sometimes the static setting rolling operational model can't achieve the shape control purposes, in other words we can't get the target strip crown and flatness. In order to solve this problem, dynamic programming is used to adjust the initial rolling operation by mean of adjusting the reduction. The experiment results show that this method can achieve the shape coordinated control purposes.

3 - Dynamic Routing of Time-Sensitive Air Cargo using Real-Time Information

Alper Murat, Industrial and Manufacturing Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, amurat@wayne.edu, *Farshid Azadian*, *Ratna Babu Chinnam*

Route planning of time-sensitive air-cargo is becoming more important with growing air-network congestion and delays. We consider dynamic routing of a time-sensitive air-cargo in presence of real-time and historical information regarding flight availability, departure delays and travel times. A novel Markov decision model is formulated and solved with backward dynamic programming. Through synthetic experiments and case studies, we demonstrate that dynamic routing with real-time information can improve delivery reliability and reduce expected cost.

4 - Dynamic Portfolio Selection with Maximum Risk Level

Mei Yu, University of International Business and Economics, China, yumei@amss.ac.cn

In this paper, a new dynamic portfolio selection model is established. Different from original consideration that risk is defined as the variance of terminal wealth, the total risk is defined as the average of the sum of maximum absolute deviation of all assets in all periods. At the same time, noticing that the risk during the period is so high that the investor may go bankrupt, a maximum risk level is given to control risk in every period. By introducing an auxiliary problem, the optimal strategy is deduced via the dynamic programming method.

■ HB-09

Thursday, 11:00-12:30
Meeting Room 108

Humanitarian Logistics

Stream: Emergency Evacuation and Response
Invited session

Chair: *Irina Dolinskaya*, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, M235, 60208, Evanston, IL, United States, dolira@northwestern.edu

1 - A Transshipment Model for Redistribution and Relocation of Relief Items under Uncertainty in Humanitarian Operations

Beate Rottkemper, Institute for Operations Research and Information Systems, Hamburg University of Technology, Schwarzenbergstr. 95, 21073, Hamburg, Germany, beate.rottkemper@tu-harburg.de, *Kathrin Fischer*

The question how to react to sudden demand peaks, e.g. an epidemical spread, or to supply lacks during aid operations is considered. These situations require quick delivery of relief goods. Transferring supply from adjacent areas might cause new shortages, hence an integrated solution approach is required, taking possible future developments in account. Therefore, a new transshipment model for stock relocation under uncertainty is formulated. Progressively increasing penalty costs for unsatisfied demand are used to balance the objectives of minimizing unsatisfied demand and operational costs.

2 - Humanitarian-logistics Response through the Use of Mobile Technologies and Optimization Models

Marco Serrato, Graduate, Consulting & Continuing Education Programs, Tecnologico de Monterrey, Camino a Jesus del Monte s/n, Col Jesus del Monte, 58350, Morelia, Michoacan, Mexico, mserrato@itesm.mx, *Roman Murillo*

The management of crisis situations through humanitarian aid operations has historically been identified as a critical issue. Extreme and unexpected events such as natural disasters, industrial accidents, infectious diseases, and terrorist attacks, among others, pose major challenges to the agencies, companies and volunteer organizations involved in the delivery of critical supplies to the impacted site.
Through this research, an optimization model based on information generated by the use of mobile technologies during disaster response is developed. Such optimization model improves the coordination among governmental, non-for-profit and private organizations involved in disaster response, in order to set up a supply chain in a faster and more accurate manner.

3 - City Logistics Distribution Strategy Based on Emergency Traffic Environment

Lei Bu, Transportation Management Engineering, Tongji University, Cao'an Road 4800, 201804, Shanghai, China, leibu04168@gmail.com, *J.h.r van Duin*, *Bart Wiegmans*, *Ruijie Bian*

This paper presents a strategy framework for city logistics distribution based on emergency traffic environment, including collection, exchange and fusion of emergency traffic information on the basis of the information and communication technology (ICT). Then adjustment process for city logistics distribution activities is analyzed, considering emergency response to urban public transportation. The framework provides a decision method for city distribution dispatch center on condition that some emergencies arise.

4 - Dynamic Multi-period Humanitarian Relief Routing Problem

Irina Dolinskaya, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, M235, 60208, Evanston, IL, United States, dolira@northwestern.edu, *Luis de la Torre*, *Karen Smilowitz*

This talk presents research in last mile operations of disaster relief. We focus on the multi-vehicle relief distribution problem over a multi-day planning horizon, where each beneficiary is visited multiple times. Uncertainty in travel and service times adds stochastic elements to the problem. We solve a multi-day routing problem for the vehicle fleet by decomposing the problem into a two-stage model: (1) a period vehicle routing model that assigns each vehicle to a delivery zone for the planning horizon, and (2) a single-vehicle dynamic routing model within each assigned zone.

■ HB-10

Thursday, 11:00-12:30
Meeting Room 111

(Re)scheduling of Vehicles and Crew

Stream: Public Transit
Invited session

Chair: *Marta Mesquita*, ISA / CIO, Technical University of Lisbon, Tapada da Ajuda, 1349-017, Lisboa, Portugal, marta@math.isa.utl.pt
Chair: *Margarida Pato*, ISEG (Technical University of Lisbon), CIO (University of Lisbon) and ISEG (Technical University of Lisbon), Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, mpato@iseg.utl.pt

1 - Ants solve scheduling and rostering problems in public transit

David Pas, Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, david.pas@student.upr.si, *Andrej Brodnik*

We will present new methods for the vehicle-crew scheduling and the crew rostering problem that are based on the ACO meta-heuristic. It has been found that the CSP does not satisfy a fundamental assumption of ACO and that the classic techniques do not work. We have accurately implemented Huisman's model and have solved his random instances. The qualities deviated from those of the IP approach for at most 7 percent and have been computed in a few seconds. Moreover, the acceptability of the qualities will be shown on real data from the public urban bus transit in Ljubljana, Slovenia.

2 - Influence of Typical Days-off Patterns on the Solutions of an Integrated Vehicle-crew-roster Problem

Margarida Pato, ISEG (Technical University of Lisbon), CIO (University of Lisbon) and ISEG (Technical University of Lisbon), Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, mpato@iseg.utl.pt, *Marta Mesquita*, *Margarida Moz*, *Ana Paias*

The integrated vehicle-crew-roster problem with days-off pattern aims to simultaneously determine minimum cost vehicle/crew schedules and a roster according to a days-off pattern. This problem is modeled as a mixed binary linear programming problem which is the basis of a heuristic approach with column generation and branch-and-bound techniques applied within a Benders decomposition. The new methodology was tested on real instances to compare rosters following two different days-off patterns. The computational results are promising for practical applications.

3 - A Stochastic Programming Model for Integrated Planning of Re-fleeting and Financial Hedging under Fuel Price and Demand Uncertainty

Marc Naumann, Decision Support & Operations Research Lab, University of Paderborn, Warburger Str 100, 33098, Paderborn, NRW, Germany, naumann@dsor.de, *Leena Suhl*, *Martin Friedemann*

Fuel costs are one of the major parts of airlines' expenditures and their fluctuations increase. The fleet assignment highly influences the fuel consumption of an airline. But the assignment has to be fixed, at least partially, when the final fuel price is still uncertain. To cope with this uncertainty, we present a SP-model under fuel price and demand uncertainty. The model also considers financial hedging to increase the robustness of the solutions. We show that the optimal fleet assignment depends on the fuel price and that the integration of hedging into the model is beneficial.

4 - Rotation-based Driver Rostering in Public Bus Transport

Lin Xie, Business Information Systems, University of Paderborn, Warburger Straße 100, 33098, Paderborn, NRW, Germany, xie@dsor.de, *Leena Suhl*, *Natalia Kliewer*

The driver rostering problem in a public bus transit company aims at assigning drivers to a set of crew duties such that management considerations, labor laws and the preferences of drivers are considered. The problem is proved to be NP-hard. Therefore, we propose that the driver rostering problem is decomposed into stages so that general solution techniques can be applied at each stage. A general modeling approach to the driver rostering and the generation of rotation-based rosters (or rotas) for large-scale real world instances are presented in the paper.

■ HB-11

Thursday, 11:00-12:30
Meeting Room 112

Algorithms for Integer Programming

Stream: Integer Programming
Invited session

Chair: *Sungsoo Park*, K A I S T, 305-701, Daejeon, Korea, Republic Of, sspark@kaist.ac.kr

1 - Solving an Extension of the Robust Optimization Problem with Cutting Planes

Jinil Han, Industrial and Systems Engineering, KAIST, Korea, Republic Of, hji@kaist.ac.kr, *Sungsoo Park*, *Chungmok Lee*

Robust optimization is a technique to solve the optimization problem under data uncertainty. In this framework, random variables are modeled as uncertain parameters belonging to an uncertainty set and one protects the solution against the worst case within that set. For this to be attractive, the uncertainty set has to be designed so that the robust problem is computationally tractable and one can control the conservativeness of the solution. We define a new type of uncertainty set which is more flexible in modeling than the existing ones and suitable to control the conservativeness effectively. A cutting plane approach is proposed to solve the robust problem and computational results are presented.

2 - Generating Cutting Planes for Unstructured Mixed-Integer Programs

Franz Wesselmann, Decision Support & OR Lab, University of Paderborn, Warburger Str. 100, 33098, Paderborn, Germany, wesselmann@dsor.de

Cutting planes are known to play a crucial role in solving mixed-integer linear programs. In this talk we consider cutting planes which can be applied independently of any problem structure. We discuss families of split cuts which can be generated efficiently such as Gomory mixed-integer cuts, reduce-and-split cuts and lift-and-project cuts and also examine the derivation of cutting planes from multi-row relaxations. We moreover describe our implementation of separation algorithms for these cutting planes and report on extensive computational experiments with the discussed cut separators.

3 - A Study of an Automatic Fingering for the Piano Score

Keisuke Hotta, Faculty of Information and Communication, Bunkyo University, 1100 Namegaya, 253-8550, Chigasaki, Kanagawa, Japan, khotta@shonan.bunkyo.ac.jp

It is important to consider the fingering for playing the piano naturally. The fingering problem is to specify the natural and reasonable fingering automatically for the piano score. For example, the model of this problem can be formulated as IP based on several rules. In this research, I am focused on being able to specify the fingering for the chord sequence.

4 - Two-stage Stochastic Mixed Integer Linear Programming

Jian Cui, Biochemical and Chemical Engineering, TU Dortmund, Kleine Rückert Str. 1, 44147, Dortmund, North Rhine-Westphalia, Germany, rossicui@hotmail.com

In this contribution, a novel dynamic two-stage stochastic mixed integer linear programming with recourse (2S-MILP) formulation for the evolving multi-period multi-uncertainty (MPMU) is developed and a corresponding method, a rolling horizon strategy (RHS) is proposed. In order to reduce the computation effort, the near future is modeled by a tree of scenarios of future uncertainties whereas the remote future is represented by the expected values. The underlying approach is implemented to a modified medium-term production planning problem of a multi-product batch plant.

■ HB-12

Thursday, 11:00-12:30
Meeting Room 205

Public Transport and Navigation

Stream: Contributed Talks
Contributed session

Chair: *Cristián Cortés*, Civil Engineering Department, Universidad de Chile, Blanco Encalada 2002, 5th floor, Santiago, Chile, ccortes@ing.uchile.cl

1 - GIS in Vehicle Direction Designation (Navigation) Optimization

Ceren Gundogdu, Administration Dept, Yildiz Technical University, Barboros Bulvari Yildiz Kampusu, H-Blok, 34349, İstanbul, Turkey, ceren_erdin@yahoo.com

Navigation is gradually becoming crucial in optimization of transportation which comprises a part of the supply chain. As navigation is a positional issue, data related to this and decisions based on these data are required. With the utilization of Geographical Information Systems (GIS) determination of alternative routes and carrying out directions by mobile systems are provided in transportation. In this study determination of alternative routes in navigation of the vehicles of a company that deals shipping on national level (Turkey) with different techniques in GIS environment is discussed.

2 - The Zoning Paratransit System with Transfers: Formulation, Optimization and Heuristic

Luca Quadrifoglio, Civil Engineering, Texas A&M University, CE/TTI Bldg., 77843-3136, College Station, Texas, United States Minor Outlying Islands, quadrifo@tamu.edu

Paratransit services often adopt decentralized zoning strategies to divide large service area into smaller zones in order to simplify their management. This causes the overall system to be inefficient, due to a large amount of empty trip miles driven. Coordination among providers is possible by including transfer points at zone boundaries and can potentially improve productivity. This practice has been adopted by some transit agencies, but never properly investigated from a research point of view. This research study evaluates the impact of transfer design on decentralized zoning paratransit.

3 - Automated Intersection Management: A Novel Intersection Control Strategy

David Fajardo, Civil Engineering, University of Texas at Austin, 12009 Sky West Dr., 78758, Austin, TX, United States, davidf@mail.utexas.edu, *Tsz-Chiu Au*, *Travis Waller*, *Peter Stone*

Automated intersection traffic control is a novel approach to traffic management at intersections in the presence of autonomous vehicles. This research explores one such innovative traffic control system called Autonomous Intersection Management (AIM), which exploits the features of computerized driving systems to coordinate vehicles at intersections. We present microscopic simulation experimental results and show that the AIM system significantly outperforms traditional traffic signals in reducing delay.

4 - Station Control Strategies Based on Fuzzy Expert Rules for the Operation of a Public Transport System

Doris Sáez, Electrical Engineering Department, Universidad de Chile, Santiago, Chile, dsaez@ing.uchile.cl, *Cristián Cortés*, *Freddy Milla*

The movement of buses is affected by uncertain conditions through the day (traffic, demand, incidents and so on). For a real-time setting, we propose a control scheme to operate a bus system, based on heuristic rules and fuzzy logic. The strategies aim at keeping regular headways between buses to reduce passengers' waiting time. The system relies on bus positions, which is easy to obtain through GPS-technology. The utilized strategies are holding and stop-skipping. Simulations showed the best performance when fuzzy rules were used. The methodology has great impact and it simple to implement.

■ HB-13

Thursday, 11:00-12:30
Meeting Room 206

Continuous Optimization, Modelling and Dynamics in Biology and Medicine III

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id

1 - Stochastic Programming Model for Environmental-based Production Planning Problem of Crude Palm Oil Industry

Firmansyah Firmansyah, University Muslim Nusantara, Mathematics graduate program, University Sumatera Utara, Indonesia, firman201178@yahoo.com, *Herman Mawengkang*

Crude palm oil industry despite obvious benefits could be obtained from industrial sector, it contributes to environmental degredation. It uses much water in production process and consumes high energy. Manufacturing process generates large quantity of wastewater, solid waste and air pollution. In the production planning and risk management, there are alternatives need to be analyzed in terms of multiple criteria. The uncertainty of data (e.g. demand, price)leads the problem to a stochastic programming model. We use scenario generation based approach for solving the model.

2 - Optimization Model of Nursing Staff Management Problem

Suryati Sitepu, Graduate School of Mathematics, University of Sumatera Utara, Indonesia, suryati.sitepu@yahoo.com, *Herman Mawengkang*

Capacity management systems create insight into required resources like staff and equipment. For hospitals, capacity management requires information on beds and nursing staff capacity. This paper presents a capacity model under uncertainty that gives insight into required nursing staff capacity and opportunities to improve capacity utilization on a ward level. A capacity model was developed to calculate required nursing staff capacity. The uncertainty factors turn up on the availability schedule of staff and the number of patient. A direct search approach is used to solve the problems.

3 - Integer Stochastic Programming Model for Solving Local Seafood Production Planning

Meslin Silalahi, UNITA/Graduate School of Mathematics, University of Sumatera Utara, Indonesia, meslin_silalahi@yahoo.com, *Herman Mawengkang*

In this paper we consider the management of small scale traditional business at North Sumatera Province which performs processing fish into several local seafood products. The inherent uncertainty of data (e.g. demand), together with the sequential evolution of data over time leads the production planning problem to an integer stochastic programming model. We use scenario generation based approach and a direct search method to solve the model. The results which show the amount of each fish processed product and the number of workforce needed in each horizon planning are presented.

■ HB-14

Thursday, 11:00-12:30
Meeting Room 207

Mathematical Programming I

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Marco A. López-Cerdá*, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Projective Geometry and the Outer Approximation Algorithm for Multiobjective Linear Programming

Melih Ozlen, School of Mathematical and Geospatial Sciences, RMIT University, 3000, Melbourne, VIC, Australia, melih.ozlen@rmit.edu.au, *Benjamin A. Burton*

A key problem in multiobjective linear programming is to find all efficient extreme points in objective space. We introduce oriented projective geometry as an efficient framework for this problem. The main advantage is that we can work with an "optimally simple" but unbounded efficiency-equivalent polyhedron, yet apply to it the familiar theory and algorithms that are traditionally restricted to bounded polytopes. We apply these techniques to Benson's outer approximation algorithm, removing an exponentially large complexity from the algorithm and a significant burden from the running time.

2 - Robust Optimization for Resource-constrained Project Scheduling with Uncertain Activity Durations

Roel Leus, Decision Sciences and Information Management, KULeuven - FBE, Naamsestraat 69, 3000, Leuven, Belgium, Roel.Leus@econ.kuleuven.be, *Christian Artigues*, *Fabrice Talla Nobibon*

We examine project scheduling with considerable uncertainty in the activity durations, to the extent that the decision maker cannot with confidence associate probabilities with the possible outcomes of a decision. Our modeling techniques stem from robust optimization, which is a theoretical framework that enables the decision maker to produce solutions that will have a reasonably good objective value under any likely input data scenario. We develop and implement a scenario-relaxation algorithm and a scenario-relaxation-based heuristic.

3 - A Branch-and-Cut Algorithm for a Class of Factorable Nonconvex Programs

Paulo Ferreira, Electrical & Computer Engineering, University of Campinas, Av. Albert Einstein, 400, 13083-852, Campinas, São Paulo, Brazil, valente@dt.fee.unicamp.br, *Alireza Ashtiani*

We address the problem of minimizing an objective function expressed as a sum of nonconvex aggregations of convex functions for which convex relaxations are known. The proposed algorithm determines an epsilon-optimal solution of the current convex relaxation of the problem by a rectangular branch-and-bound procedure and tests it with respect to its feasibility. If not feasible, an adequate linear cut removes the current epsilon-optimal solution and improves the outer approximation of the problem. Progressively tighter convex relaxations are generated until the convergence of the algorithm.

4 - Solving MPCC Feasibility Problems as Smooth Systems of Equations

Oliver Stein, Institute of Operations Research, Karlsruhe Institute of Technology, 76131, Karlsruhe, Germany, stein@kit.edu

We present a new numerical solution method for finding feasible points of mathematical programs with complementarity constraints (MPCCs). The method is based on a combination of nonlinear least squares and the lifting approach for MPCCs. The latter lifts the originally nonsmooth problem to a higher-dimensional, but smooth problem. We investigate regularity properties of the lifted problem, discuss a connection to Kojima functions, and report our numerical experience with the new approach.

■ HB-15

Thursday, 11:00-12:30
Meeting Room 208

OR and Land Warfare Analyses

Stream: Military, Defense and Security Applications
Invited session

Chair: *David Marlow*, Air Operations Division, DSTO, 506 Lorimer St, 3207, Fishermans Bend, Vic, Australia, david.marlow@dsto.defence.gov.au

1 - Finding Bottlenecks in Distributed Human-Machine Systems Using Macroscopic Workload Modelling

Lydia Byrne, DSTO, Australia, lydia.byrne@dsto.defence.gov.au

An increasingly interconnected world demands OR practices that can draw conclusions about large-scale distributed socio-technical systems — involving hundreds of actors in tens of physically separated locations. This paper documents the method used to analysing one such system, the Australian Defence Force air land integration organisation. It describes a workload model developed from a combination of existing literature, observation and advice from domain experts. It then discusses how this model was used to identify and propose solutions for bottlenecks in the operation of the system.

2 - Complexities of Measures of Effectiveness for analysing Military Operations.

Maria Athanassenas, Joint Operations Division, Defence Science and Technology Organisation, 506 Lorimer St, Fishermans Bend, VIC3207, Australia, Maria.Athanassenas@dsto.defence.gov.au, *Justine Perry*

DSTO OR practitioners deployed in areas of operations are facing challenges in formulating MOE for campaign assessments due to a complex and fast changing environment. There is a need for common definitions, terminology and MOE frameworks for analysing current operations.
This paper draws upon case studies and the experience of returned analysts to address, among other topics, the role of surrogate metrics and intricacies of qualitative measures; understanding of cultural norms and their impact on assessing MOE; collection, storage and interpretation of data.

3 - War Crimes - Are They Preventable?

Richard Loe, Försvarsanalys, FOI, Gullfossgatan 6, 164 90, Stockholm, Sweden, richard.loe@foi.se

Military OR is often focussed on assessing ongoing and completed military operations with the aim of improving future operations. Much of this analysis is relatively routine but occasionally some unique tasks present themselves. This paper describes an investigation into allegations of war crimes, considers the analytical and ethical challenges such investigations pose and goes on to discuss some of the underlying causes of war crimes. Finally, the paper considers what these findings imply both for the military and for the police and what impact this may have on how we use such forces.

■ HB-16

Thursday, 11:00-12:30
Meeting Room 209

OR for Hospital and Regional Health Services I

Stream: Health Care Applications

Invited session

Chair: *Angela Testi*, Department of Economics and Quantitative Methods (DIEM), University of Genova, Facolta di Economia, via Vivaldi 5 -16126, 16126, Genova, Italy, testi@economia.unige.it

Chair: *Elena Tanfani*, Department of Economics and Quantitative Methods (DIEM), University of Genova, Via Vivaldi 5, 16126, Genova, Italy, etanfani@economia.unige.it

Chair: *Paolo Landa*, Department of Economics and Quantitative Methods (DIEM), University of Genova, Via Vivaldi 5, 16126, Genova, Italy, paolo.landa@yahoo.it

1 - Stochastic Advance Surgery Scheduling

Paolo Landa, Department of Economics and Quantitative Methods (DIEM), University of Genova, Via Vivaldi 5, 16126, Genova, Italy, paolo.landa@yahoo.it, *Elena Tanfani*, *Angela Testi*

We deal with the "advance surgery scheduling" problem assuming stochastic durations of the surgical cases. In particular, given an elective waiting list, the aim is assigning, over a given the planning horizon, a surgery date and Operating Room (OR) to each patient. The problem is first formulated by a chance-constrained stochastic model that considers the variability pertaining surgery durations by means of probabilistic capacity constraints for each OR block. A Montecarlo simulation algorithm has been developed to verify the impact on OR performance assuming different surgery duration distributions. Moreover, the algorithm calculates safety slack times for each OR and day combination to be iteratively added to the deterministic approximation of the model until a robust solution is reached. The results of the framework testing on real and randomly generated instances are presented.

2 - Operating Room Management in a Hospital of China: An Application of Multi-machine Scheduling

Liwei Zhong, Medical Department, Shanghai Jiaotong University Affiliated First People's Hospital, 100, Hainin Road, 200080, Shanghai, China, zhongliwei@gmail.com, *Shoucheng Luo*, *Lin Xu*, *Guochun Tang*

A multi-machine scheduling problem was used in hospital operating rooms, in which a surgery was regarded as a job that require execution in different machines, while surgeons, anesthetists, nurses, and ESE were considered as machines. The problem was transformed into P||Cmax by means of weighting and computer simulation technology. Our results showed that, compared with the traditional scheduling, the number of surgeries per month, the utilization rate of ESE and patient satisfaction rate increased by 10.33%, 9.66% and 1.12%, and waiting-in-bed time decreased by 0.46 days.

3 - Humanitarian Operations Research in Southern Africa

Hildah Mashira, Applied Mathematics, National University of Science and Technology, 499 Block 6, Mbare Flats, Harare, Zimbabwe, hilda.mashira@gmail.com

There is a wealth of literature pertaining to the application of hard OR techniques in determining optimal ordering, inventory and allocation policies within developed economies. In contrast, there is a dearth of research relating to similar applications in developing economies, or more particularly in the unique context of a developing country. The HIV/AIDS pandemic has reached an unprecedented scale in South Africa. The burden that this has placed on the country's already restricted health care resources place a greater emphasis on the value of Anti Retroviral drug distribution. The aim of my project is to design a vehicle routing and scheduling system for the department of health in the Limpopo province .This will seek to present major stages applicable to building effective models and routes that are cost effective. My project will also aim to come up with an inventory model that will comply with the routing model that I would have come up with. All this will aim to have an effective drug distribution to the Aids infected hence serve lives of many in South Africa.

4 - A Multicriteria Decision Support Model to Rank Medical Equipments

Rui Oliveira, CESUR/IST, Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, roliv@ist.utl.pt, *Miguel Snow*

In this paper it presented a multicriteria model that allocates a priority index to each piece of equipment in order to support decisions on appropriate strategies for medical equipment protection against earthquakes in the context of hospitals design. This model comprises, as fundamental points of view, the equipment's price, seismic vulnerability and clinical relevance in that catastrophic scenario. The problem framing and process associated with the development of the model is described and results and conclusions are presented herein.

■ HB-17

Thursday, 11:00-12:30
Meeting Room 214

OR in Finance 3

Stream: Finance

Invited session

Chair: *William Malcolm*, Defence Department Australia, DSTO, Fairbairn Park, 2002, Canberra, ACT, Australia, paul.malcolm@dsto.defence.gov.au

Chair: *Mariana Funes*, Facultad de Ciencias Económicas - Universidad Nacional de Córdoba, Avda. Valparíso s/n Ciudad Universitaria, 5000, Córdoba, Argentina, mfunes@eco.unc.edu.ar

1 - Composite Indicator to Evaluate the Credit Quality of Developing Countries

Mariana Funes, Facultad de Ciencias Económicas - Universidad Nacional de Córdoba, Avda. Valparíso s/n Ciudad Universitaria, 5000, Córdoba, Argentina, mfunes@eco.unc.edu.ar, *Maria Ines Stimolo*

The International community has focused its attention on evaluating the credit quality of developing countries, especially since the capital markets globalization. Considering a group of indicators used to assess the credit quality of countries, we applied an unsupervised classification method and identified three groups of developing countries with similar characteristics. Countries of each group were ranked according to their credit quality using the TOPSIS Multicriteria Decision Aid Method.

2 - Application of Real Options Theory to value a Toll Road Concession Project

Tara Keshar Nanda Baidya, Industrial Engineering, PUC-Rio, Rua Marquês de São Vicente 225 — Gávea, 22451-041, Rio de Janeiro, RJ, Brazil, baidya@puc-rio.br

Brazil is very interested that the private sector invests in infrastructure project. Public Private Partnership (PPP) is being used to create conditions so that the private sector can participate in the construction and operation of public projects, which look infeasible in the first hand. Governments can make such projects viable by offering guarantees and subsidies under certain conditions and taxing under other conditions. These have been used very much in transport concessions where the main risk factor is related to demand or traffic, which is difficult to estimate.

3 - Dynamical Recursive Representation for Order M >= 2 Discrete-Time Markov Chains, with Applications to Hidden-State Estimation Problems

William Malcolm, Defence Department Australia, DSTO, Fairbairn Park, 2002, Canberra, ACT, Australia, paul.malcolm@dsto.defence.gov.au

We present a new recursive representation for higher order Markov chains Our dynamics are computed through a tensor product of previous state values of the chain according to the order of the chain each identified on a simplex of unit vectors. This new representation facilitates calculation of recursive filters smoothers and detection schemes Our dynamics describe more general modelling ie systems whose hidden state and observation state are of different orders

■ HB-18

Thursday, 11:00-12:30
Meeting Room 215

DEA Theoretical Development - 2

Stream: Data Envelopment Analysis
Invited session
Chair: *Jorge Santos*, Matematica, Universi. Evora, 7000 - 671 Évora, 7000 - 671, 7000 - 671 Évora, j0p@pol.pt

1 - DEA Approach for Performance Evaluation Considering Specified Requirements

Sheu-Hua Chen, Distribution Management Dept., National Chin-Yi University of Technology, Taipin, 411, Taichung, Taiwan, shchen@ncut.edu.tw, *Hong Tau Lee*

Some decision making units can reach performance efficiency by their outstanding performance on some relative unimportant output items. This may twist the initial purpose of the performance evaluation. In this research, we try to add the strictly predefined relationships of output items in the existed model. According to this approach, only the DMUs that really match the predefined requirements and have good performance can be regarded as efficient units. This is meaningful for managerial practices. That is to say the meaning of performance depends on the goals the organization pursues.

2 - Proposition of A Performance Evaluation Method Based on Extrapolated Facets

Tohru Ueda, Faculty of Science and Technology, Seikei University, 3-3-1 Kichijoji-Kitamachi, 180-8633, Musashino-Shi, Tokyo, Japan, ueda@st.seikei.ac.jp, *Hirofumi Amatatsu*

To overcome some shortcomings in SBM (Slacks-Based Measure) model, we proposed the unified DEA model. In the unified DEA model, efficient facets are derived and then the nearest point, Z, on these facets to the target, DMU o, is decided. Then efficiency scores are calculated, based on the distance D(oZ) between DMU o and the point Z interpolated among efficient DMUs. We suppose that a segment of a line, AB, is an efficient facet. In this case any point, Y, on the line extrapolating AB is also efficient. Thus we propose a new performance evaluation method based on extrapolated facets.

3 - Weight Adjustment in Data Envelopment Analysis with an Application to Real Data

Jorge Santos, Matemaatica, Univ Evora, Rua Romão Ramalho, 59, 7000-671, Évora, Portugal, jmas@uevora.pt

DEA is a technique where weights are allowed to vary from one Unit to another. This flexibility is the key factor for the success of this tool. Some authors althought complain that it turns out to be a not much selective technique, so they suggest weights restrictions. The technique of weights restrictions has some inconveniences that will be presented. Another technique will be suggested where weights are not restricted, but adjusted smoothly to a desirable region. This technique can remove infeasibility from the superefficiency models. This is ilustrated with an application to real data.

4 - The Worst-practice Piecewise Linear DEA Model

Mohsen Rostamy-Malkhalifeh, Department of Mathematics, Science and Research Branch,Islamic Azad University, Hesarak, Poonak, 96857, Tehran, Iran, Islamic Republic Of, mohsen_rostamy@yahoo.com, *Farhad Hosseinzadeh Lotfi*, *Zohreh Moghaddas*, *Razieh Mehrjoo*

In real world applications traditional DEA models, reveal that how inefficient a DMU is in the most favorable setting, which does not fit to the real world applications. In many situations,differences in values may not be reflected adequately by linear pricing. This paper addresses output measure based on the worst practice frontier in presence of variables which have nonlinear impact on efficiency. Using numerical example, we will demonstrate how to use the result.

■ HB-19

Thursday, 11:00-12:30
Meeting Room 216

Good Practices - In OR and Education

Stream: Education and Operations Research
Invited session
Chair: *Joao Miranda*, Technologies and Design, ESTG/IPPortalegre, Lugar da Abadessa, Apt 148, 7301-901, Portalegre, Portugal, jlmiranda@estgp.pt

1 - A Study in Cooperation and Good Practices in OR/MS Teaching

Joao Miranda, Technologies and Design, ESTG/IPPortalegre, Lugar da Abadessa, Apt 148, 7301-901, Portalegre, Portugal, jlmiranda@estgp.pt

The approaches in OR/MS teaching are focusing either typical problems or specific business and industry issues. Moreover, the wide range of OR/MS applications and the gap between theory and practice are well known difficulties too. However, international cooperation and sharing good practices are effective to enhance the quality of OR/MS teaching and the following subjects are specifically addressed: the enrolment of pre-university students; the retention of first year students; the OR/MS courses in Engineering and Science programs; and the transition and retention of graduates onto SMEs.

2 - Systemic Modelling for Meta-evaluation Educational System

William Vianna, Production Engineering, Federal University at Santa Catarina (UFSC) - Brazil, Rua Cônego Bernardo, 100. ap. 202, Trindade, 88036570, Florianópolis, Santa Catarina, Brazil, wpwilliam@hotmail.com, *Leonardo Ensslin*, *Edilson Giffhorn*

The aim of this study is to use the Methodology Multicriteria Decision Support Constructivist (MCDA-C) associated with other technical support role to meta-evaluation.The modeling strongly considers the complex nature of the problem and identifies the contributions that an appropriate contextualization can bring to Performance Evaluation of Educational Systems.

3 - Trends in Professional Engineering Practice

Franz-Josef Kahlen, Mechanical Engineering, University of Cape Town, 14 University Avenue, 7701, Cape Town, South Africa, fj.kahlen@uct.ac.za

The praise of Lean Engineering has been sung in nearly all manufacturing industries and service delivery environments. While Lean grew out of engineering, little research has been presented on how this philosophy affects engineering education. Even less research has been carried out in how professional engineering practice must adapt to societal (sustainability) and operational (systems thinking) demands. The authors present their research on how Lean can support and shape the debate around professional practice development, so that future engineers are better prepared to enter the workplace.

■ HB-20

Thursday, 11:00-12:30
Meeting Room 217

Knowledge Management

Stream: Knowledge Management
Invited session
Chair: *Jo Smedley*, Newport Business School, University of Wales, Newport, Usk Way, NP20 5DA, Newport, Wales, United Kingdom, jo.smedley@newport.ac.uk

1 - Knowledge Transfer in NPD Projects

Wenli Xiao, College of Management, Georgia Tech, 800 W. Peachtree St. NW, 30308, Atlanta, GA, United States, wenli.xiao@mgt.gatech.edu, *Cheryl Gaimon*, *Janice Carrillo*

Two models characterize knowledge creation in a NPD project with three parallel stages: prototyping, pilot line testing, and on-line experimentation. We determine the optimal rates each activity should be pursued over time. We recognize knowledge gleaned from prototyping (pilot line) transfers and benefits pilot line (on-line) activities. In one model, knowledge transfer is fluid and occurs continuously over time reflecting highly interactive teams. In the second model, knowledge is accumulated at one stage and transferred to the next stage at discrete times reflecting teams that work separately. The manager maximizes revenue earned when the product is released less development costs.

2 - Mechanism for Team Effectiveness

Kei Ogiwara, Kinboshi building 306, Operating Research, 370-4,Tegata Ohsawa, Akita-shi, 010-0851, Akita, Japan, d12s005@akita-pu.ac.jp, *Tsutomu Mishina*, *Alejandra Gomez_Padilla*

Collaboration in a team contributes to an improved performance in two aspects, superior work efficiency and the attainment of higher goals. The former expects an effective method to achieve a goal and the latter a work of higher quality. We examined the success of a team collaboration by utilizing an indicator originally developed to measure personal performances, defined as the excess beyond the predetermined goal. This indicator advantageously allows for the combining of various evaluation factors and also has the capability to directly compare performances from different teams.

3 - Minimising the Gap: Developing Organisational Approaches to Support Personal Knowledge Management through Technology

Jo Smedley, Newport Business School, University of Wales, Newport, Usk Way, NP20 5DA, Newport, Wales, United Kingdom, jo.smedley@newport.ac.uk

Organisational strategies to support personal knowledge management through technological approaches should reflect individual learner needs. Insight into these individual attributes informs efficient delivery approaches to build on existing practice and maximise participant understanding. Various styles of audience engagement enables individuals to feel "ownership' of their developing knowledge and confidence in its use. A case study from a corporate organisation illustrates an organisational delivery model to maximise the quality of the learning experience.

■ HB-21

Thursday, 11:00-12:30
Meeting Room 218

Ship Design, Terminal and Fleet Operations

Stream: Maritime Transportation and Logistics
Invited session

Chair: *Sophia Everett*, Australian Maritime College, University of Tasmania, TAS 7001, Hobart, Australia, sophiae@amc.edu.au

1 - Improving Container Terminal Efficiency by Utilizing Twin Load Capability of Straddle Carriers

Roel G. Van Anholt, Faculty of Economics and Business Administration, Department of Information Systems and Logistics, VU University Amsterdam, De Boelelaan 1105, Room 14A-15, 1081 HV, Amsterdam, Netherlands, ranholt@feweb.vu.nl, *Iris F.A. Vis*

At a seaport container terminal where the quay-side transport and the stacking operation are performed by self lifting vehicles, a major challenge is to achieve fast vessel turn-around times by dispatching these vehicles efficiently. Only limited attention has yet been given to the vehicle's twin-load capability. Despite particular balancing problems in certain circumstances, this capability can improve efficiency dramatically when utilized correctly. We propose a dispatching strategy for twin load straddle carriers and test its performance in an exhaustive discrete event simulation study.

2 - Increased Environmental Concern Adds Another Dimension to Fleet Scheduling

Haakon Lindstad, Marintek AS, Otto Nielsensvei 10, 7450, Trondheim, Norway, Haakon.Lindstad@marintek.sintef.no, *Harilaos Psaraftis*, *Jan Tore Pedersen*

Shipping companies must manage their fleets effectively in order to stay in business. Ship scheduling and routing which concerns the optimal assignment of available cargoes play an important role in this respect. Increased environmental concern due to climate change adds another dimension to the scheduling and makes it multi-objective. This study focus on enabling vessel and fleet operation in the most environmental friendly way as a function of sea states for given voyage requirement such as minimizing voyage fuel consumption, minimize voyage cost, maximize revenue or maximize profit.

3 - Optimization of Machinery System in Conceptual Ship Design

Siri Solem, Marine Systems, NTNU, Otto Nielsens vei 10, NTNU, 7491, Trondheim, Norway, siri.solem@ntnu.no, *Kjetil Fagerholt*, *Stein Ove Erikstad*

Decisions on machinery system are made during conceptual phase of ship design. This paper presents a decision tree model for deterministic optimization of machinery systems. Machinery selection deals with determining type and number of engines, their capacities and internal connections for satisfying demand for propulsive, maneuvering and electrical power. The proposed model considers energy efficiency and emission to air over the vessel's lifetime on the assumption that the vessel's operations are known. A computational study is carried out and suggestions are made for further work.

4 - Ongoing Reform in Australian Ports: The Move towards Chain Integration

Sophia Everett, Australian Maritime College, University of Tasmania, TAS 7001, Hobart, Australia, sophiae@amc.edu.au

The objective of port reform in Australia has been underway since the 1980s. Driven by a market oriented policy agenda reform initially focused on efficiency improvements and the reduction and/or elimination of ongoing deficits. In more recent times the focus has included the notion of integrating the ports into efficient supply chains. This paper will examine recent policy and legislation changes in a number of Australian state government jurisdictions in a move towards chain integration. It will evaluate the rationale behind these changes in a number of Australian states and the success or otherwise of government policies.

Thursday, 13:30-15:00

■ HC-01

Thursday, 13:30-15:00
Plenary Hall 3

OR Applications in Renewable Energy Generation - I

Stream: OR Applications in Energy
Invited session
Chair: *Hayri Onal*, University of Illinois, United States, h-onal@uiuc.edu

1 - A MILP Model to Evaluate the Investment on Renewable Energy Sources

Julio Flores, INGAR-UTN, Avellaneda 3657, S3002GJC, Santa Fe, Santa Fe, Argentina, jflores@santafe-conicet.gov.ar, *Maria Analia Rodriguez*, *Aldo Vecchietti*

A multiperiod mathematical program is formulated with the aim of minimizing investment and operating costs of energy sources, so as to meet energy demands in Argentina. The main purpose is to replace fossil fuels used in transportation and electricity generation by renewable alternatives: biodiesel and bioethanol for transportation; wind turbines, hydrokinetic turbines and nuclear plants to produce electricity, and solar energy collectors for heating residential and commercial facilities. The results obtained show an alternative composition of Argentina's energy matrix for the next 20 years

2 - Decision Support Systems in Defining Sustainability of Alternative Bioenergy Production Chains

Pekka Leskinen, Research Programme for Production and Consumption, Finnish Environment Institute, Joensuu, Finland, pekka.leskinen@ymparisto.fi, *Katja Lähtinen*, *Tanja Myllyviita*

This presentation analyse how decision support systems can be utilized in defining sustainability of alternative bioenergy production chains. The sustainability analyzes were especially linked to regional characteristics, differences in raw materials used and end-products processed, and differences in scales of production. As a result of complexities in problem formulation, ecological, economic, social and cultural sustainability indicators used in the analysis were defined by using sophisticated decision support systems including cognitive mapping and preference assessment techniques.

3 - An Extension of Dantzig-Wolfe Decomposition to Nonlinear Economic Equilibrium Problems: Computational Experience with a Large-Scale Model for US Biofuels Industry

Hayri Önal, Agricultural and Consumer Economics, University of Illinois, 305 Mumford Hall, 1301 W. Gregory Dr., 61801, Urbana, Illinois, United States, h-onal@illinois.edu, *Xiaoguang Chen*

Dantzig-Wolfe decomposition is an efficient way to solve large-scale linear programming models with decomposable structures. Although the theoretical foundation of the decomposition algorithm existed for decades, empirical applications to large-scale real world problems are not too many. We extend the decomposition method to solve a spatially explicit nonlinear economic equilibrium model for US agricultural and transportation fuel sectors and present an empirical application. Our computational experience shows that the solution time can be reduced dramatically with little accuracy loss.

■ HC-02

Thursday, 13:30-15:00
Meeting Room 101

Shipping and Transportation Scheduling

Stream: Scheduling
Contributed session
Chair: *Natashia Boland*, School of Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, natashia.boland@newcastle.edu.au

1 - Ship Scheduling with Time-Varying Draft Constraints

Elena Kelareva, ANU/NICTA/OMC International, 601/422 Collins St, 3000, Melbourne, VIC, Australia, elena@omc-international.com.au

Existing ship scheduling algorithms only represent draft restrictions at ports as static constant values. Many ports have begun to use dynamic under-keel clearance rules to increase cargo throughput. Existing ship scheduling algorithms are unable to benefit from this improved accuracy, due to not accounting for time variation in vessel draft. We introduce a new problem formulation for ship scheduling at a port with deterministic time-varying environmentally-dependent draft restrictions, and present an application that uses our formulation to maximise throughput at a major Australian port.

2 - Call-a-ride Routing/ Scheduling Problems for Paratransit Services

Hokey Min, Department of Management, Bowling Green State University, 3008C, 43403, Bowling Green, Ohio, United States, hmin@bgsu.edu, *Emanuel Melachrinoudis*

The demand for paratransit services is expected to double over the next decades. In response to such increased demand, the public transit authority wants to improve paratransit services. However, paratransit services are more expensive and difficult to offer than traditional mass transit systems due to diverse customized services such as door-to-door or curb-to-curb services, peak-hour feeder services, and overnight service. This paper develops a mathematical model and solution procedures to handle practical paratransit services.

3 - Stockyard Allocation for Make-to-order Export Cargoes at a Bulk Goods Port

Natashia Boland, School of Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, natashia.boland@newcastle.edu.au, *Damon Gulczynski*, *Martin Savelsbergh*

As ships notify a make-to-order bulk goods export provider of their intended arrival at the port, planners must allocate resources to meet their orders. In particular, each cargo for a ship must be assigned a position on a stockyard pad, and a time to start building the stockpile. These decisions are very difficult to change closer to day of operations, so it is important that they are made with sufficient forethought. We present algorithms to automate and improve this decision process, and demonstrate their effectiveness on data from a real coal export operation

■ HC-03

Thursday, 13:30-15:00
Meeting Room 102

Travel behaviour 2

Stream: Travel Behaviour
Invited session
Chair: *Emma Frejinger*, KTH, Stockholm, Sweden, emma.frejinger@abe.kth.se

1 - A Topological Route Choice Model for Metro

Sebastian Raveau, Pontificia Universidad Catolica de Chile, Santiago, Chile, sraveau@uc.cl, *Juan Carlos Muñoz*, *Louis de Grange*

We present a route choice model for transit networks that incorporates variables related to the topology and user knowledge of the network. The model also captures comfort through characteristics from the vehicles and stations, complementing the variables found in traditional models based on service levels and user socioeconomic characteristics. The results provide transfer valuations and demonstrate the importance of transit maps on user behavior. We conclude that these new variables significantly improve the explanatory and predictive ability of existing route choice specifications.

2 - Integrating Latent Concepts in a Demand Model for Electric Vehicles

Aurélie Glerum, Transport and Mobility Laboratory, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, aurelie.glerum@epfl.ch, *Michaël Thémans*, *Michel Bierlaire*

In the context of the imminent commercial release of mass-market electric cars, this research aims at modeling the future demand for the private use of such vehicles. In that purpose a stated preferences survey was designed to analyze individuals' preferences between their current car and an analogous electric model. An advanced discrete choice model will be estimated to identify socio-demographic population segments that should be targeted with electric cars. The impact of latent characteristics, such as individuals' attitudes towards ecology or new technologies, will also be investigated.

3 - A Dynamic Discrete Choice Approach for Consistent Estimation of Route Choice Models

Emma Frejinger, KTH, Stockholm, Sweden, emma.frejinger@abe.kth.se, *Mogens Fosgerau*, *Anders Karlstrom*

We propose a dynamic discrete choice approach for consistently estimating route choice model parameters based on path observations using maximum likelihood. The approach is computationally efficient, does not require choice set sampling and the resulting path probabilities do not exhibit the independence from irrelevant alternatives property. If link attributes are deterministic and the link choice is modeled with a logit model, we demonstrate that we can efficiently compute the value functions by solving a system of linear equations. We present results based on real data (7288 states).

■ HC-04

Thursday, 13:30-15:00
Meeting Room 103

Supply Chain Inventory and Scheduling

Stream: Supply Chain Management
Invited session

Chair: *Rodney Parker*, Booth School of Business, University of Chicago, 60637, Chicago, IL, United States, rodney.parker@chicagobooth.edu

1 - Dynamic Inventory Competition with Stockout-Based Substitution

Tava Olsen, ISOM, University of Auckland, 1142, Auckland, New Zealand, t.olsen@auckland.ac.nz, *Rodney Parker*

We examine when there is a commitment value to inventory in a dynamic duopoly under stockout-based substitution. The firms face independent direct demand but some fraction of a firm's lost sales will switch to the other firm. This problem has been previously studied in the stationary infinite horizon (open loop) setting but not in a Markov perfect (closed loop) setting. We give conditions under which the stationary infinite horizon equilibrium is also a Markov perfect equilibrium.

2 - Scheduling and Uncertainty

Andrew Wirth, University of Melbourne, 3010, Parkville, Victoria, Australia, wirtha@unimelb.edu.au

Early results on uncertainty in scheduling concentrated on a probabilistic approach. More recently researchers have considered the stability or robustness of deterministic schedules, that is the extent to which such schedules are affected by perturbations. Online scheduling assumes extreme uncertainty, so that problem information is only released over time, say, and scheduling decisions must be made without prior knowledge. This talk will report on some of my students' research, with examples from scheduling of batches, parallel machines and flowshops.

3 - An Inventory Manager with Time-inconsistent Preference

Xiaobo Zhao, Industrial Engineering, Tsinghua University, 100084, Beijing, China, xbzhao@tsinghua.edu.cn, *Yun Zhou*, *Xie Jinxing*

We consider a periodic review inventory system with a manager with time-inconsistent preference in quasi-hyperbolic discounting rate. A laboratory experiment exhibited low order quantities of subjects. The system is modeled as an intra-personal sequential game, with a result of base-stock level that is lower than the standard optimal level. An empirical study shows evidence of time-inconsistent preference of decision makers. A dyadic channel that comprises a perfectly rational supplier and a quasi-hyperbolic retailer is analyzed, with a contract to coordinate the channel.

4 - Competing for Shelf Space under a Buyback Contract

Rodney Parker, Booth School of Business, University of Chicago, 60637, Chicago, IL, United States, rodney.parker@chicagobooth.edu

We investigate how competition between upstream suppliers for a limited retailer shelf-space affects terms in buyback and wholesale-price contracts. We observe that such competition can endow the retailer with rents beyond those offered with a monopolist supplier. We further examine the effects of competition upon wholesale price contracts vis-a-vis buyback contracts, to observe the effects upon channel efficiency.

■ HC-05

Thursday, 13:30-15:00
Meeting Room 104

Retail competition, Insurance and Energy Markets

Stream: Marketing and OM Interface
Invited session

Chair: *Mabel Chou*, Decision Sciences, National University of Singapore, 1 Business Link, BIZ 1, #04-08, 117592, Singapore, Singapore, bizchoum@nus.edu.sg

1 - Optimal Strategies for Simultaneously Determining the Location and Design of Competitive Facilities

Li-Jiuan Huang, Graduate Institute of Logistics Management, National Dong Hwa University, 1,Sec. 2, Da Hsueh Rd., Shou-Feng, 97401, Hualien, Taiwan, ived7326@yahoo.com.tw, *Tsung-Sheng Chang*

This research seeks to help a retailer develop its optimal strategies for simultaneously determining its facility location and design in a competitive environment. The decision problem is modeled as a stochastic program. Two main features differentiate the proposed model from others in the literature. One is that the model simultaneously and explicitly captures the three important aspects in real-world retailing: demand cannibalization, market expansion and agglomeration effect. The other is that the model takes the strategies of the retailer's competitors into account by way of scenarios. This research also proposes a solution algorithm to the model for solving large-scale problems.

2 - Developing Markdown Strategies to Phase-out Items in Retail Stores

Emanuel Melachrinoudis, Mechanical and Industrial Engineering, Northeastern University, 360 Huntington Avenue, 2115, Boston, MA, United States, emelas@coe.neu.edu, *Nizar Zaarour*, *Marius M. Solomon*

When new items are put forward by distributors to replace similar existing items in retail stores, the existing items have to be phased-out within a limited time, e.g. 10 weeks. In order to clear the inventory, retail stores offer discounts. To find an optimal markdown strategy, we collected data to determine the price elasticity of demand for these items and developed multi-period non-linear programming models that maximize revenue. The mathematical properties of the models are established and efficient algorithms are developed. The models are tested with real data provided by a retailer.

3 - Cost Efficiency and Total Factor Productivity: An Empirical Analysis of Insurance Sector in Pakistan

Uzma Noreen, Economics Dept., International Islamic University, sector H-10, Women Campus, 46000, Islamabad, Pakistan, uzma.iiui@yahoo.com, *Shabbir Ahmad*

Data Envelopment Analysis is used to examine the efficiency and productivity of Pakistan's insurance sector over the period 2000-2009.The results indicate that insurance sector is 39 percent cost inefficient, mainly due to allocative inefficiency. However firms remain more technically efficient. Malmquist results are also indicative of productivity growth, with significant improvement in efficiency change. Tobit model is used to investigate the impact of firm characteristics on performance, results illustrate that large firms are not efficient in equating marginal products to factor prices

4 - Analysis of the LNG Market

Mabel Chou, National University of Singapore, 1 Business Link, BIZ 1, #04-08, 117592, Singapore, Singapore, mabelchou@nus.edu.sg

Prior to the introduction of Liquefied Natural Gas (LNG), movement of natural gas has been a limitation for gas-producing countries to serve the global demand. Since the introduction of LNG in the global energy market, gas-producing countries has more room to commercialise their natural gas reserves to the gas-consumption countries. With the improvement in LNG technology and lower investment cost over the years, global LNG trade has been accelerating and is expected to be of growing importance. We present an overview of the emergence of LNG market and the current trading patterns.

■ HC-06

Thursday, 13:30-15:00
Meeting Room 105

Intelligent Transport Systems

Stream: Transportation

Invited session

Chair: *Alberto Colorni*, Department of Industrial Design, delle Arti e della Comunicazione, Politecnico di Milano, c/o Metid, p.zza Leonardo da Vinci 32, 20133, Milano, Italy, alberto.colorni@polimi.it

Chair: *Maurizio Bruglieri*, INDACO, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it

1 - Carsharing and Carpooling: Two Different MIP Optimization Approaches

Gonçalo Correia, Department of Civil Engineering, University of Coimbra, Faculdade de Ciências e Tecnologia. Dep. Eng. Civil, sala SA 2.8 Rua Luis dos Reis Santos, 3030, Coimbra, Portugal, gcorreia@dec.uc.pt, *Antonio Antunes*

Carsharing is often mistaken as being the same as carpooling, while in reality these are two different transport options: carpooling denotes a system by which people share their own vehicles mainly in commuter trips in order to save money on transport costs; whereas carsharing is a near term car rental mainly suited for city center trips avoiding car ownership and providing the comfort of using an automobile. For the first alternative we present a MIP model for finding the best ridesharing groups while for the second we address the problem of locating depots and assigning trips to vehicles.

2 - A New Agent-based Simulation Procedure to Assess the Market Potential of Shared Taxis: An Application to the Lisbon Municipality

Luis Martinez, Civil Engineering, Instituto Superior Tecnico, Avenida Rovisco Pais, 1049-001, Lisbon, Portugal, martinez@civil.ist.utl.pt, *Gonçalo Correia*, *José Viegas*

This paper presents a simulation procedure to assess the market potential for the implementation of shared taxi services in urban areas using new ITS solutions for easy booking and payment from the clients fro the city of Lisbon. The paper proposes an agent based simulation model in which a set of rules for space and time matching between the shared taxis and passengers is and then presents an algorithm that seeks to optimize different interests by conciliating the perspectives of the clients and the operators.

3 - A New Optimization Procedure to Estimate the Market Potential of a New Express Minibus Service for the Lisbon Metropolitan Area

Tomás Eiró, Department of Civil Engineering and Architecture, Instituto Superior Técnico, Avenida Rovisco Pais, Civil Engieneering Building, room 4.25, 1049-001, Lisbon, Portugal, teiro@civil.ist.utl.pt, *Luis Martinez*

This paper presents a new comprehensive optimization procedure to estimate the market potential and configuration of a new flexible and demand responsive Express Minibus service, which integrates the comfort and commercial speed of the private car and the semi-fixed location of stops and route's schedules. The optimization procedure integrates several steps that go from the potential stops location and the creation of met-demand points that are used to estimate service during the day using an adaption of a routing-vehicle algorithm.

4 - A Carpooling Service for Universities: A Case Study in Milan

Alberto Colorni, Department of Industrial Design, delle Arti e della Comunicazione, Politecnico di Milano, c/o Metid, p.zza Leonardo da Vinci 32, 20133, Milano, Italy, alberto.colorni@polimi.it, *Maurizio Bruglieri*, *Alessandro Luè*, *Diego Ciccarelli*

Carpooling is an ITS based on a shared use of private cars. We present the project to design, implement and test a car pooling service for Università Statale and Politecnico di Milano universities. At the best of our knowledge no work in the literature faces the problem of designing a carpooling service for university students taking into account the needs of this particular class of users e.g. friend/enemy list, possible multiple destinations, imposition of partial pools. For this reason we have put right a tailored matching algorithm to form the crews meeting all these needs.

■ HC-07

Thursday, 13:30-15:00
Meeting Room 106

Topics in Combinatorial Optimization IV

Stream: Combinatorial Optimization

Invited session

Chair: *Paulo Morelato França*, Dept. Matemática, Estatística e Computação, Universidade Estadual Paulista, Av. 11 de maio 2137, apto. 172 B, 19061-360, Presidente Prudente, SP, Brazil, paulo.morelato@gmail.com

1 - Scheduling Wireless Mesh Networks

Celia Glass, Cass Business School, City University, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, c.a.glass@city.ac.uk

Wireless Mesh Networks provide low cost internet and broadband access, but have distinct limitations for scheduling. The access points, used e.g. for WiFi, cannot multi-task. This disposes them to perfect periodic scheduling which offers both reliability of service, and energy saving. We employ number-theoretic results to go beyond previous approach, e.g periodicities related by powers of 2, to perfect periodic scheduling. We report on the theoretical approaches and computational results to demonstrate that perfect periodic scheduling can form the basis for efficient scheduling of WMNs.

2 - Heuristic Algorithms for Assigning Personalized TV Advertisements: Deterministic and Stochastic Scenarios

Ron Adany, Computer Science, Bar-Ilan University, 52900, Ramat-Gan, Israel, adanyr@cs.biu.ac.il, *Sarit Kraus*, *Fernando Ordonez*

We consider the problem of assigning personalized TV ads to viewers with finite viewing capacity in order to maximize revenue. We consider the deterministic scenario (DET) and the stochastic scenario (STO) where the viewers' viewing capacities are uncertain. Since the problem is NP-Hard, we present heuristic solutions which we evaluated using computational experiments. Our heuristics for DET, on average, attains 98% of the possible revenue, outperforming a MIP solver, and our robust heuristics attains almost the same revenue as DET even when the uncertainty is very high, e.g. 50%.

3 - GRASP with Path-Relinking for two Arc Routing Problems

Fábio Usberti, DENSIS, Universidade Estadual de Campinas, Av. Albert Einstein, 400, 13083-852 , Campinas, SP, Brazil, fusberti@yahoo.com, *Paulo Morelato França*, *André Luiz Morelato*

The NP-hard Capacitated Arc Routing Problem (CARP) and Open CARP are defined on an undirected graph G(V,E), where minimum cost tours must cover a set of required edges. In CARP tours are constrained to form cycles starting from the depot, while in Open CARP the tours may start and end at any two nodes. This work proposes a GRASP with Path-Relinking to solve several instances from literature, and results reveal that our metaheuristic is competitive with other state-of-the-art metaheuristics.

■ HC-08

Thursday, 13:30-15:00
Meeting Room 107

Multi-criteria Dynamic Models

Stream: Dynamic Programming
Invited session
Chair: *Lidija Zadnik Stirn*, Biotechnical Faculty, University of Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

1 - A Multi-criteria, Group and Dynamic Model for Classifying Industrial Buildings with respect to Their Long Term Impact on Environment

Lidija Zadnik Stirn, Biotechnical Faculty, University of Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

Group decision methods are efficiently used for modeling and solving many multi-criteria and multi-period processes. We evaluate several group methods within the frame of AHP, using satisfactory index, fitting performance index and three new measures. Then, we generate a hierarchical dynamic model based on group AHP methods for weighting multiple criteria with interval comparison matrices. Finally, the model is applied to the problem of selecting the most appropriate industrial building construction in respect to the long term impact on environment and opinions of experts and NGOs.

2 - Some Issues in the Strategic University Management

Nurul Nazihah Hawari, Universiti Utara Malaysia, Malaysia, nnazihah@uum.edu.my, *Razman Mat Tahar*

Universiti Utara Malaysia (UUM) has been described as the first Malaysian university with a broad Management scope. Today, in the quest to be among notable universities in the nation and world, UUM is striving hard to be a comprehensive research university that blends the main elements of national agenda, education missions and sustainable research tradition. One of the core strategies is to develop a culture of excellence in scholarly activities. This paper describes how system thinking can help in developing a shared vision within the University for achieving the ambition.

3 - Dynamic Programming Model of Sharing Profits for Single Period Split order Supply Chain

Arshinder Kaur, Department of Management Studies, Indian Institute of Technology Madras, 600036, Chennai, Tamilnadu, India, arshinder@gmail.com, *Kalpana P*

This paper primarily deals splitting of single period order into two orderings and proposes a profit sharing mechanism which fairly shares the profit gain among the supply chain members. The objective of this is to develop a complete mathematical with the help of dynamic programming approach, which incorporates the profit sharing factor in the model itself, that maximizes the expected profit of the supply chain. The time at which the second ordering has to be done is also considered as a decision variable in this model. The performance indicators like expected profit of the supply chain members and the number of units to be ordered in the second period are evaluated in this paper.

4 - A Novel Scheduling Maintenance Management Method for Wind Farms

Fausto Pedro Garcia Marquez, Administración de Empresas, Universidad de Castilla-La Mancha, ETSII, Edificio Politecnico, C/ Camilo Jose Cela, s/n, 13071, Ciudad Real, Spain, FaustoPedro.Garcia@uclm.es, *Diego Ruiz-Hernandez*

The high cost of the machinery and infrastructure of a windturbines, combined with the difficulty of access by human resources to them, requires to use a complex maintenance systems to achieve a high availability, reliability, maintainability and safety. We analyse the maintenance scheduling problem for wind farms. The problem is modelled as a multi-armed restless bandit problem. In this work we deploy Whittle index heuristics to a collection of case studies in order to minimize the operation and maintenance costs, as well as to reduce the chances (and likely huge costs) of a breakdown.

■ HC-09

Thursday, 13:30-15:00
Meeting Room 108

Rescue and Response in Disasters

Stream: Emergency Evacuation and Response
Invited session
Chair: *Elise Miller-Hooks*, University of Maryland, Civil and Environmental Engineering Dept., Parkville, 20742, College Park, MD, United States, elisemh@umd.edu

1 - Resource Location and Relocation Models with Rolling Horizon Forecasting for Wildland Fire Planning

Joseph Chow, Institute of Transportation Studies, University of California, Irvine, 4000 Anteater Instruction and Research Bldg (AIRB), 92697, Irvine, CA, United States, joseph.chow@gmail.com, *Amelia C. Regan*

Relocation models are proposed for air tanker initial attack basing in California for wildland fires that require multiple, co-located air tankers. An index from NFDRS is modeled as a discrete mean-reverting process and estimated from 2001-2006 data from each of 12 CDF units being studied. The standard p-median formulation is changed into a k-server p-median problem to assign multiple servers to a node, and extended into a chance-constrained dynamic relocation problem. Results identify a threshold for preferring regional relocation with rolling horizon forecasting from fire weather data.

2 - Small Airport Scheduling in Natural Disaster Rescue and Relief Situations - The Static Model

Guoqing Wang, Department of Business Administration, Jinan University, Guangzhou, China, tgqwang@jnu.edu.cn

In this paper we introduce the operation situations of small size airports arising in massive natural disaster rescue and relief processes like those in Haiti and Yushu earthquakes. We model the airport transportation operation system as a 2 stage flexible reentrant flowshop with no intermediate buffer in process. The first stage consists of a single machine, i.e., the runway, and the second stage includes several identical parallel machines i.e., apron stands. Each incoming flight has three operations, landing, unloading, and takeoff, and all operations have to be processed in that order. The objective is to schedule a given set of incoming flights in order to minimize the makespan. We analyze the complexity of the problem, and propose a heuristic to deal with it.

3 - Simulation Based Busy Probability Estimation for Deterministic Emergency Service Location Models

Tonguc Ünlüyurt, Manufacturing Systems/Industrial Engineering, Sabanci University, Orhanlý Tuzla, 34956, Ýstanbul, Turkey, tonguc@sabanciuniv.edu, *Yasir Tunçer*

Many deterministic models have been proposed for locating emergency services in the literature. Most of these models are set covering models with different objective functions and possibly with some side constraints. One major drawback of such models is that some of the locations may not be covered when all the service providers at a certain service point are busy. In this study, we aim to estimate these busy probabilities by simulating various scenarios for well known deterministic models proposed in the literature.

4 - Optimal Team Deployment in Urban Search and Rescue

Elise Miller-Hooks, University of Maryland, Civil and Environmental Engineering Dept., Parkville, 20742, College Park, MD, United States, elisemh@umd.edu, *Lichun Chen*

The problem of optimally deploying urban search and rescue teams to disaster sites in post-disaster circumstances is formulated as a multistage stochastic program. A portion of sites requiring assistance arrive dynamically over the decision horizon and demand levels at the sites and on-site service times are known only with uncertainty a priori. Decisions are taken dynamically over the decision horizon as situational awareness improves. An exact solution technique is proposed for its solution.

■ HC-10

Thursday, 13:30-15:00
Meeting Room 111

Computational Developments in Stochastic Programming

Stream: Stochastic Programming

Invited session

Chair: *Miguel Lejeune*, Decision Sciences, George Washington University, 2201 G Street, NW, 20052, Washington, DC, United States, mlejeune@gwu.edu

1 - Computations with Fenchel Decomposition for Stochastic Integer Programming

Lewis Ntaimo, Industrial & Systems Engineering, Texas A&M University, 3131 TAMU, 77843, College Station, TX, United States, ntaimo@tamu.edu

We present the computational performance of the Fenchel decomposition (FD) method for two-stage stochastic integer programs. FD is a cutting plane method based on Fenchel cutting planes. In this talk, we report on two implementations of the FD method: one based on cuts derived using both first- and second-stage variables, and the other based only on the second-stage variables. Computational results with instances from the literature demonstrating the comparative performance of the FD method to disjunctive decomposition (D2) and a direct solver will be presented.

2 - Stochastic Network Design for Disaster Preparedness

Xing Hong, Engineering Management & Systems Engineering, The George Washington University, United States, xhong@gwmail.gwu.edu, *Miguel Lejeune*, *Nilay Noyan*

We propose a method enabling to prepare commodities for disasters affected areas. The problem is formulated as a probabilistically constrained model which determines the inventory levels of commodities and the transportation capacities. A pre-processing method is used to simplify the probabilistic constraint, and then the obtained problem is solved with a pattern-based method, which permits to characterize the demand uncertainty finely and solve the problem efficiently. Our model is applied to the risk of hurricanes in the Southeastern US region and the risk of earthquakes in the Seattle area.

3 - Dynamic Probabilistic Lot-Sizing with Service Level Constraints

Simge Kucukyavuz, Ohio State University, 43210, Columbus, OH, United States, kucukyavuz.2@osu.edu, *Saumya Goel*

We consider a dynamic probabilistic lot-sizing problem with a type-I service level constraint. We assume that the distribution of the random demand over the planning horizon is non-stationary and has finite support. We formulate this problem as a multi-stage chance-constrained program and develop a branch-and-cut method for its solution. We present computational results to show the effectiveness of the proposed method.

4 - Game Theoretical Approach for Reliable Enhanced Indexation

Miguel Lejeune, Decision Sciences, George Washington University, 2201 G Street, NW, 20052, Washington, DC, United States, mlejeune@gwu.edu

We propose a game theoretical model to construct an enhanced indexation model. The goal is to maximize the excess return that can be attained with high probability, while ensuring that the relative risk does not exceed a given threshold. The asset returns are characterized by a joint discrete probability distribution. To hedge against the estimation risk, we consider that only limited information about the probability distribution of the index return is available. We show that the game theoretical model can be recast as a convex programming problem, and present numerical results.

■ HC-11

Thursday, 13:30-15:00
Meeting Room 112

Knapsack, Assignment Problems

Stream: Integer Programming

Invited session

Chair: *Takuro Hidaka*, Department of Information and System Engineering, Chuo University, Kasuga, Bunkyo-ku, 112-8551, Tokyo, Japan, taku_hidaka@yahoo.co.jp

1 - A Branch-and-bound Procedure for the Precedence-constrained Knapsack Problem

Byungjun You, Computer Science, National Defense Academy of Japan, 1-10-20 Hasirimizu, 239-8686, Yokosuka, Kanagawa, Japan, g48095@nda.ac.jp, *Takeo Yamada*

The knapsack problem (KP) is generalized to the case where items are partially ordered through a set of precedence relations. Each item can be accepted only when all the preceding items have been included in the knapsack. The knapsack problem with these additional constraints is referred to as the precedence-constrained knapsack problem (PCKP). To solve PCKP exactly, we present a branch-and-bound procedure based on the "tree KP relaxation'. Computational experiments on a series of instances demonstrate advantage of our method over commercial MIP solvers.

2 - Two Pegging Tests for the Assignment Problem with Multiple Constraints

Takeo Yamada, Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239 8686, Yokosuka, Kanagawa, Japan, yamada@nda.ac.jp

We present soft and hard pegging tests to reduce the size of the assignment problem with multiple constraints (MCAP). To apply the pegging test to MCAP, we need to have the simplex tableau in optimality, and for large instances this is often beyond the computer capacity. We avoid this difficulty by introducing the Lagrangian relaxation, before applying the pegging test. Moreover, we present a 'hard' pegging approach to the resulting assignment problem, as opposed to the standard 'soft' pegging where the thresholds are only approximately computed.

3 - Metaheuristic Approach for Task Assignment with Dynamic Durations

Markus Günther, Department of Business Administration and Economics, Bielefeld University, Universitaetsstr. 25, 33615, Bielefeld, Germany, markus.guenther@univie.ac.at, *Verena Schmid*

We consider a problem typically faced by companies operating in a multinational environment. Given different project characteristics and hand-over efforts we investigate the assignment of tasks to geographically dispersed employees. Geographic and cognitive distance among employees determines hand-over times between tasks. Their duration depends on the skill levels in various domains of the assigned employee. Depending on previously performed tasks their skill levels may change over time. We propose a mixed integer problem formulation which will be solved using Variable Neighborhood Search.

4 - Inverse Assignment Model for Class Scheduling Problem in Tutoring School

Takuro Hidaka, Department of Information and System Engineering, Chuo University, Kasuga, Bunkyo-ku, 112-8551, Tokyo, Japan, taku_hidaka@yahoo.co.jp, *Tomomi Matsui*

We consider a problem for constructing a class schedule of a tutoring school. Given sets of students and teachers, we need to assign each student to a teacher. The problem finds an assignment which maximizes the sum of fitness of selected student-teacher pairs. When we use the assignment model, we need to determine a value of fitness for each student-teacher pair. We propose an inverse optimization model for finding fitness values which accommodate to real schedule data used in a tutoring school. We show that our inverse optimization problem becomes to a linear programming problem.

■ HC-12

Thursday, 13:30-15:00
Meeting Room 205

Maritime Transport

Stream: Contributed Talks

Contributed session

Chair: *Shigeki Toriumi*, Information and System Engineering, Chuo University, 1-13-27 Kasuga, 112-8551, Bunkyo-ku, Tokyo, Japan, toriumi@taguchi-lab.ise.chuo-u.ac.jp

1 - Multicriteria and Multivariate Analysis for Construction of a System to Improve Brazilian Port Performance

Armando Madeira, Engenharia Mecânica Aeronáutica, ITA (Aeronautics Institute of Technology), Rua Cel Moreira César 259 apto 201, Icaraí, 24230-052, Niterói, RJ, Brazil, madeira_ita@yahoo.com.br, *Moacyr Machado Cardoso Junior*, *Anderson Correia*, *Mischel Carmen N. Belderrain*

This paper presents a model for obtaining an attractiveness score of container terminals based on multicriteria methodology. All operational and price indicators from the annual report at ANTAQ were considered in this study. Factor Analysis was used to reduce the number of criteria and ensure the independence among them. The model has proved to be satisfactory in the ordering of container terminals considering the available data from 2006 to 2009. The model also provides the decision maker with both a local and a global evaluation leading to improvement of port services.

2 - Time-space Network Analysis of Piracy Activity in Maritime Transportation

Daisuke Watanabe, Department of Logistics and Information Engineering, Tokyo University of Marine Science and Technology, 2-1-6,Etchujima, 135-8533, Koto-ku, Tokyo, Japan, daisuke@kaiyodai.ac.jp, *Shigeki Toriumi*

In this presentation, we find geographical features of hot spot for sea piracy using the map which shows all the piracy and armed robbery incidents reported to the IMB Piracy Reporting Centre. First, we develop a time-space network of vessels using the LMIU's vessel movements database. Then, we analyze vessels sailing in the region where the piracy incidents occur.

3 - Containerized Goods Security

Halima El Adnani, Laboratory CERENE, University of Havre, France, heladnani@gmail.com, *Jaouad Boukachour*, *Mehdi Najib*, *Charles H. Fredouet*, *Dalila Boudebous*

Our work concerns, in one hand, the tracking of containerized goods movement in and through the port of Le Havre and through the global Supply Chain, and other hand, maritime container security. Typically, we have two independent systems. The goal of the first one is dedicated to dangerous goods through and outside the port of Le Havre, by sending alert and threats. The second system focus on risks of the security failures and threats associated with container transportation.

4 - An External Cost Calculator for Transport: Assessing the Sustainability of Different Transport Options

Tom van Lier, MOSI-T, Vrije Universiteit Brussel, Pleinlaan 2, Building M room M219, 1050, Brussels, Belgium, tom.van.lier@vub.ac.be, *Cathy Macharis*

The framework for an external cost calculator for transport is described. Based on current knowledge of external cost calculation, a preliminary version of the calculator is developed, which is applied in two case studies. First, it is used to examine to what extent external costs are avoided when choosing barge transport via an inland port instead of truck transport. Secondly, the tool calculates the external transport cost savings of internal co-loading opportunities in a multinational company based on a discrete event simulation. Suggestions for further development of the tool are proposed.

■ HC-13

Thursday, 13:30-15:00
Meeting Room 206

Mathematical Programming II

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Shunsuke Hayashi*, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp

Chair: *Ekaterina Kostina*, Department of Mathematics and Computer Science, University of Marburg, Hans-Meerwein-Str., 35032, Marburg, kostina@mathematik.uni-marburg.de

1 - A Unified Classification Model Based on Robust Optimization

Akiko Takeda, Keio University, Japan, takeda@ae.keio.ac.jp, *Hiroyuki Mitsugi*

For binary classification, there exists a wide variety of machine learning algorithms such as support vector machine, minimax probability machine (MPM), Fisher discriminant analysis (FDA), and so on. The purpose of this work is to provide a unified optimization problem for those classifiers using a robust optimization approach. There are several benefits obtained from the unified model. One of the benefits is that clarified relationship between MPM and FDA leads to a new maximum margin classifier based on FDA. We present some of the promising numerical results.

2 - Evaluating an e-customer Value by Linear Programming

Tomohito Nakagawa, Web Business Technology, The Kyoto College of Graduate Studies for Informatics, 502 Goshomae Sky Mansion 419 Kusuriya-cho Kamigyo-ku, 602-0918, Kyoto, Japan, valuation123@gmail.com, *Jiatong Teng*, *Hui Jiayi*, *Maotao Chen*, *Hong Seung Ko*

It is a very important issue to retain the most valuable e-customer in e-business. In this paper, we propose a selecting way for picking up the most valuable e-customer who should be retained by calculating e-customer evaluation factors with Linear Programming. These factors are variables for evaluating an e-customer value and derived from motives in the 7 steps model of e-customer behavior process proposed by Ko et al. As a result, it is possible to build up the effective marketing strategy for retaining the most valuable e-customer.

3 - Eco-Finance Networks: Recent Continuous-Discrete Models, Optimization and Control

Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr, *Erik Kropat*, *Ozlem Defterli*, *Armin Fügenschuh*, *Busra Zeynep Temocin*

This talk represents the recent research state of eco-finance and gene-environment networks, their modeling and optimization. That includes aspects of finance, medicine and education. We include uncertainty in polyhedral, ellipsoidal and SDE forms. For turning from time-continuous to -discrete models, we use advanced Heun's schemes. We present hybrid models and use stochastic hybrid control.

4 - Convergence of Constraint Gauss-Newton Methods, Well-Posedness of Parameter Estimation Problems and the Reliability of Confidence Estimates

Ekaterina Kostina, Department of Mathematics and Computer Science, University of Marburg, Hans-Meerwein-Str., 35032, Marburg, kostina@mathematik.uni-marburg.de

Gauss-Newton methods are variants of Newton methods where the Hessian of Lagrangian is approximated by ignoring second order terms. Gauss-Newton methods show good local convergence in so-called small residual problems. In large residual problems, where the second order information is too significant to be ignored the performance of the Gauss-Newton is poor or even divergent. In this talk we show that the bad performance of Gauss-Newton is an advantage rather than a disadvantage of the method, since it indicates ill-posedness of the problem, insufficient modelling or lack of data.

■ HC-14

Thursday, 13:30-15:00
Meeting Room 207

New Approaches to Multi-objective Optimization Problems I

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Basak Akteke-Ozturk*, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, e114474@metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Combining Low Cost Procedures for the Improvement Directions of Negative Curvature

Javier Cano, Rey Juan Carlos University, Spain, javier.cano@urjc.es, *Javier M. Moguerza*, *Francisco Prieto*

In this work, we show how to combine procedures to improve directions of negative curvature within an interior-point algorithm for constrained optimization. These directions lead to a decrease in the iteration count of the procedure and ensure convergence to second-order KKT points. The key feature is that the combined directions have to be computed within the null subspace of the Jacobian matrix of the constraints. To conclude, some numerical experiments are presented, including real problems from the CUTEr collection, and simulated problems with a controlled spectral structure.

2 - Multi-objective, Multimodal Transport Network Design, using an Evolutionary Algorithm

Ties Brands, Centre for Transport Studies, University of Twente, Postbus 217, 7500AE, Enschede, Netherlands, t.brands@utwente.nl, *Eric van Berkum*

The paper is about the design of a multimodal transport network that is optimal with respect to multiple objectives. We focus on transfer facilities and service lines as decision variables. For the multi-objective optimization a bi-level approach is chosen which includes a fast multimodal network assignment module and an evolutionary algorithm. This results in a set of Pareto-optimal solutions which provides insight in the interdependencies between objective functions. After applying a pruning method on the Pareto set a concise overview of promising networks and their properties is provided.

3 - The Hyperbolic Smoothing Approach for Continuous Hub-and-Spoke Location in Multiple Assignment Networks

Adilson Elias Xavier, Graduate School of Systems Engineering and Computer Sciences, Federal University of Rio de Janeiro, P.O. Box 68511, Ilha do Fundão - Centro Tecnologia - H319, 21941-972, Rio de Janeiro, RJ, Brazil, adilson@cos.ufrj.br, *Claudio Gesteira*, *Henrique Pacca Loureiro Luna*

This paper considers the problem of finding the least expensive hub locations, given demands between pairs of cities and transportation costs. The problem leads to a formulation that is strongly non-differentiable. The proposed method overcomes this difficulty with a smoothing strategy. The final solution is obtained by solving a sequence of differentiable unconstrained optimization subproblems. The most important feature of the methodology is the low dimension of the subproblems. The efficiency of the method is shown through a set of computational experiments with large problems.

■ HC-15

Thursday, 13:30-15:00
Meeting Room 208

OR Practice: Practical Aids for the Military

Stream: Military, Defense and Security Applications

Invited session

Chair: *Maria John*, Defence Science & Technology Organisation, SA, Australia, maria.john@dsto.defence.gov.au

1 - An Operations Research Support to the Basis of Provisioning in an Army Project

Maria John, Defence Science & Technology Organisation, SA, Australia, maria.john@dsto.defence.gov.au, *Richard Egudo*, *Nicholas Kempt*, *Nikoleta Tomecko*, *Natasha Weaver*, *David Sanderson*

The presentation outlines the development of a decision support tool for the acquisition of an Army capability. The capability representation consists of two key dimensions: role requirements and classes of systems. A matrix is formulated describing the suitability of classes of systems in meeting the role requirements. Feasible options are generated by an integer programming model that incorporates the suitability matrix, role priorities, system costs and budget. The results of the model enable an Options Working Group to recommend a set of feasible options for further development by Army.

2 - Multi-Agency Security Risk Management

Svetoslav Gaidow, LOD, DSTO, DSTO-LOD-205L, West Avenue, 5111, Edinburgh, South Australia, Australia, svetoslav.gaidow@dsto.defence.gov.au, *Fred Bowden*, *Richard Nunes-Vaz*

A governance framework is proposed for recursive application of risk management in complex, multi-agency security environments. A transactional view is adopted in describing the logic of each phase in the process, to ensure the integrity and coordination of each agency's contribution to strategic objectives. Transactions between phases and agencies may be represented using both generic and tailored devices, which also have direct utility in focusing agency interactions.

3 - Factors Effecting Reach Back Support to Decision Making Processes

Tim McKay, JOD, DSTO, PO Box 1500, 5111, Edinburgh, SA, Australia, tim.mckay@dsto.defence.gov.au, *Goran Mihelcic*, *Stefan Pickl*, *Christian Wittmann*

Having expertise at hand when it is needed is crucial in several military as well as civilian crises scenarios. Quite often, the expertise needed is globally distributed or the sending of experts into the problem area may be too dangerous or time consuming. By connecting the team within the crisis area to a remote organizational unit — the "reach back' - this situation can be tackled by providing remote expertise. The challenges and enabling factors of this distributed decision support cooperation are discussed in this paper.

■ HC-16

Thursday, 13:30-15:00
Meeting Room 209

OR for Hospital and Regional Health Services II

Stream: Health Care Applications

Invited session

Chair: *Kristian Rotaru*, Monash University, 1 Douglas Ct, 3074, Thomastown, Victoria, Kristian.Rotaru@buseco.monash.edu.au

1 - Bed Management in Critical Care Unit

Izabela Komenda, Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, United Kingdom, komendai@cardiff.ac.uk, *Jeff Griffiths*, *Vincent Knight*

Hospital managers are faced with many problems relating to bed management. These include coping with the uncertainty in daily demand for the services, whilst also attempting to increase the flow levels of patients through the system. In this paper we propose a mathematical model which shows how improvements in bed management may be achieved by distinguishing between various categories of patients. Previous literature in this field is concerned mainly with steady-state conditions, whereas in reality activities in virtually all hospital environments are very much time-dependent.

2 - Impact of Different Discharge Patterns on Bed Occupation Rate and Bed Waiting Time: A Simulation Approach

Zhecheng Zhu, Health Services & Outcomes Research, National Healthcare Group, Singapore, Zhecheng_ZHU@nhg.com.sg

Beds are one of the most important resources in healthcare system. In recent years, population growth and aging society impose extra pressure on bed requirement, which makes bed management more challenging. There are usually two key performance indicators of the bed management system: bed occupation rate and bed waiting time. In this paper, different discharge patterns and their impacts are studied. Simulation results show that a proper discharge pattern significantly smooth the fluctuation of bed occupation rate and reduce the bed waiting time.

3 - Application of Risk-aware Value Focused Process Engineering for Risk Identification in Acute Stroke Thrombolysis Clinical Pathway

Kristian Rotaru, Accounting and Finance, Monash University, Australia, 900 Dandenong Rd, 3145, Caulfield East, Victoria, Australia, kristian.rotaru@monash.edu, *Leonid Churilov*, *Helen Dewey*

The objective of this paper is to demonstrate how Risk-aware Value Focused Process Engineering methodology can be effectively applied for operational risk identification in acute stroke thrombolysis clinical pathway. The novelty and original contribution of this research is in enabling hierarchical decomposition of process risks according to decision makers' values and the representation of such risks as a result of the systemic interrelationship between the clinical process elements.

■ HC-17

Thursday, 13:30-15:00
Meeting Room 214

OR in Finance 4

Stream: Finance

Invited session

Chair: *Rita Decclesia*, Economic and Social Analysis, Sapienza University of Rome, Piazza Aldo Morto 5, 00185, Rome, Italy, rita.decclesia@uniroma1.it

Chair: *Michael Leyer*, Frankfurt School of Finance & Management, Germany, m.leyer@fs.de

1 - The Binomial Option Pricing Models with Different Parameters

Yunjiao Hu, Department of Mathematics and Informatics, Beijing University of Chemical Technology, 100029, Beijing, China, huyj@mail.buct.edu.cn

This papers use the probability theory to derive a new type of binomial model with different parameters (NCRR), and it gives another proof of the convergence of the existed generalized binomial model (GCRR). At last, it applies the CRR, NCRR and GCRR to the pricing of European options and Asia options.

2 - The Impact of Learning Maths on Studying Accounting and Finance Course at University Level

Xin Shi, Business School, Manchester Metropolitan University, Aytoun Building, Aytoun Street, Manchester, United Kingdom, x.shi@mmu.ac.uk

This paper aims to investigate the impacts of learning maths on studying accounting and finance courses at University level. Probabilistic decision-making model which is recently developed will be applied to measure the impacts over the course. The logistic regression model uses to estimate students' perspectives on the aspects of studying accounting and finance course. Then the Monte Carlo simulation approach will be applied to predict the pattern of learning maths during the course.

3 - Analyzing the „Black Box" of Business Processes in Financial Services: The Case of Loan Application Processing

Michael Leyer, Frankfurt School of Finance & Management, Germany, m.leyer@fs.de, *Anne Dohmen*

This paper presents a methodology which combines Data Envelopment Analysis with Business Process Simulation. DEA is used to measure the efficiency of a business process on an input-output basis while BPS is used to simulate process changes leading to reductions in inefficiency. The methodology is applied to a case study, a loan application process of a German bank. The results show that it allows to analyze changes in process throughput, the "blackbox', and their impact on business process efficiency. However, limitations of this approach for application in real cases are also revealed.

■ HC-18

Thursday, 13:30-15:00
Meeting Room 215

Applications of DEA in Banking and Financial Institutions

Stream: Data Envelopment Analysis

Invited session

Chair: *Sunity Shrestha*, Management, Tribhuvan University, Central Department of Management, Kathmandu, Bagmati Zone, Nepal, sunity.shresthahada7@gmail.com

1 - The Efficiency of Islamic Microfinancing Schemes: A DEA Approach

Husniyati Ali, Islamic Banking and Finance, Faculty of Business Management, Universiti Teknologi MARA, Shah Alam, 40450, Shah Alam, Selangor, Malaysia, hamro64@yahoo.com

The main agenda of any of the microfinance institutions in Malaysia is to provide financial services to the entrepreneurs as inspires by the New Economic Model (NEM), which perceives that the Islamic micro financing could become an effective tools and mechanisms of inclusiveness of citizen to the fair and equal economic opportunities. The main aim of this paper is to produce analysis of efficiency of the Islamic microfinancing schemes, as issued by the Credit Guarantee Corporation(CGC), using DEA.

2 - Case Study: Technological Progress, Inefficiency and Productivity Growth in the Rural Credit Cooperatives of Sichuan Province, China, 2001-2007

Nan Zhu, EMBA Education Centre, Southwestern University of Finance and Economics, 55 Guanghuacun, 610074, Chengdu, Sichuan, China, zhunan@swufe.edu.cn, *Qiang Huang*, *Yi Liu*, *Xinwei Chen*, *Xingchen Zhu*

This paper applies the data envelopment analysis and Malmquist index method to measure the productive efficiency and Malmquist index of the Rural Credit Cooperatives of Sichuan Province, China?over the period between 2001 and 2007. The results and conclusion are provided.

3 - Hedge Fund Performance Appraisal: A Panel of Non-parametric Approaches using Directional Measures

Nicolas Nalpas, Economics & Finance, Toulouse Business School, 20 bld Lascrosses, 31000, Toulouse, France, n.nalpas@esc-toulouse.fr, *Léopold Simar*, *Anne Vanhems*

Unlike standard approaches, production frontiers' methods do not require either the specification of a benchmark or a statistical structure (e.g. normality) on returns. Nevertheless, such methods are sensitive to signs of inputs/outputs combinations. Using recent results proposed by Simar and Vanhems (2010), we propose to assess Hedge Funds performance through various directional techniques applied to DEA and FDH that preserve unit invariance and that allow to handle the negative inputs/outputs found in the data.

4 - Relative Efficiency of Commercial Banks in Nepal

Sunity Shrestha, Management, Tribhuvan University, Central Department of Management, Kathmandu, Bagmati Zone, Nepal, sunity.shresthahada7@gmail.com

Commercial banks are the backbone of any country which reflects the financial strength and sustainability of the nation. This study focuses on examining the relative efficiency of commercial banks in Nepal by employing Data Envelopment Analysis (DEA). Based on the twenty seven commercial banks, the efficiency through the asset approach is found to be volatile while it was found to be fluctuating through the Operations approach. This study has explored the possibility of using the tool like DEA in performance analysis in Nepalese banking sector where simply financial ratios are considered so far. The forecasting of banking performance over the period, taking quarterly data, reflects the efficiency of the banks selected under study.

■ HC-19

Thursday, 13:30-15:00
Meeting Room 216

Discrete and Global Optimization with Applications

Stream: Discrete and Global Optimization

Invited session

Chair: *Chi-Kong Ng*, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, N.T, Hong Kong, ckng@se.cuhk.edu.hk

Chair: *Xiaoling Sun*, School of Management, Fudan University, 670 Guoshun Road, 200433, Shanghai, China, xls@fudan.edu.cn

1 - Disaggregation and Dimension Reduction Methods in Solving Diophantine Equations

Duan Li, Systems Engineering & Engineering Management Dept., The Chinese University of Hong Kong, Shatin, NT, Hong Kong, dli@se.cuhk.edu.hk, *Bojun Lu*, *Baiyi Wu*, *Jianjun Gao*

0-1 Diophantine equations arise naturally in both real applications and theoretical studies. We investigate disaggregation and dimension reduction schemes in this study and present numerical comparison results with CPLEX.

2 - Heuristics for Parallel Machine Scheduling with Batch Delivery Consideration

Zhaohui Liu, Mathematics, East China University of Science and Technology, 200237, Shanghai, China, zhliu@ecust.edu.cn, *Leiyang Wang*

Consider the parallel machine scheduling problem in which the finished jobs need to be delivered to a customer in batches by a single vehicle. The goal is to minimize the makespan. We distinguish two types of batching strategies. The strategy of Type 1 permits the jobs processed on different machines to compose a delivery batch; however, the strategy of Type 2 assumes that only the jobs processed on the same machine can compose a batch. For both types of the m-machine case, we propose 2-1/m-approximation algorithms respectively. For both types of the two-machine case, we obtain two improved 4/3-approximation algorithms.

3 - A Dynamic Programming Method for Separable Quadratic Integer Programming

Jun Wang, Management Science & Engineering, Qingdao University, No. 308, Ningxia Road, 266071, Qingdao, Shandong, China, jwang@qdu.edu.cn, *Duan Li*, *Qing Xu*

A dynamic programming method is proposed for solving nonlinear integer programming problem with separable quadratic objective function and separable convex quadratic constraints. To mitigate the curse of dimensionality in dynamic programming, the surrogate constraint formulation is used as a platform for powerful utilization of dynamic programming. In this paper, by investigating the contour of objective function, the feasible region constrated by the convex quadratic functions and their relationship in domain space, we find the condition under which zero duality gap is attained and propose a domain-cutting scheme to reduce the duality gap successively and eventually eliminate it.

4 - A Modified Test-Problem Generator for Unconstrained Global Optimization

Chi-Kong Ng, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, N.T, Hong Kong, ckng@se.cuhk.edu.hk, *Duan Li*

A software for benchmarking unconstrained global optimization algorithms is developed. By combining n sophisticated univariate problems and applying linear transformation of variables, a class of inseparable test-problems with 2**n local minima is obtained. The generator, and a standard set of 300 test problems with 10 different sizes and 3 difficulty levels for MATLAB and GAMS are produced, and are available for download. Computational experiments have demonstrated the stability of the generating process and the controllability of assigning the difficulty level to the test problems.

■ HC-20

Thursday, 13:30-15:00
Meeting Room 217

Building Bridges between OR and Strategy

Stream: OR and Strategy

Invited session

Chair: *Martin Kunc*, Warwick Business School, University of Warwick, Office E0.10, WBS Social Studies Building, CV4 7AL, Coventry, United Kingdom, martin.kunc@wbs.ac.uk

1 - System Dynamics and Innovation: A Complex Problem with Multiple Levels of Analysis

Martin Kunc, Warwick Business School, University of Warwick, Office E0.10, WBS Social Studies Building, CV4 7AL, Coventry, United Kingdom, martin.kunc@wbs.ac.uk

System Dynamicists analyze innovation processes using two concepts: feedback processes and stock and flows. Feedback processes usually represent innovation processes comprising industry, organization and process levels. System dynamicists represented innovation processes differently using stock and flows. Practitioners have followed system hierarchical principles.

2 - Defence Capability Prioritisation — A Systematic Approach

Thitima Pitinanondha, Defence Science and Technology Organisation, Australian Department of Defence, F4-GF-029, 24 Fairbairn Avenue, Defence Establishment Fairbairn, 2600, Canberra, ACT, Australia, thitima.pitinanondha@defence.gov.au, *Andrea Hadley*

In Defence capability planning, prioritisation has increasingly become an important consideration for decision-makers who have to decide on the best fiscally-constrained investment strategy to deliver an appropriate set of capabilities. A number of techniques have been applied to different capability context levels to help in prioritising the Defence capability portfolio. There is a need for a systematic approach to select appropriate prioritisation techniques to assist decision-makers to achieve their expected outcomes and ensure transparency and accountability in the decision- making process. This paper describes a systematic framework developed to assist in the selection of agreed and appropriate prioritisation techniques.

3 - Good Governance: A Strategy for Economic Growth in Africa

Moses Dowart, Department of Applied Mathematics, National University of Science and Technology (NUST), 8327 Unit K Seke Chitungwiza Harare Zimbabwe, 263, Harare, Zimbabwe, mdowart@gmail.com

Africa, a continent endowed with immense natural and human resources as well as great cultural, ecological and economic diversity, remained underdeveloped. Most African nations suffer from deep poverty and underdevelopment. Numerous development strategies have failed to yield the expected results. Although some believe that the continent is doomed to perpetual poverty and economic slavery, Africa has immense potential. The paper reveals that substantial resource endowment generally has a slowing effect on economic development, but Natural resource richness with good governance promotes economic growth.

■ HC-21

Thursday, 13:30-15:00
Meeting Room 218

Sustainable Logistics

Stream: OR and Real Implementation

Invited session

Chair: *Belarmino Adenso-Diaz*, Engineering School at Gijon, Universidad de Oviedo, Campus de Viesques, 33204, Gijon, Spain, adenso@epsig.uniovi.es

Chair: *Ben Lev*, Decision Sciences, Drexel University, LeBow College of Business, 101 N. 33rd st., 19104, Philadelphia, Pa, United States, blev@drexel.edu

1 - Performance Assessment of Shipping Agents

Sebastián Lozano, Dept. of Industrial Management, University of Seville, Escuela Superior de Ingenieros, Camino de los Descubrimientos, s/n, 41092, Seville, Spain, slozano@us.es, *Ester Gutiérrez*, *Belarmino Adenso-Diaz*, *Pilar González-Torre*

Two-stage DEA is used to assess the relative efficiency of 85 shipping agents operating in Spanish ports. In the first stage, an input-oriented, variable Returns to Scale model is used to compute efficiency scores. The model considers labor as input and number of containers and ships handled as outputs. In the second stage, regression is used to relate the obtained efficiency scores to a number of exogenous variables such as the specific port where the shipping agent operates, the number of years in business or the number of container lines with which it operates.

2 - A Model to Assess the Advantages of Merging Logistic Networks

Belarmino Adenso-Diaz, Engineering School at Gijon, Universidad de Oviedo, Campus de Viesques, 33204, Gijon, Spain, adenso@epsig.uniovi.es, *Sebastián Lozano*, *Placido Moreno*, *Roberto Rodriguez*

Logistics costs represent a large fraction of the operational costs of any company. Looking for synergies with others is a way to reduce them. By merging the transportation needs, their global costs are reduced due to increased negotiation power, use of larger vehicles and increased possibilities of connecting trips. In this paper a Mixed-Integer Linear Program is presented to study the cost savings that different companies may achieve by merging their networks. The model allows testing and quantifying the synergies among different partners, and proposes and validates an a priori index.

3 - A Quantitative Model of Smart Equipment as a Basis for Truly Sustainable Manufacturing

Maximilian Etschmaier, GME International Corp., 2702 Berryland Drive, 22124, Oakton, Virginia, United States, etschmaier@cox.net

Unless sustainable manufacturing considers overall social, economic, environmental, and health and safety impacts, it degenerates into favoring some resources over others. We present a quantitative model that optimizes manufacturing systems toward overall sustainability. The model evolved from the Smart Machining Systems program of NIST. It defines equipment in terms of functionality, design, and condition and can be scaled to the enterprise level. Using our previously published system of accounting for environmental burdens, it can yield truly sustainable manufacturing enterprises.

4 - Optimizing the Visits of Sales Agents to their Customers in a Brewery Company

Marcos Colebrook, Depto. de Estadistica, Investigacion Operativa y Computacion, Universidad de La Laguna, Facultad de Matematicas, av. Astrofisico F. Sanchez s/n, 38271, La Laguna, Santa Cruz de Tenerife, Spain, mcolesan@ull.es, *Ana González Larsson*, *Antonio Sedeño-Noda*

We have developed a software application that optimizes the annual planning of visits of a brewery sales/marketing staff to their customers. Each customer must be annually visited a provided number of times. Besides, each salesperson is assigned to a set of customers that must be visited each week. The application has to assign all the visits of a salesperson to each customer so that all weeks should have more or less the same number of visits. With this approach, the brewery company wants to diminish their marketing operating costs, as well as improving their customer relationships.

Thursday, 15:30-17:00

■ HD-01

Thursday, 15:30-17:00
Plenary Hall 3

OR Applications in Renewable Energy Generation - II

Stream: OR Applications in Energy

Invited session

Chair: *Maria Teresa Vespucci*, Department of Information Technology and Mathematical Methods, University of Bergamo, via Marconi, 5a, 24044, Dalmine (BG), Italy, mtvespucci@tin.it

1 - Optimal Capacity Expansion in Power Systems with Large-Scale Wind Power

Jonas Christoffer Villumsen, Dept. of Management Engineering, Technical University of Denmark, Produktionstorvet bldg. 424, 2800, Kgs. Lyngby, Denmark, jcvi@man.dtu.dk, *Andy Philpott*

In 2025 electricity production from wind power should constitute nearly 50% of electricity demand in Denmark. In this paper we look at optimal expansion of the transmission grid and location of off-shore wind parks in order to integrate 50% wind power in the system, while minimising total fixed investment cost and expected cost of power generation. We allow for active switching of transmission elements to eliminate negative effects of Kirchhoff's voltage law. Preliminary results suggest that switching may yield a better utilisation of transmission grids with large-scale wind power.

2 - Robust Optimization Model for Installing Photovoltaic System

Shimpei Okido, Keio University, Japan, oks1024@hotmail.com, *Akiko Takeda*

We deal with the problem of determining the optimal size of grid-connected photovoltaic system for a residential building in Japan. Ren et.al proposed a novel approach using a simple linear programming that minimizes the total energy cost of a given customer. However, the approach is not applicable to a new net metering that started recently in Japan. We propose a modified approach for the new net metering. We also extend the approach by using a robust optimization technique to cope with uncertainty in photovoltaic power generation caused by weather variability.

3 - Mid-term Market-based Hydrothermal Electric Power Planning using Fuzzy-possibilistic Programming Approach

Mohammad Mehdi Lotfi, Industrial Engineering, Faculty of Engineering, University of Tehran, North Karegar, 1439955961, Tehran, Iran, Islamic Republic Of, s.f.ghaderi@gmail.com, *Seyed Farid Ghaderi*

A novel fuzzy-possibilistic price-based mixed integer linear programming model for the mid-term planning in a hydrothermal electric power plant of a Generation Company (GenCo) in a restructured market is proposed. We use possibilistic numbers as well as fuzzy constraints to analyze imprecision and ambiguity of parameters into decision making. The GenCo's market share as one of the most important imprecise parameters plays a critical role in model development. A fuzzy solution method is developed based upon a number of efficient methods and the proposed model is tested through a real-world case study. Notably, the proposed approach can be easily matched with a regulated environment.

4 - Stochastic Models for the Investment Decision Problem of a Power Producer in the Italian Electricity Market

Maria Teresa Vespucci, Department of Information Technology and Mathematical Methods, University of Bergamo, via Marconi, 5a, 24044, Dalmine (BG), Italy, mtvespucci@tin.it, *Stefano Zigrino*, *Marida Bertocchi*, *Mario Innorta*

Constraints on renewable energy production and CO2 emissions are being imposed to generation companies by growing environmental concern and compelling regulatory directives. These constraints impact on the economy of generation, acting as a bias towards the adoption of novel generation technologies, mostly in the field of renewable energy generation. Moreover the definition of a generation planning strategy requires taking into account uncertainties in energy prices and fuel costs. The proposed procedure is applied to a case study related to an Italian generation company.

■ HD-02

Thursday, 15:30-17:00
Meeting Room 101

Production Scheduling

Stream: Scheduling
Contributed session

Chair: *Sergio Maturana*, Ingenieria Industrial y de Sistemas, P. Universidad Catolica de Chile, Casilla 306 Correo 22, Santiago, Chile, smaturan@ing.puc.cl

1 - Metaheuristic Solution Approaches for the Open-pit Mine Production Scheduling Problem with Grade Uncertainty

Amina Lamghari, Mining and Materials Engineering, McGill University, Frank Dawson Adams, Rm 113, 3450 University street, H3A 2A7, Montreal, Quebec, Canada, amina.lamghari@mail.mcgill.ca, *Roussos Dimitrakopoulos*

We consider a stochastic version of the open-pit mine production scheduling problem. In this problem, the mineral deposit is represented as a three-dimensional grid of blocks, and the metal content of the blocks is the source of uncertainty. The problem can be formulated as a two-stage stochastic program with recourse. We propose two metaheuristic solution approaches based on tabu search and variable neighborhood search. Numerical results are provided to indicate the efficiency of the proposed methods to generate very good solutions in reasonable computational times.

2 - Operative Production Planning under Demand Uncertainty in the Context of the Automotive Industry with Rolling Horizons

Stefan Kloepfer, CIM, Heinz Nixdorf Institute, Fürstenallee 11, 33102, Paderborn, Germany, stefan.kloepfer@hni.upb.de, *Wilhelm Dangelmaier*

In order to achieve efficient production planning, the subtasks of lot-sizing,scheduling and capacity assignment under demand uncertainty have to be solved simultaneously because of their interdependencies. To cope with this problem, we present a holistic 2-stage stochastic model with a time based aggregation scheme that reduces complexity at small loss of accuracy by integrating the concept of rolling horizons. Moreover,we show the benefit of using a stochastic model and elaborate on an approach for deriving realistic scenario sets in this context of long term customer-supplier relationships.

3 - Minimising the Cycles Traversed on a Unidirectional Cyclical Picking Line

Jason Matthews, Department of Logistics, University of Stellenbosch, South Africa, 14855054@sun.ac.za, *Stephan Visagie*

A real life order pick operation making use of cyclical picking lines used by Pep Stores Ltd, South Africa, is considered. Multiple pickers walk in a clockwise direction around a conveyor belt picking from fixed bin locations. The problem of sequencing orders for these pickers is discussed. A strong lower bound on the number of cycles needed for a wave of picking is established. Results on a dynamic solution approach to the real life problem are presented

4 - Integrating Planning and Scheduling Sawmill Operations

Sergio Maturana, Ingenieria Industrial y de Sistemas, P. Universidad Catolica de Chile, Casilla 306 Correo 22, Santiago, Chile, smaturan@ing.puc.cl, *Mauricio Varas*

A recurring problem faced by many firms is how to plan and schedule their operations. Although both stages are required, frequently they are difficult to integrate taking into account the uncertainty faced by the firm. An "optimal' plan might result in a suboptimal schedule due to unforeseen changes. We present a preliminary study on integrating planning and scheduling of operations at a sawmill using an optimization model for the planning stage, and a simple heuristic for the scheduling stage. Monte-Carlo simulation is used to study the properties of the solutions generated by the approach.

■ HD-03

Thursday, 15:30-17:00
Meeting Room 102

Travel Behaviour 3

Stream: Travel Behaviour
Invited session

Chair: *John Rose*, The University of Sydney, NSW 2006, Sydney, Australia, JohnR@itls.usyd.edu.au

1 - Measuring the Impact of Individuals' Perceptions on their Transport Mode Choice

Aurélie Glerum, Transport and Mobility Laboratory, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, aurelie.glerum@epfl.ch, *Bilge Atasoy*, *Michel Bierlaire*

This research aims at analyzing the impact of individuals' perceptions on their transport mode preferences through an integrated choice and latent variable model. Here perceptions are measured through adjectives describing several different transport modes. The adjectives were freely reported by respondents of a survey conducted in low-density areas. They build a new type of data consisting of words that can be classified according to a perception scale and introduced in a discrete choice model as measurement equations of a latent perception of a transport mode.

2 - Profiling Public Events from Mobility Data

Francisco Pereira, SMART/ITS, MIT, 77 Mass Ave. Room 1-249, 02139, Cambridge, MA, United States, camara@dei.uc.pt

This paper describes a methodology for identifying public home distributions in planned special events. We analyze a massive dataset of localized cell-phone records to infer crowd traces. A neural network model then predicts crowd home distributions at the zipcode area level. Experiments based on 52 events in the city of Boston show an RMSE of 4.89% in the prediction for high demand areas. This work demonstrates the value of mobility data for the support of travel demand management and ultimately to a more responsive city without compromising critical issues such as privacy or security.

■ HD-04

Thursday, 15:30-17:00
Meeting Room 103

Carbon Emissions and Supply Chains

Stream: Supply Chain Management
Invited session

Chair: *Tarkan Tan*, Industrial Engineering, Eindhoven University of Technology, Den Dolech 2, Pav F-07, 5612AZ, Eindhoven, Netherlands, t.tan@tue.nl

1 - Effect of Carbon Emission Regulations on Transport Mode Selection in Supply Chains

Tarkan Tan, Industrial Engineering, Eindhoven University of Technology, Den Dolech 2, Pav F-07, 5612AZ, Eindhoven, Netherlands, t.tan@tue.nl, *Kristel Hoen*

We investigate the effect of two regulation mechanisms to drive down carbon emissions on the transport mode selection decision: an emission cost and an emission constraint. We use an accurate calculation method to determine the carbon emissions and incorporate them explicitly in our model. Our results show that introducing an emission cost for freight transport, e.g. via a market mechanism such as cap-and-trade, will not result in large emission reductions.

2 - Carbon-optimal Supply Chains

Charles Corbett, UCLA Anderson School of Management, 110 westwood plaza, box 951481, 90095-1481, Los Angeles, CA, United States, charles.corbett@anderson.ucla.edu, *Felipe Caro*, *Tarkan Tan*, *Rob Zuidwijk*

In this paper we explore the differences between making a supply chain carbon-neutral by offsetting all emissions vs. making it carbon-optimal by inducing all parties to invest appropriately in reducing GHG emissions. We examine conditions under which first-best can and cannot be achieved, and examine various decentralized outcomes.

3 - Cost versus Carbon Emissions in the Management of Operations

Saif Benjaafar, Industrial and Systems Engineering, University of Minnesota, 111 Church Street SE, 55419, Minneapolis, MN, United States, saif@umn.edu

We examine the tradeoff between reducing costs and carbon emissions in the context of four foundational Operations Management (OM) models. In each case, we show that there exists a regime of cost and emission parameter values for which emissions can be significantly reduced without significantly increasing cost.

■ HD-05

Thursday, 15:30-17:00
Meeting Room 104

Consumer Credit Risk and Supply Chain Risk

Stream: Marketing and OM Interface
Invited session

Chair: *Merja Halme*, Information and Service Economy, Aalto School of Economics, Pl 11000, 00076, Aalto, Finland, merja.halme@aalto.fi

1 - Modelling Supply Chain Risks in Agile Fast Moving Consumer Goods (FMCG) Supply Chains

Ozias Ncube, Graduate School of Business Leadership, University of South Africa, P O Box 392, Muckleneuck, 0003, Pretoria, Gauteng, South Africa, ncubeo@unisa.ac.za, *Venkata Yadavalli*

In this paper , a model for agility of supply chains is presented. Furthermore, it is observed that in the quest for agility, supply chains expose themselves to various risks. These risks are identified in terms of source, impact and likelihood of occurrence. A model for mitigation is proposed. The benefits of these mitigation strategies are illustrated by an example on the application of the model to the fast moving consumer goods supply chain.

2 - Models for Measuring Marketing Activities

Milan Gasovic, Marketing, Faculty of Economics, Sazonova, 96, 11000, Belgrade, Serbia, milangasovic@yahoo.com

Measurement of marketing activities, especially those related to new products, is extremely important. Marketing managers can use several models for measuring marketing activities and results. In practice, is often used a model which consists of the following elements: market characteristics, measurement expressed in financial indicators, measurement related to product, measurement related to consumers, measurement related to the marketing mix.

3 - Stress Testing the Credit Card Portfolios

Meko Meechi So, Management, University of Southampton, Highfield, Southampton, SO17 1BJ, Southampton, United Kingdom, M.So@soton.ac.uk

After the global credit crunch, lenders realized assessing the default risk of a consumer credit borrower under different economic environments is critical for ensuring the stability of a retail bank. In this paper, we try to quantify the impact of the economy on credit card accounts' risk migration. We use credit card datasets to demonstrate the impact of economy on the credit card accounts, and hence provide empirical evidence to encourage lenders to use macroeconomic measurements in estimating the potential default risk on credit card portfolios.

4 - Sustainability and Consumer's Purchase Decisions

Markku Kuula, Information and Service Economy, Aaalto University School of Economics, Runeberginkatu 22-24, P.O.Box 21220, 00076 Aalt, Helsinki, Finland, Markku.Kuula@aalto.fi, *Anu Bask*, *Merja Halme*, *Markku Kallio*

Sustainability has attained increased attention in academic research. We study how the inclusion of sustainability aspects, affect the Finnish consumer's purchase choice in selecting a mobile phone. In the first stage, focus group discussions are used to identify the key characteristics of sustainability in the choice. As a flexible frame in the discussions we use our earlier work, the categorization of different sustainability features into four areas: environmental strategy and policy, sustainable product design, sustainable sourcing, and sustainable product end-of-life management. In the second stage, quantitative preference data is gathered, and individual value functions estimated.

■ HD-06

Thursday, 15:30-17:00
Meeting Room 105

Intelligent Traffic Management and Control

Stream: Transportation
Invited session

Chair: *Maurizio Bruglieri*, INDACO, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it

Chair: *Alberto Colorni*, Department of Industrial Design, delle Arti e della Comunicazione, Politecnico di Milano, c/o Metid, p.zza Leonardo da Vinci 32, 20133, Milano, Italy, alberto.colorni@polimi.it

1 - New Directions for Urban Traffic Control Systems

Michael Taylor, Barbara Hardy Institute, University of South Australia, GPO Box 1, 5001, Adelaide, SA, Australia, map.taylor@unisa.edu.au, *Rocco Zito*, *Nikolaos Vogiatzis*

This paper discusses the employment of Intelligent Transport Systems (ITS) technologies to provide more effective schemes for Travel Demand Management (TDM). It starts by considering the existing state of the art in Urban Traffic Control Systems (UTCS) and reporting on recent research to use the historical traffic network performance data routinely recorded by a state of the art system (SCATS). It then considered the conceptual development of a new age UTCS, based on the principle of 'Intelligent Organic Transportation) (iOT).

2 - Optimisation for Dynamic Link Toll Control System

Suh-Wen Chiou, Information Management, National Dong Hwa University, Da Hsueh Rd., Shou-Feng, 97401, Hualien, Taiwan, chiou@mail.ndhu.edu.tw

This paper presents a computationally efficient scheme for a dynamic toll control problem formulated as a mathematical program with equilibrium constraints (MPEC). A dynamic user equilibrium (DUE) obeying Wardrop's principle is expressed as an equivalent continuous time variational inequality.Numerical calculations are conducted using a small scale road network where preliminary results have shown capability of the proposed approach solving a continuous time toll optimisation problem compared to conventional approach.

■ HD-07

Thursday, 15:30-17:00
Meeting Room 106

CP-MIP Hybridisation

Stream: Constraint programming (CP-AI)
Invited session

Chair: *Mark Wallace*, Faculty of Information Technology, Monash University, Building H, Level 6, Caulfield Campus, 3145, Caulfield, VIC, Australia, mark.wallace@infotech.monash.edu.au

1 - Valid Inequalities for the Cumulative Constraint and the Cumulative Job Shop Scheduling Problem

Tallys Yunes, Management Science, University of Miami, 33124-8237, Miami, Florida, United States, tallys@miami.edu, *Dimitris Magos*, *Yiannis Mourtos*

The cumulative constraint describes scheduling problems in which a machine can process more than one job at a time. We study the set of feasible solutions to the cumulative constraint when (i) jobs are identical, and (ii) jobs differ in their resource utilization rates. In the first case, we revisit some of the previous work in the literature; in the second, we propose a new family of facet-defining inequalities. We also present computational results obtained with a branch-and-cut algorithm for a cumulative version of the well-known job shop scheduling problem.

2 - Retail Store Workforce Scheduling by Expected Operating Income Maximization

Nicolas Chapados, DIRO, Université de Montréal, H3C 3J7, Montréal, QC, Canada, chapados@apstat.com, *Louis-Martin Rousseau*

We address the problem of retail store sales personnel scheduling by casting it in terms of an expected operating income maximization. In this frame- work, salespeople are no longer only responsible for operating costs, but also contribute to operating revenue. We model the marginal impact of an additional staff by making use of historical sales and payroll data, conditioned on a store-, date- and time-dependent traffic forecast. The expected revenue and its uncertainty are then fed into a constraint program which builds an operational schedule maximizing the expected operating income. A case study with a medium-sized retailer suggests that revenue increases of 7% and operating income increases of 3% are possible with the approach.

3 - Column Generation Approach for a Dynamic Technician Dispatch Exploiting Historical Information

Cristián Cortés, Civil Engineering Department, Universidad de Chile, Blanco Encalada 2002, 5th floor, Santiago, Chile, ccortes@ing.uchile.cl, *Michel Gendreau*, *Jose Rojas*, *Louis-Martin Rousseau*, *Andrés Weintraub*

We show a formulation for a dynamic dispatch of technicians, formulated as a VRP with soft time-windows and idle points representing potential future requests, where historical information is utilized to build efficient routes in terms of quality of service. In this work, the quality of service is measured by the waiting time of clients that call for service and by the violation of the time window, which is based on each client priority. We formulate the general problem under a Column Generation scheme, where the sub-problems are computationally solved by using Constraint Programming.

■ HD-08

Thursday, 15:30-17:00
Meeting Room 107

Deterministic, Stochastic and Nondeterministic Dynamic Programming

Stream: Dynamic Programming

Invited session

Chair: *Toshiharu Fujita*, Graduate School of Engineering, Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata-ku, 804-8550, Kitakyushu, Japan, fujita@mns.kyutech.ac.jp

1 - Continuous-time Deterministic/ Stochastic Dynamic Optimization — Evaluation-optimization and Bellman equation —

Seiichi Iwamoto, Economics, Kyushu University, Kashi-eki-higashi 4-23-6, 813-0012, Fukuoka, Japan, iwamotodp@kyudai.jp

This talk considers three continuous-time dynamic optimization problems. The three problems have linear dynamics and a discounted quadratic criterion. The first problem is on deterministic dynamics. The second is on an Ornstein-Uhlenbeck process and the third is on a geometric Brownian motion. We give the optimal solution through two approaches: evaluation-optimization and Bellman equation. An analytic optimal solution to each problem is given in a closed form. Further a zero-sum property between optimal value and optimal rate is shown. This is common to three problems.

2 - Non-deterministic Monotone Sequential Decision Process and Non-deterministic Dynamic Programming

Yukihiro Maruyama, General Economics, Nagasaki University, 4-2-1, Katafuchi, 850-8506, Nagasaki, Japan, maruyama@nagasaki-u.ac.jp

This paper will make clear the relation between a non-deterministic discrete decision process (nd-ddp) and a non-deterministic sequential decision process (nd-sdp), by using the automata theory, where we assume that the original discrete optimization problem, for example, shortest path problem, is given in the form of the process (nd-ddp). Further, this paper will study a subclass of nd-sdp's, namely non-deterministic monotone sequential decision process (nd-msdp) which admits a functional equation in non-deterministic dynamic programming.

3 - Minimization of Linear Quadratic Risk-Sensitive Criterion

Takayuki Ueno, Department of Economics, University of Nagasaki, 123 Kawashimo-cho, Sasebo-city, Nagasaki 858-8580, 858-8580, Japan, ueno@sun.ac.jp

We consider a risk-sensitive criterion. Any decision-maker wants a large return with small risk. However both wishes are inconsistent. In such cases, the risk-sensitive criterion applies. In this paper, we minimize the expected value of the linear quadratic risk-sensitive criterion. Linear quadratic means that the transition function is specified by a linear equation and the cost function and terminal function are quadratic. We consider discounted finite-stage and infinite-stage processes. We solve two Bellman equations which are raised from the two processes respectively.

4 - Mutually Dependent Decision Processes

Toshiharu Fujita, Graduate School of Engineering, Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata-ku, 804-8550, Kitakyushu, Japan, fujita@mns.kyutech.ac.jp

This paper proposes a new framework of multistage decision processes. The framework consists of two mutually dependent decision processes called main process and sub process. The target problem is represented as main process, but each stage reward in main process is given by the optimal value of a problem represented as sub process. Moreover each stage reward in sub process is given by the optimal value of a problem represented as main process. We formulate this type of problem and derive a system of recursive equations by using dynamic programming.

■ HD-09

Thursday, 15:30-17:00
Meeting Room 108

Disaster Planning and Preparedness

Stream: Emergency Evacuation and Response

Invited session

Chair: *Layna Groen*, Mathematical Sciences, University of Technology, Sydney, PO Box 123, 2007, Broadway, New South Wales, Australia, Layna.Groen@uts.edu.au

1 - Role and Evacuation Prepardness of Public Transit in Rural Communities- A Case Study of the Northern Gulf of Mexico Region, United States

Jaydeep Chaudhari, Western Transportation Institute-Montana State University, 2327 University Way, 59717, Bozeman, Montana, United States, jaydeep.chaudhari@coe.montana.edu, *Zhirui Ye*, *David Kack*, *Benedict Posadas*

During natural disaster, rural coastal communities are difficult to evacuate quickly due to the larger geographical areas and limited resources. Public transit can be a successful partner in an evacuation. The objective of this study is to assess the emergency preparedness of public transit in rural coastal communities in the Northern Gulf Coast of the United States.The assessment focuses on how adequately transit systems are prepared and what role they can play in the event of an evacuation. Lesson learned from this assessment may be utilized in improving rural evacuation practices.

2 - Optimizing Multiple Natural-disaster Management by Integrating Resource Preparedness and Deployment Planning

Yu-Hwa Chen, Graduate Institute of Logistics Management, National Dong Hwa University, No. 1, Sec. 2, Da Hsueh Rd., Shoufeng, Hualien 97401, Taiwan, R.O.C., 97401, Hualien, Taiwan, becky0935@hotmail.com, *Tsung-Sheng Chang*

This research seeks to optimize the management of multiple nature disasters by integrating resource preparedness and deployment planning. The considered management problem deals with the decisions of the location and design for storing resources, the level of the storage and deployment plans. This research first constructs a mathematical model for the management problem that involves multiple objectives (minimizing total cost and maximizing equity) and stochasticity resulting from the consideration of various disaster scenarios. Then, the research proposes a solution algorithm to the model.

3 - Improving Tsunami Warning Times for the Coastal Populations of the Mediterranean Sea

Layna Groen, Mathematical Sciences, University of Technology, Sydney, PO Box 123, 2007, Broadway, New South Wales, Australia, Layna.Groen@uts.edu.au

Effective tsunami warning was given a higher priority on the world agenda following the Boxing Day tsunami of 2004. International cooperation saw comprehensive planning undertaken across the globe. Progress in implementation has been made but in some regions it is unclear that performance targets would be met by the improved infrastructure. The warning system serving the countries of the Mediterranean is a case in point. We examine the effectiveness of the current and planned Mediterranean warning systems and suggest how its performance can be improved using set covering techniques.

■ HD-10

Thursday, 15:30-17:00
Meeting Room 111

Stochastic Dynamic Optimisation and Bayesian Methods

Stream: Stochastic Programming
Invited session

Chair: *Riadh Zorgati*, OSIRIS, EDF R&D, 1, Avenue du Géneral de Gaulle, 92141, Clamart, IDF, France, riadh.zorgati@edf.fr

Chair: *Pierre Girardeau*, OSIRIS, EDF R&D, Place de la Division Leclerc, 92140, Clamart, France, pierre.girardeau@ensta.org

1 - Probabilistic Optimization Applied to Inversion

Riadh Zorgati, OSIRIS, EDF R&D, 1, Avenue du Géneral de Gaulle, 92141, Clamart, IDF, France, riadh.zorgati@edf.fr, *Rene Henrion*, *A. Moeller*

We are dealing with the problem consisting in estimating an unknown vector x which minimizes the residue between Ax and b when matrix A and vector b are random. This problem, formulated as a bi-sided Chance-Constrained Programming, is solved, in the linear case, by using rough conic approximations derived from probability bounds. The approach is applied to electromagnetic inversion and energy management. The results are compared with the exact solution obtained in a multivariate setting with Gaussian distributions. The extension to probabilistic least squares is discussed.

2 - A Bayesian Framework for Probabilistic Inversion

Nicolas Bousquet, EDF R&D, France, npg_bousquet@yahoo.fr, *Shuai Fu*, *Gilles Celeux*, *Mathieu Couplet*

Having observations of a multidimensional random output of a time-consuming computer code H, and knowing a set of deterministic environmental inputs, the probabilistic inversion problem is estimating the distribution of the multidimensional unobserved random input. Assuming expert knowledge can be elicited about it, we consider a Bayesian statistical framework. A MCMC approach is carried out to estimate its posterior predictive distribution, involving a kriging emulator of H based on various static or sequential designs of experiments, then illustrate its benefits on a hydraulical case-study.

3 - Dual Approximate Dynamic Programming Applied to Chained Systems

Pierre Girardeau, OSIRIS, EDF R&D, 1 avenue du Général de Gaulle, 92141, Clamart, France, pierre.girardeau@gmail.com, *Kengy Barty*, *Pierre Carpentier*

We consider a dynamical system which can be influenced by exogenous noise. In the Dynamic Programming framework, we look for policies as functions of a state variable that characterizes the system. On some flower-shaped structured systems, a Lagrangian dualization-type algorithm, called Dual Approximate Dynamic Programming (DADP), has been successfully proposed and applied to get round the curse of dimensionality.
We show how DADP may be applied to the more general setting of chained subsystems and give interpretations about the approximate policies that we obtain.

■ HD-11

Thursday, 15:30-17:00
Meeting Room 112

Industry Applications - Airlines, Fishery

Stream: Integer Programming
Invited session

Chair: *Bilge Atasoy*, Transport and Mobility Laboratory, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, Switzerland, bilge.kucuk@epfl.ch

1 - Integrated Airline Schedule Planning with Supply-demand Interactions

Bilge Atasoy, Transport and Mobility Laboratory, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, Switzerland, bilge.kucuk@epfl.ch, *Matteo Salani*, *Michel Bierlaire*

In this study, we integrate a schedule design and fleet assignment model and a demand model into an optimization problem to maximize the revenue of an airline. The model considers spill and recapture effects to cope with capacity restrictions. For the demand modeling, fares, fare classes, departure times and number of stops are modeled by linear and nonlinear specifications. A heuristic method is proposed to deal with the high complexity of the resulting mixed integer nonlinear problem.

2 - Study on Improving Solution Regularity for Crew Pairing Problems

Hanyu Gu, Constraint Technologies International, Australia, Hanyu.Gu@constrainttechnologies.com, *Ian Evans*

When producing optimised crew pairings to cover airline schedules, many airlines consider that regular pairings are easier to implement and manage, and are to be preferred if there is limited cost impact. In this paper we propose a column generation based solution approach to consider regularity, which is regarded as the repeatability of pairings in the planning horizon, as well as cost. The contributions of our method include the use of a fully dated model, an improved k-shortest path pricing algorithm and comprehensive computational results for a schedule from a large Asian airline.

3 - Column Generation for Fair-share Airline Crew Rostering

Ranga Muhandiramge, Caulfield School of IT, Monash University, 900 Dandenong Rd, Caulfield East, 3145, Melbourne, Victoria, Australia, ranga.muhandiramge@monash.edu

Airlines usually assign crew to tasks in two stages. In the first, flights are grouped into pairings with the aim of minimizing costs. In the rostering stage, these pairings are assigned to specific crew members. The aim of the second stage is to maximize the perceived fairness of the roster, rather than cost minimization.
We apply an exact branch and price algorithm to a fair-share rostering problem based on data from a large Asian airline. Different strategies to solve the subproblem, which is a weight constrained shortest path problem on an acyclic graph, are investigated.

4 - Optimizing Cage Net Use with Operations Research: A Salmon Farm Pilot Project

Diego Delle Donne, Instituto de Ciencias, Universidad Nacional de General Sarmiento, Juan María Gutierrez 1150, 1613, Los Polvorines, Buenos Aires, Argentina, diegodd@gmail.com, *Francisco Cisternas*, *Guillermo Duran*, *Andrés Weintraub*, *Cristian Polgatiz*

Salmon farming in Chile constitutes one of the principal exporting sectors. Salmon are cultivated in floating cages with nets to hold the fish during the grow-out process. Maintenance of these nets is done at land facilities. In this article we present a mixed-integer programming tool to optimize resource use, improve planning and generate evaluations for analysis and decision-making about repair and periodic changing of cage nets. The prototype was tested at one of Chile's largest salmon farmers and results showed a reduction in maintenance costs of 16%, and many qualitative benefits.

■ HD-12

Thursday, 15:30-17:00
Meeting Room 205

Location and Bulk Port Operations

Stream: Contributed Talks

Contributed session

Chair: *Nitish Umang*, Transport and Mobility Laboratory (Transp-OR), École Polytechnique Fédérale de Lausanne, Avenue Ruchonnet 55, 1003, Lausanne, Vaud, Switzerland, nitish.umang@epfl.ch

1 - Equitable Partitioning for Multi-depot Vehicle Routing

John Carlsson, Industrial and Systems Engineering, University of Minnesota, 111 Church St SE, Office 130C, 55455, Minneapolis, Minnesota, United States, jgc@isye.umn.edu

We consider an uncapacitated stochastic vehicle routing problem in which vehicle depot locations are fixed and client locations in a service region are unknown, but are assumed to be i.i.d. samples from a given probability density function. We present an algorithm for partitioning the service region into subregions so as to balance the workloads of all vehicle when the service region is simply connected and point-to-point distances follow some "natural' metric, such as any Lp norm.

2 - Simulation Modelling of Break Bulk Terminal operations

Muhammad Ashlyzan Razik, Technology Management, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300, Kuantan, Pahang, Malaysia, arazik07@yahoo.com, *Waleed Khalid Abduljabbar*, *Razman Mat Tahar*

This paper presents a simulation study to providing sustainable solutions for bulk port operations. There are many research have been done in container terminal but little attentions in bulk port operations. So this study using operation research methods and techniques to improve bulk port operations. In this research, we aim to develop simulation model for bulk port operations, with emphasis on integrated planning, port capacity, and also environmental analysis. This simulation will be tested and validated and using case study at Kuantan Port Pahang Malaysia.

3 - Berth Allocation Problem in Bulk Ports

Nitish Umang, Transport and Mobility Laboratory (Transp-OR), École Polytechnique Fédérale de Lausanne, Avenue Ruchonnet 55, 1003, Lausanne, Vaud, Switzerland, nitish.umang@epfl.ch, *Ilaria Vacca*, *Michel Bierlaire*

While significant contributions have been made in the field of optimization models and methods for container terminals, relatively little attention has been directed to bulk ports. Through our collaboration with SAQR port in Ras Al Khaimah, UAE, we have identified some key issues in bulk ports. We focus in particular on the berth allocation problem. We present a model for the continuous case that is validated using real world instances and provide computation results. Additionally, we emphasize on how the berth allocation problem in bulk ports is different from that in container terminals.

■ HD-13

Thursday, 15:30-17:00
Meeting Room 206

New Approaches to Multi-objective Optimization Problems II

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Basak Akteke-Ozturk*, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, e114474@metu.edu.tr

Chair: *Walter Habenicht*, Business Administration, University of Hohenheim, Lst. fuer IBL(580 B), 70593, Stuttgart, Germany, walter.habenicht@uni-hohenheim.de

1 - A Learning Method Based on a Reference Point for the Multiobjective Multiclass Support Vector Machine

Keiji Tatsumi, Division of Electrical, Electronic and Information Engineering, Osaka University, Yamada-Oka 2-1, 565-0871, Suita, Osaka, Japan, tatsumi@eei.eng.osaka-u.ac.jp, *Tetsuzo Tanino*

In this paper, we focus on support vector machines (SVM) for multiclass classification, especially a new all-together model maximizing margins, multiobjective multiclass SVM. Its Pareto solutions represent classifiers with the high generalization ability. However, its learning method requires a large amount of computational time. This is partly because it uses the solution of the original all-together model. Therefore, we propose a new learning method based on a reference point which is easily calculated. Through numerical experiments, we verify the advantage of the proposed method.

2 - Quadtrees in Discrete Vector Optimization Problems

Walter Habenicht, Business Administration, University of Hohenheim, Lst. fuer IBL(580 B), 70593, Stuttgart, Germany, walter.habenicht@uni-hohenheim.de

A quadtree is a data structure which supports the exploitation of dominance relations in multidimensional spaces. This ability can be used in two ways. Firstly, it can be used to identify non-dominated solutions in an enumerative or metaheuristic scheme. On the other hand, the data structure can be used to perform different versions of neighborhood searches in outcome space. We present an interactive searching procedure for discrete vector optimization problems with a huge number of efficient solutions.

■ HD-14

Thursday, 15:30-17:00
Meeting Room 207

Computational Statistics with Optimization I

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Pakize Taylan*, Mathematics, Dicle University, 21280, Diyarbakır, Turkey, ptaylan@dicle.edu.tr

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Boguslaw Bieda*, Management Department, AGH-University of Science and Technology, ul. Gramatyka 10, 30-067, Krakow, Poland, bbieda@wzn6.zarz.agh.edu.pl

1 - Modelling Precipitation for Newly Defined Arid and Humid Climate Regions of Turkey

Inci Batmaz, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr, *Ceylan Yozgatligil*, *Vilda Purutcuoglu*, *Elcin Kartal Koc*, *Sipan Aslan*, *Ceyda Yazici*

Because climate change is in effect in Turkey, new climate regions have been defined in recent studies. In this study, we concentrated on two critical regions: arid and wet. For these regions, precititation models are developed by using classical regression methods such as nonlinear regression and time series regression as well as computational ones such as Multivariate Adaptive Regression Splines. In the study, data gathered from Turkish Meteorological Stations in the time period 1950-2009 are used. The results obtained can be utilized by the goverment for development plans.

2 - Quality Slab Prediction via Logistic Regression and Neural Network

Zdenek Franek, School of Business Administration, Silesian University in Opava, School of Business in Karvina, University Sq. 1634/3, 734 01, Karvina, Czech Republic, franek@opf.slu.cz

In the paper empirical pieces of knowledge on searching dependences of the influence of thermal process of semi-finished products — slabs are investigated. The course of thermal processes at continuous steel casting has the significant influence on the quality of slabs. Simple linear and quadratic regression, logistic regression and neural network were used to find optimal solution. These results enable to make the correction of selected casting parameters which should bring elimination of deficiencies on slabs by selecting optimal values.

3 - Mean Shift Outlier Model with MARS and Continuous Optimizaton

Fatma Yerlikaya Ozkurt, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06531, Ankara, Turkey, fatmayerlikaya@gmail.com, *Pakize Taylan*, *Gerhard-Wilhelm Weber*

The outlier detection problems is very important problem in statistics. Because, outliers observations affects estimation and inference as negatively. There are several outliers detection methods. One of these methods is given by Mean Shift Outlier model. We consider Mean Shift Outlier model and construct a new problem for this model. Then, we approach solving this problem using continuous optimization techniques and Multivariate Adapted Regression Spline, becoming an important complementary technology and alternative to the outliers detection methods.

4 - Prognostic Model Based on the Relationships between Waste Composition and Structural Size, ArcelorMittal Steel Plant of Poland SA, in Krakow Case Study

Boguslaw Bieda, Management Department, AGH-University of Science and Technology, ul. Gramatyka 10, 30-067, Krakow, Poland, bbieda@wp.pl

The objective of the paper is to develop the industrial waste prognostic model based on the database time-series waste quantities and compositions over the period of up to 20 years (data from 1980 to 2006). In this paper the slag and ash are used for statistical analysis to examine relationships between waste stream composition and structural size of the steel plant. The framework for the study is based on the ArcelorMittal Steel Plant Poland SA in Krakow. Data analysis has been conducted using Statistica software.

■ HD-15

Thursday, 15:30-17:00
Meeting Room 208

Linguistic Uncertainty in the Design of Decision Aid Systems

Stream: Fuzzy Logic

Invited session

Chair: *Javier Montero*, Faculty of Mathematics, Complutense University, Plaza de las Ciencias, 3, E-28040, Madrid, Spain, javier_montero@mat.ucm.es

Chair: *Jie Lu*, School of Software, University of Technology, Sydney, PO box 123, Broadway, 2007, Sydney, NSW, Australia, jie.lu@uts.edu.au

Chair: *Begoña Vitoriano*, Estadística e Investigación Operativa I, Fac. Matemáticas, Universidad Complutense de Madrid, Plaza de Ciencias, 3, Ciudad Universitaria, 28040, Madrid, Spain, bvitoriano@mat.ucm.es

1 - A Disaster-severity Assessment DSS Comparative Analysis

Begoña Vitoriano, Estadística e Investigación Operativa I, Fac. Matemáticas, Universidad Complutense de Madrid, Plaza de Ciencias, 3, Ciudad Universitaria, 28040, Madrid, Spain, bvitoriano@mat.ucm.es, *J. Tinguaro Rodriguez*, *Javier Montero*

SEDD is a decision support system for the assessment of the severity of natural disasters based on fuzzy rule-based inference. SEDD provides an interpretable assessment on the consequences of almost every potential disaster scenario, through a learning and reasoning process based on historical information about similar scenarios. Data requirements are small, which enables its adaptation to the context of NGOs and countries requiring humanitarian aid. An analysis to compare this DSS with some statistical techniques have been developed, concluding that SEDD outranks these techniques.

2 - A New Auction for Object with Bimodal Valuation

Rosa Espinola, Statistic and Operation Research, Complutense University, Avda Puerta de Hierro s/n, 28040, Madrid, Spain, rosaev@estad.ucm.es, *Javier Castro*

Several auctions have been defined for the sale of an object whose valuation is subjective. However, in the simplest case, the benchmark model, the results given in Myerson (1981) are the reference for these auctions. Myerson proved that under different conditions for buyers and auction, any auction obtains the same expected value for the seller. In this work we will change one of the hypotheses about the auction and we will obtain that when the valuation of the object is bimodal, with presence of linguistic uncertainty, the expected return to the seller is greater than the Myerson auction.

3 - A Dynamical Analysis Method of Opinions in Social Network for Decision Support

Jun Ma, University of Technology, Sydney, Australia, junm@it.uts.edu.au, *Jie Lu*, *Guangquan Zhang*

This paper presents a gradual-changing opinion analysis (GCOA) method. In the GCOA method, a gradual aggregation operator is developed. By means of the gradual aggregation operator, the GCOA method takes both the values and the orders of the opinions into account; moreover, it implements an implied weighting procedure which can help decision makers to analyse obtained information dynamically in real applications. Some real cases are then used to evaluate the presented GCOA method.

4 - Financial Early Warning System: Adaptive Inference-based Fuzzy Neural Network

Vahid Behbood, Information Technology, University of Technology Sydney, 2007, Sydney, NSW, Australia, vbehbood@it.uts.edu.au, *Jie Lu*

This study develops an innovative Bank Failure Prediction (BFP) approach which effectively integrates a fuzzy inference system with the learning ability of a neural network to generate knowledge in the form of fuzzy rules. The proposed approach uses a preprocessing phase in order to deal with the imbalance problem. This study also develops an adaptive inference-based learning algorithm as a means to reduce prediction error in the BFP approach. A set of experiments has been conducted to validate the proposed approach. The results show that it outperforms three existing financial warning systems: GenSo-EWS; FCMAC-EWS; and MLP and, two popular fuzzy neural networks: ANFIS; DENFIS.

■ HD-16

Thursday, 15:30-17:00
Meeting Room 209

OR for Health Contingency Operations

Stream: Health Care Applications

Invited session

Chair: *Lawrence Fulton*, CIS & QM, Texas State University, 112 Valona Drive, 78108, Cibolo, TX, United States, lf25@txstate.edu

1 - Two-Stage Stochastic Optimization for the Allocation of Medical Assets in Steady State Combat Operations

Lawrence Fulton, CIS & QM, Texas State University, 112 Valona Drive, 78108, Cibolo, TX, United States, lf25@txstate.edu, *Leon Lasdon*, *Reuben McDaniel*, *Nick Coppola*

We present a two-stage stochastic optimization model for optimizing medical asset emplacement in military stabilization operations. This model, updated from previous work, evaluates the primary components of the medical system in current combat operations, including the primary treatment and evacuation components. Currently, this model is undergoing revision to support an analysis of future medical requirements in stabilization operations.

2 - A Flexible Approach To Paramedics and Healthcare Staff Scheduling

Patrick Soriano, Management Sciences, HEC Montreal, 3000, ch. Côte-Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, patrick.soriano@hec.ca

Staff scheduling in Canadian hospitals and emergency medical services is a decentralized management task where a large number of very different schedules is generally needed to run daily operations. To deal with this situation, we propose a flexible heuristic algorithm inspired from mathematical decomposition techniques. Our approach can solve a large variety of healthcare staff scheduling problems, including the typically more complex paramedic staff scheduling problems.

■ HD-17

Thursday, 15:30-17:00
Meeting Room 214

OR in Finance 5

Stream: Finance

Invited session

Chair: *Shanying Xu*, Academy of Mathematics and Systems Science, CAS, No.55, Zhongguancun Dong Lu, 100190, Beijing, China, xsy@iss.ac.cn

Chair: *Michi Nishihara*, Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka, 560-0043, Osaka, Japan, nishihara@econ.osaka-u.ac.jp

Chair: *Alex Manzoni*, Business College, RMIT University, GPO Box 2476, Melbourne, Victoria, Australia, alex.manzoni@rmit.edu.au

1 - Evaluation of Factors Affecting China's Export - an Empirical Study Based on the Structural Dynamic Factor Model

Shanying Xu, Academy of Mathematics and Systems Science, CAS, No.55, Zhongguancun Dong Lu, 100190, Beijing, China, xsy@iss.ac.cn, *Lin Zhao*

Research on the factors affecting China's export is of great significance; it can help forecast the export volume, and promote China's economic development. Traditional econometric models are ineffective in this research, because they cannot do well in dealing with the high dimensional data. The structural dynamic factor model (SDFM) can solve this problem successfully and provide some useful impulse response information. We use SDFM to explore the main factors affecting China's export, to evaluate the varieties and interactions between these factors. We also compared the SDFM to VAR model.

2 - ETF Performance Measurement — Data Envelopment Analysis

Kwai-sun Leung, Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, ksleung@se.cuhk.edu.hk, *Frank Y Chen*

In this paper we apply Data Envelopment Analysis (DEA) to evaluate the performance of exchange-traded funds (ETFs). Contrary to other DEA studies that rely on CCR and BCC models, the range directional measure (RDM) is employed in this paper to measure ETF performance with an aim to overcoming the problem of negative-valued data. By including the upside potential and downside deviation into our DEA model, our results indicate that our DEA model is able to provide a more comprehensive picture of the ETF performance appraisal and hence a viable complement to traditional risk-adjusted index.

3 - Optimal Investment Timing under Debt Financing Capacity Constraint

Takashi Shibata, Graduate School of Social Sciences, Tokyo Metropolitan University, 1-1, Minami-osawa, 192-0397, Hachioji, Tokyo, Japan, tshibata@tmu.ac.jp, *Michi Nishihara*

This paper examines the optimal investment timing decision problem of a firm subject to an endogenous debt financing capacity constraint. We show that the investment thresholds have a U-shaped curve with the debt capacity constraint, in that they are increasing with the constraint for high-liquidity firms while decreasing for low-liquidity firms. Although the financing constraint distorts investment timing, it may encourage the constrained levered firm to overinvest compared with the nonconstrained levered firm.

4 - Measuring Organisation Performance and Corporate Social Responsiblity using Data Envelopment Analysis

Alex Manzoni, Business College, RMIT University, GPO Box 2476, Melbourne, Victoria, Australia, alex.manzoni@rmit.edu.au

A new approach to measuring performance shows propositions where efficiency can be calculated for tangible/intangible productivity factors using DEA to measure performance of corporate social responsibility in a major Australian bank consistently rated as best performer on a national social responsibility index. This study shows how it identified the best performing business units. DEA has not previously been used in this fashion. This study shows how measuring performance for an organization and its complete supply chain is possible with an unifying standardized algorithm.

■ HD-18

Thursday, 15:30-17:00
Meeting Room 215

Applications of DEA in Health Sector

Stream: Data Envelopment Analysis

Invited session

Chair: *Chris O'Donnell*, University of Queensland, School of Economics, University of Queensland, 4072, Brisbane, QLD, Australia, c.odonnell@economics.uq.edu.au

1 - An Econometric Approach to Estimating the Components of Productivity Change in Public Hospitals

Chris O'Donnell, University of Queensland, School of Economics, University of Queensland, 4072, Brisbane, QLD, Australia, c.odonnell@economics.uq.edu.au, *Kim Nguyen*

Econometric estimation of output distance functions is complicated by the fact that the outputs are endogenous. Our solution is to use linear programming to construct an output index. This allows us to write the distance function in the form of a conventional stochastic production frontier model where the explanatory variables are uncorrelated with the error term. We use the approach to estimate and decompose indexes of productivity change in Australian public hospitals. We find that the main drivers of productivity change are changes in scale and mix efficiency.

2 - Year-to-year Stability of Data Envelopment Analysis Efficiency Scores: An Empirical Assessment Using Performance of Coronary Artery Bypass Graft Surgeries

Mitchell Glavin, Health Care Administration, Stonehill College, 320 Washington Street, 02357, Easton, Massachusetts, United States, mglavin@alum.mit.edu, *Jon Chilingerian*

Some critics of DEA maintain that construction of performance frontiers can be distorted by data errors or extreme values among units evaluated. We investigated the efficiency of Pennsylvania surgeons and hospitals performing coronary artery bypass graft surgeries over the 1994-2004 period. Our examination of efficiency scores in consecutive years support the conclusion that in practice DEA may not be prone to distortions from noisy or extreme data values. We observed statistically significant correlations between efficiency scores and persistence in ranking among the most efficient units.

3 - Measuring Technical Efficiency of the Tertiary Public Hospitals: Evidence from the National Capital Region (NCR), Philippines Using Data Envelopment Analysis (DEA)

Rhory Fernandez, Business Dept., Assumption College, San Lorenzo Village, Makati, Metro Manila, 1223, Philippines, rhory_fernandez@yahoo.com

The services provided by the health care facilities in the Philippines have long been problematic. Since the tertiary public hospitals in NCR received 32.26% of the total budget of the Department of Health (DOH)and public hospitals' performance measurement (PM) is currently one of the priority agenda of health policy makers especially among the developing countries, this study was made to measure the degree technical efficiency of the tertiary public hospitals and to determine the potential resource reductions and cost savings of the government using input oriented constant returns to scale data envelopment analysis (DEA). The results indicate that 54% of the hospitals operate at technical efficiency level way below the efficient frontier and savings could have been P1.5 billion. This study was able to prove that technical inefficiency exists among the tertiary public hospitals in NCR. This is the first study to measure technical efficiency among tertiary public hospitals in the Philippines.

■ HD-19

Thursday, 15:30-17:00
Meeting Room 216

Integer and Combinatorial Optimization

Stream: Discrete and Global Optimization
Invited session

Chair: *Xiaoling Sun*, School of Management, Fudan University, 670 Guoshun Road, 200433, Shanghai, China, xls@fudan.edu.cn
Chair: *Duan Li*, Systems Engineering & Engineering Management Dept., The Chinese University of Hong Kong, Shatin, NT, Hong Kong, dli@se.cuhk.edu.hk

1 - On the Optimization of Copper Extraction in Mining under Uncertainty in Copper Prices

Laureano Fernando Escudero, Dept. de Estadística e Investigación Operativa, Universidad Rey Juan Carlos, c/Tulipan, S/n, 28933, Mostoles (Madreid), Spain, laureano.escudero@urjc.es, *Antonio Alonso-Ayuso*, *Felipe Carvallo*, *Monique Guignard-Spielberg*, *Jiaxing Pi*, *Raghav Puranmalka*, *Andrés Weintraub*

Deterministic planning models along a time horizon have proved to be very effective in supporting decisions on sequencing the extraction of material in copper mines. Some of these deterministic models have been developed for — and used successfully by -CODELCO, the Chilean state copper mining company. Here, we develop a new multiperiod stochastic mixed 0-1 model and algorithm for CODELCO by considering the uncertainty in a very volatile parameter of the problem, namely, the copper price along the planning horizon. Promising results were obtained with data from a large underground mine.

2 - Time-Varying Shortest Path Problem with Incomplete Probability Information

Dan Sha, Business Information Management School, Shanghai Institute of Foreign Trade, 201620, Shanghai, China, danielsha@hotmail.com

We address a type of time-varying shortest path problem where the transit time travelling an arc is a random variable with incomplete probability information. The problem is to find the path from the source vertex to the sink vertex which can be travelled in time limit T, such that the total travelling cost is minimized. We propose a dynamic approach to find the optimal solution or a series ranked satisfied solutions.

3 - On-line and Semi-online Scheduling of Flow Shop Problems on Two Machines

Xiwen Lu, Dept. of Math, East China University of Science & Technology, 200237, Shanghai, China, xwlu@ecust.edu.cn

We investigate the on-line and semi-online versions of flow shop problems on two machines with the objective to minimize the makespan. We derive several lower bounds for the problem with and without preemption. For some semi-online versions, we provide the on-line algorithms and show that the upper bounds are tight. At last we derive the lower bound of the problem with the unavailable time interval on machine A and prove that no on-line algorithm has a constant competitive ratio for the problem with unavailable time interval on the second machine

4 - Lagrangian Decomposition and Mixed-Integer Quadratic Reformulation for Probabilistic Constrained Quadratic Programs

Xiaoling Sun, School of Management, Fudan University, 670 Guoshun Road, 200433, Shanghai, China, xls@fudan.edu.cn, *Xiaojin Zheng*, *Duan Li*

We consider probabilistic constrained quadratic programming (PCQP) in which there is only one probabilistic constraint and the random vector has a finite discrete distribution. We derive second-order cone programming (SOCP) relaxation and semidefinite programming (SDP) relaxation for the problem via Lagrangian decomposition. We then give a mixed integer quadratic programming (MIQP) reformulation and show that this new MIQP reformulation is more efficient than the standard MIQP reformulation. Some preliminary computational results are also reported.

■ HD-20

Thursday, 15:30-17:00
Meeting Room 217

Strategy

Stream: OR and Strategy
Invited session

Chair: *Ratna Babu Chinnam*, Industrial & Systems Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu

1 - Strategic Adherence in Process Industry Supply Chains

Albert Munoz, School of Management and Marketing, University of Wollongong, Northfields Ave, 2500, Wollongong, NSW, Australia, amunoz@uow.edu.au, *Tim Coltman*

The dynamism and complexity inherent to managing process industries has presented many operational challenges for supply chain theory and practice. Research suggests that process industry managers frequently make decisions using simple decision rules. We use this basis to construct a system dynamics simulation model of a process industry supply chain to investigate adherence to a number manufacturing strategies given alternative demand scenarios. Results indicate the inclusion of trade-off considerations and internal feedback loops in strategy design are instrumental in achieving firm goals.

2 - Strategic Planning of Urban Public Transport Company Passenger

Rosa Maria Paría, E.A.P Investigacion Operativa, UNMSM, Lima, Peru, meryross45@hotmail.com

In this paper we will develop a business strategic planning for urban passenger transport. It starts the process of Strategic Planning with identifying Vision, Mission,and objectives. Following the analysis of the internal environment, external components identified for diagnostic and evaluation tools, these tools are the matrices MEFI, MEFE, SWOT and Competitive Profile Matrix SPACE Matrix. The next action will be the revaluation of the Vision, Mission and Objectives of the organization, formulating strategies and implementing.

3 - Strategic Planning of Configurable Products

Ratna Babu Chinnam, Industrial & Systems Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu, *Edward Umpfenbach*, *Alper Murat*

Strategic planning of configurable products is often an interactive process between several functions within a company (e.g., marketing, PD, manufacturing, purchasing, supply chain), each of which has objectives that often conflict. Under sequential planning, these functions can reach solutions that optimize their own interests, rather than benefiting the company as a whole. We introduce a hybrid model with elements of assortment planning, supply chain planning, and product development for strategic planning of configurable products, in particular, for automotive OEMs.

■ HD-21

Thursday, 15:30-17:00
Meeting Room 218

OR in Science-Based Applications

Stream: OR and Real Implementation
Invited session

Chair: *Margaret Shipley*, Management, Marketing & Business Administration, University of Houston Downtown, 320 N. Main Street, 77002, Houston, Texas, United States, shipleym@uhd.edu

1 - Sustaining Fisheries Ecological Environments: A Fuzzy Rule-Based Model for Artificial Reef Placement

Margaret Shipley, Management, Marketing & Business Administration, University of Houston Downtown, 320 N. Main Street, 77002, Houston, Texas, United States, shipleym@uhd.edu, *Brooke Shipley*

A fuzzy rough set theory model was developed to determine the optimal number of artificial reefs for sustaining fish ecosystems based upon red snapper (Lutjanus campechanus) in Gulf of Mexico waters. Consumption estimates and presumed foraging behavior provided input into a rule-based approach to determine how far apart artificial reefs must be placed to eliminate density-dependent competition for prey resources. The ecosystem parameters and potential reef distances as triangularly defined fuzzy sets were simulated. Based upon the strength of belief in a rule, the artificial reef placement location can be accepted or rejected. Ease of utilization of the model is highlighted by spreadsheet application.

2 - Applying Capacitated Assignment Problem to Interviewer Allocation at the Australian Bureau of Statistics

Olena Gavriliouk, Australian Bureau of Statistics and CSIRO Mathematics, Informatics and Statistics, GPO Box 2796Y, 3001, Melbourne, VIC, Australia, olena.gavriliouk@abs.gov.au, *Rosslyn Starick*

In this presentation we address the workload allocation model (WAM) which arises in the process of coordinating work assignment to interviewers employed by the Australian Bureau of Statistics (ABS) for data collection in household surveys.
WAM appears to be an assignment problem with different types of capacity constraints and hence not easy to solve. Also the size of WAM grows very quickly due to: (1) the number of surveys being conducted at any one time, and (2) the length of the data collection periods.
We show how WAM is being used at the ABS to assign work to interviewers.

3 - Secure Multi-party Collaboration Applications and Technologies: An Overview

Shiping Chen, CSIRO ICT Centre Australia, PO Box 76, 1710, Epping, NSW, Australia, shiping.chen@csiro.au, *Chen Wang*, *Dongxi Liu*, *Gaurav Singh*

The business scopes and processes are becoming larger and complicated. As a result, there are needs for multiple parties to collaborate with each other to complete a complicated process for global and mutual interests. While each party contributes its data for collaboration, how to protect the contributed sensitive business data remains a challenge. This paper presents our recent findings in a landscape study for secure multi-party collaboration with focus on industry needs and existing technologies.

4 - Modelling Real-world Oil Transportation in the Baltic Sea Region

Antti Hallamäki, Mathematical Information Technology, University of Jyväskylä, Agora PL 35, 40014, Jyväskylä, Finland, antti.hallamaki@jyu.fi

Real-world transportation problems are more difficult to solve than academic benchmark problems. There are multiple constraints, the cost structure is complex and most of the existing solution methods focus only on small subgroups of constraints. We present a complex model for an oil transportation problem in Baltic Sea region based on a real-world case. The model was produced via incremental approach and we discuss the advantages and disadvantages of such approach. We also present our solution methodology consisting of both standard and custom algorithms guided by the objective function.

Friday, 9:00-10:30

■ FA-01

Friday, 9:00-10:30
Plenary Hall 3

OR Applications in Energy Policy and Planning

Stream: OR Applications in Energy
Invited session
Chair: *Alan Pearman*, Leeds University Business School, University of Leeds, Maurice Keyworth Building, LS2 9JT, Leeds, West Yorkshire, United Kingdom, a.d.pearman@leeds.ac.uk

1 - Climate Policy Uncertainty and Investment Behavior: Evidence from Small Hydropower Plants

Ane Marte Heggedal, Dept. of Industrial Economics and Technology management, Norwegian University of Science and Technology, Alfred Getz vei 3, 7491, Trondheim, Norway, ane.m.heggedal@iot.ntnu.no

In the coming years, Europe needs more power from renewable sources to meet greenhouse gas and renewable targets. However, market and climate policy uncertainty affects cash flows and make investors hesitate to invest in new capacity. Having access to a river may contain an investment opportunity which can be considered to be a real option. Using data from 229 small hydropower projects, we test whether investors behave according to investment signals given by the NPV method or a real options approach, and whether climate policy uncertainty affects the investor's decision.

2 - Stakeholder Preference Mapping —Helping Understand how to Process Spent Nuclear Fuel

Alan Pearman, Leeds University Business School, University of Leeds, Maurice Keyworth Building, LS2 9JT, Leeds, West Yorkshire, United Kingdom, a.d.pearman@leeds.ac.uk, *Gregg Butler*, *Grace McGlyn*

Growing plans for nuclear power have ignited new interest in how best to make evidence-based decisions about divisive issues. Stakeholder Preference Mapping, described here, is a way of applying multi-attribute decision analysis (MADA) in consultative settings. It uses the recorded views of stakeholders, supplemented where necessary by direct stakeholder contact, to understand stakeholder perspectives and to anticipate arguments for and against particular outcomes. It is flexible in use and can be applied within a 1-day workshop through to much wider, more resource-intensive consultations.

■ FA-02

Friday, 9:00-10:30
Meeting Room 101

Scheduling: Algorithms and Complexity

Stream: Scheduling
Contributed session
Chair: *Frits Spieksma*, Operations Research and Business Statistics, Katholieke Universiteit Leuven, Naamsestraat 69, B-3000, Leuven, Belgium, frits.spieksma@econ.kuleuven.be

1 - A Solution to the Astronomical Observation Scheduling Problem

Mauricio Solar, Informatic, UTFSM, Av Santa Maria 6400, Vitacura, 7660251, Santiago, Chile, msolar@inf.utfsm.cl

ALMA is a multinational astronomical project. When completed in 2013 it will be the largest radio-telescope on earth, with more than 60 antennas that will provide the possibility to be used as a single array or as up to 6 groups of antennas. The astronomy scheduling problem is NP-hard. We describe a solution using genetic algorithm.

2 - Scheduling Jobs on two Identical Parallel Machines with a Single Operator

Djamal Rebaine, Informatique et mathématique, Université du Québec à Chicoutimi, 555, boul. de l'Université, G7H 2B1, Chicoutimi, Québec, Canada, drebaine@uqac.ca

We address the problem of scheduling jobs on two identical parallel machines with a single operator so as to minimize the makespan. The presence of an operator is necessary to operate the machines through a subset of working modes. A working mode models the way the operator divides up his interventions over the machines. The processing times then become variable as they depend on the working mode being utilized. A schedule is thus a partition of the jobs on the machines with the corresponding sequences, a subset of working modes along with their duration, and the order of their utilization. Based on a dominance result, we present an algorithm to produce an optimal solution within the free changing mode.

3 - Balanced Round-robin Tournament with Court Shortage

Shinji Imahori, Department of Computational Science and Engineering, Nagoya University, Furo-cho, Chikusa-ku, 464-8603, Nagoya, Japan, imahori@na.cse.nagoya-u.ac.jp

In the field of sports scheduling and timetabling, problems to design round-robin tournaments are well studied. When the number of courts is not enough for the number of teams, some teams play games and others rest (called byes) in each slot. Excessive consecutive games/byes will unsettle conditions of teams and should be avoided. In this talk, we study single round-robin tournaments with byes, in which games and byes appear in a proper balance. For even number of teams, a simple constructive algorithm is designed; in contrast, the problem becomes hard for odd number of teams.

4 - Breaks, Cuts, and Patterns

Frits Spieksma, Operations Research and Business Statistics, Katholieke Universiteit Leuven, Naamsestraat 69, B-3000, Leuven, Belgium, frits.spieksma@econ.kuleuven.be, *Dries Goossens*

In sports scheduling, a team is said to have a break when it plays two home (or two away) matches in a pair of consecutive rounds. In this paper, we generalize this concept by also considering pairs of nonconsecutive rounds. We show that a set of home-away patterns minimizing the number of generalized breaks cannot be found in polynomial time, unless P=NP. For the special case where all teams have the same set of breaks, the decision version becomes polynomially solvable; the optimization version remains NP-hard. For this special case, we also provide a lower bound for the number of generalized breaks for a given break set, thereby generalizing a classical result by De Werra.

■ FA-03

Friday, 9:00-10:30
Meeting Room 102

Decision Support and Software

Stream: Contributed Talks

Contributed session

Chair: *Chun-Hung Cheng*, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, Hong Kong, chcheng@se.cuhk.edu.hk

1 - Service-enabling and Parallelizing Standard Solvers

Lars Beckmann, University of Paderborn, Germany, lars.beckmann@gmail.com

Standard solvers like Cplex and Gurobi provide various ways for practitioners and researchers to interact with them, e.g. the console or dynamic linked libraries. Providing the same functionality via a service interface not only makes it easier to use solver functionality in an existing enterprise infrastructure but also enables solvers to act in concert while tackling a mathematical problem. In this talk we present an easy to use optimization framework that allows multiple solvers to work together while running on different nodes in a P2P network.

2 - A Posteriori Analysis for Bicriteria Location Problems

Sérgio Fernandes, Instituto Politécnico de Setúbal, Escola Superior de Tecnologia, Campus do Instituto Politécnico de Setúbal, Estefanilha, 2910-761, Setúbal, Portugal, sergiof@est.ips.pt, *Maria Eugénia Captivo*, *João Clímaco*

SABILOC is a Decision Support System aimed at supporting decision-making concerning bicriteria location models with environmental effects. A Geographical Information System (GIS) was already embedded in SABILOC in order to easily evaluate the environmental effects of open facilities. Once a set of compromise alternatives is known, a second phase procedure, consisting in a multi-attribute a posteriori analysis, should be carried out, for a more detailed analysis of this subset of alternatives. In this presentation we describe and exemplify the use of the last procedure in SABILOC.

3 - Bounded Dual Simplex Algorithm and its Application to Transmission Expansion Planning

Mohsen Rahmani, Faculdade de Engenharia de Ilha Solteira, Universidade Estadual Paulista, Avenida Brasil, 56 - Centro, Av 15 de Novembro 1728, 15385000, Ilha Solteira, Brazil, rahmani15@gmail.com, *Ruben Romero*, *Marcos J. Rider*, *Masoud RashidiNejad*

A new bounded dual simplex algorithm with re-optimization technique is implemented to solve the transmission expansion planning (TEP). The algorithm starts with equality constraints and iteratively adds the most violated constraint to the problem using re-optimization techniques until it find the solution. The proposed method takes the advantages of a TEP model with reduced number of the variables and constraints. With these characteristics, the proposed solver is very fast and robust which can be employed in any optimization process, such as classic, heuristics or metaheuristics algorithm.

4 - China as an Outsourcing Destination for Software Development: Hong Kong Experience

Chun-Hung Cheng, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, Hong Kong, chcheng@se.cuhk.edu.hk, *Kam-Fai Wong*

China has emerged as a major outsourcing destination for software development projects. However, the literature rarely documents it. In this work, we try to understand this experience by studying the activities of several Hong Kong companies in China. We hope that this analysis gives us a better understanding of the outsourcing activities in China. Although our analysis only focuses on Hong Kong executives, our results may still be valuable to other companies interested in outsourcing their software projects to Chinese developers.

■ FA-04

Friday, 9:00-10:30
Meeting Room 103

Information and Incentives in the Supply Chain

Stream: Supply Chain Management

Invited session

Chair: *Wanshan Zhu*, Singapore Management University, 50 Stamford #0401, 178899, Singapore, adamzhu@smu.edu.sg

Chair: *Zhengping Wu*, Singapore Management University, 178899 , Singapore, zpwu@smu.edu.sg

1 - Ordering, Pricing, and Lead-Time Quotation under Lead-Time and Demand Uncertainty

Zhengping Wu, Singapore Management University, 178899 , Singapore, zpwu@smu.edu.sg, *Burak Kazaz*, *Scott Webster*, *Kum-Khiong Yang*

In this paper, we study the newsvendor problem with endogenous setting of price and quoted lead-time. This problem can be observed in situations where a firm orders semi-finished product prior to the selling season and customizes the product in response to customer orders during the selling season. The total demand during the selling season and the lead-time required for customization are uncertain. The demand for the product depends not only on the selling price, but also on the quoted lead-time. To set the quoted lead-time, the firm has to carefully balance the benefit of increasing demand as the quoted lead-time is reduced against the cost of increased tardiness. Our model enables the firm to determine the optimal selling price, quoted lead-time, and order quantity simultaneously, and provides a new set of insights to managers.

2 - The Newsvendor Problem with Advertising Revenue

Wanshan Zhu, Singapore Management University, 50 Stamford #0401, 178899, Singapore, adamzhu@smu.edu.sg

We study a modified newsvendor model in which the newsvendor obtains a revenue from the sales to end users as well as from an advertiser paying to obtain access to those end users. We study the optimal decisions for both a price-taking and a price-setting newsvendor when the advertiser has private information about its willingness to pay for advertisements. We find that the newsvendor's optimal policy excludes advertisers with low willingness to pay and distorts the price and quantity from their system-efficient level to screen the advertiser.

3 - Comparing Contract Performance through Experiments in Dual Channel Management

Murat Kaya, Faculty of Engineering and Natural Sciences, Sabanci University, Sabancı Universitesi, MDBF Orhanli Tuzla, 94305, Istanbul, Turkey, mkaya@sabanciuniv.edu, *Aysegul Tizer*, *Sevilay Gokduman*

We conduct an experimental study with human decision makers on dual sales channel contracting. We aim to determine dual channel strategies for a manufacturer who sells its product through both its totally-owned direct online channel and an independent retailer channel. The two channels compete in service. We study the theoretical and experimental performance of the wholesale price and buyback contracts between the firms. Experimental data exhibits deviations from theoretical predictions that can be attributed to behavioral factors, such as risk aversion.

4 - Departure Process Variability of Queues and Networks

Yoni Nazarathy, Mathematics, Swinburne University of Technology, John Street Hawthorn, Mail H38, PO Box 218, 3122, Hawthorn, VIC, Australia, YNAZARATHY@groupwise.swin.edu.au

Supply Chains may sometimes be roughly modelled as queuing networks where a key performance measure is the throughput and a secondary key measure is variability. It often occurs that the variance of the number of items departing grows linearly with time. In this case, a natural quantity of interest is the asymptotic variance rate: the asymptotic slope of the variance of the number of departures. We have discovered a remarkable phenomenon: When the service and arrival rate are equated, the asymptotic variance rate is reduced. The impact of this on supply chains remains to be explored.

■ FA-05

Friday, 9:00-10:30
Meeting Room 104

Consumer Behavior and Inventory Model

Stream: Marketing and OM Interface
Invited session

Chair: *Felix Papier*, Operations Management Department, ESSEC Business School, Av. Bernard Hirsch, BP 50105, 95021, Cergy-Pontoise Cedex, France, papier@essec.fr

1 - An Integrated Inventory Model with Price Dependent Demand Rate under Two Levels of Storage

Shiv Raj Singh, Mathematics, D. N.(PG) College, Railway Road, 250001, Meerut, Uttar Pradesh, India, shivrajpundir@yahoo.com

a two-warehouse integrated production-inventory model from the perspectives of both the manufacturer and the retailer with price dependent consumption rate. The manufacturer's stores goods in OW before RW, but clears the stocks in RW before OW. The model considered both ameliorating and deteriorating effects taking account of multiple deliveries, partial backordering and time discounting. Numerical experiment and the sensitivity analysis are given to illustrate the theory of the model.

2 - Customer Lifetime Value Measurement for an Online Grocery Retailer

Evsen Korkmaz, Rotterdam School of Management, Erasmus University, Burgemeester Oudlaan 50, 3062 PA, Rotterdam, Netherlands, ekorkmaz@rsm.nl, *Roelof Kuik*

Because of limited delivery-service capacity of online retailers, it is important for them to know how much revenue they can expect from each customer in order to prioritize and retain the most valuable ones. In this paper we focus on measuring the value of each customer in a non-contractual setting of a Dutch online grocery retailer. We extend the Pareto/NBD model of Schmittlein et al. (1987) by using a hierarchical Bayesian framework. We explain the heterogeneity on purchase and death process parameters among customers by industry-specific covariates (e.g. basket mix, missing item rate).

3 - ERP as a Tool for Sustainable Logistics Management

Andrejs Tambovcevs, Riga Technical University, Riga, Latvia, ata2000@inbox.lv

In recent years, consumers and governments have been pressing companies to reduce the environmental impact of their activities. This study aim is to investigate the most important tools and concepts of ERP systems that help in supply chain information sharing, cooperation and cost optimization to reduce the environmental impact of firm's activity. Study summarizes the results of analysis based on literature review and case study. These results can be used to measure the potential monetary value of such issues, and to minimize logistic system influence on environmental performance.

4 - Advance Demand Information in Multi-Location Inventory Allocation Settings

Felix Papier, Operations Management Department, ESSEC Business School, Av. Bernard Hirsch, BP 50105, 95021, Cergy-Pontoise Cedex, France, papier@essec.fr

We develop a multi-location newsvendor model in which supply is allocated before demand realization and in which the decision maker can acquire advance demand information (ADI). Our model is motivated by the inventory allocation problem of a corn seed producer, which needs to allocate its annual supply to markets which differ in price and selling season begin. The company acquires imperfect ADI through promotions and pre-reservation tools to improve decision making. We use dynamic programming to solve the model for revenue maximization and to study the value of ADI in the different markets.

■ FA-06

Friday, 9:00-10:30
Meeting Room 105

Maritime Routing

Stream: Transportation
Invited session

Chair: *Bjørn Nygreen*, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred getz vei 3, NO-7491, Trondheim, Norway, bjorn.nygreen@iot.ntnu.no

1 - A Heuristic for Maritime Inventory Routing

Oddvar Kloster, SINTEF ICT, Postboks 124 Blindern, 0314, Oslo, Norway, okl@sintef.no, *Truls Flatberg*

In maritime inventory routing, a fleet of vessels is employed to transport products that are produced and consumed in different ports, in order to keep stock levels in each port legal. In addition, regular bookings/orders may be transported. We describe construction and optimization heuristics that can solve a wide range of problem variants, including pure inventory, pure tramp, mixed, single/ multiple products, tank stowage, tank cleaning, boil-off.

2 - A Stochastic and Dynamic Maritime Pickup and Delivery Problem

Lars Magnus Hvattum, Dept of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, Sentralbygg 1, N-7491, Trondheim, Norway, lars.m.hvattum@iot.ntnu.no, *Gregorio Tirado*, *Kjetil Fagerholt*, *Jean-François Cordeau*

Recent years have shown that static and deterministic vehicle routing problems can be solved to near optimality with acceptable computational times using metaheuristics. However, many real world applications are dynamic and include stochastic aspects, such as unknown future customer requests. Explicitly taking into account available stochastic information may yield benefits in these cases. Here, three different heuristics are considered and evaluated in terms of their ability to minimize transportation costs in a dynamic and stochastic maritime planning problem.

3 - Practical Methods for LNG Inventory Routing

Kevin Furman, ExxonMobil Upstream Research Company, ExxonMobil, P.O. Box 2189, URC-URC-S310, 77098, Houston, TX, United States, kevin.c.furman@exxonmobil.com, *Vikas Goel*, *Jin-Hwa Song*, *Amr El-Bakry*

We introduce a practical problem for simultaneous optimization of ship routing and inventory management of LNG. Even though this ship inventory routing problem and the conventional Inventory Routing Problem (IRP) have similar structures, differences arise in various characteristics that arise in the application specifically to the LNG industry. We develop a discrete time optimization model and heuristic algorithms for solving annual delivery plans. Computational results comparing various algorithmic approaches are presented.

4 - Maritime Split Pickup Split Delivery Problems

Bjørn Nygreen, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred getz vei 3, NO-7491, Trondheim, Norway, bjorn.nygreen@iot.ntnu.no, *Frank Hennig*, *Marco Lübbecke*

We discuss a multiproduct industrial shipping problem with several loading ports and several discharging ports for each product. Some of the ports have handle or than one product. The non-predetermined amount of a given product shipped from a loading port time window to a discharging port time window can be split between several ships. The distances between the ports and their geographical clustering are such that it is natural to discharge a ship completely after starting a sequence of discharges before loading it again. Our solution approach uses SCIP and is based on nested column generation.

■ FA-07

Friday, 9:00-10:30
Meeting Room 106

Queueing Theory

Stream: Applied Probability
Invited session

Chair: *Ernie Love*, Information Systems and Operations Management, American University of Sharjah, PO Box 26666, 1 University City Road, Sharjah, United Arab Emirates, clove@aus.edu

1 - A Retrial Queue with Limitation

Laszlo Lakatos, Computer Algebra, Eotvos Lorand University, Pazmany Peter s. 1/C, H-1117, Budapest, Hungary, lakatos@inf.elte.hu

We consider a retrial queueing system with Poisson arrivals and exponentially distributed service time. The service is realized in the order of arrivals and can be started at moments of arrivals or at moments differing by the multiples of a cycle time T. Such model can describe e.g. the transmission of optical signals. The system is investigated by using the embedded Markov chain technique. We find the distribution of number of customers and waiting time, the stability condition. If T tends to zero, one gets the ergodic distribution for the M/M/1 system, the mean value of waiting time.

2 - Delay Propagation in Re-scheduled Queueing Systems

Claus Gwiggner, ATM Modeling Group, Electronic Navigation Research Institute, 7-42-23 Jindaiji Higashi-machi, Chofu-shi, 182-0012, Tokyo, Japan, claus@enri.go.jp, *Sakae Nagaoka*

We analyze a single server, where customers are initially scheduled but arrive with a possible delay. Additionally, the system has two waiting rooms. The delays may propagate through the arrival process and decrease system performance. We obtain an analytical description of these inefficiencies that mainly depends on the ratio of the waiting time spent in the two rooms. Its decreasing shape is a necessary condition for the existence of a waiting cost minimium. We obtained the result in the context of fuel-efficient aircraft flows, where it can be used as a sustainable scheduling policy.

3 - Robust Design for Two Speed Processor

Tuan Dinh, FICT, Swinburne University of Technology, 2/179 Auburn Rd, 3123, Melbourne, VIC, Australia, tdinh@swin.edu.au, *Lachlan Andrew*

We consider an M/M/1 queue in which the server can run at a fixed upper speed or a lower speed, to be determined. We find the lower speed that is robust to uncertainty in the load, with respect to the objective of the weighted sum of the mean occupancy and a convex increasing function of the speed. Specifically, we find the lower speed that minimizes the maximum over load of the difference between (a) the optimal cost given that choice of lower speed and (b) the optimal cost when the lower speed is optimized for the load. We apply this to energy saving in a CPU.

4 - Analysis of Queues with an Imperfectly Repairable Server

Ernie Love, Information Systems and Operations Management, American University of Sharjah, PO Box 26666, 1 University City Road, Sharjah, United Arab Emirates, clove@aus.edu

We consider a queueing system where the server is subject to failures. After an "imperfect" repair, the server will be in a state between "as good as new" and "as bad as old". The server state will determine either the failure rate and/or the service rate. A Quasi Birth Death process is developed and we investigate the effect of maintenance policy on the queue and on overall performance. Under a cost structure, we illustrate the search for the optimal maintenance policy to minimize the costs. Queueing effects on the average cost of operating such a system are examined with numerical analysis.

■ FA-08

Friday, 9:00-10:30
Meeting Room 107

Markov Decision Processes

Stream: Dynamic Programming
Invited session

Chair: *Masayuki Horiguchi*, Institute of Mathematics, Faculty of Engineering, Kanagawa University, 3-27-1 Rokkakubashi, Kanagawa-ku, 221-8686, Yokohama, Japan, horiguchi@kanagawa-u.ac.jp

1 - Monotonicity of Expected Revenue in Revenue Management: Two Models of Consumers' Choice

Yasushi Masuda, Faculty of Science and Tech, Keio University, 3-14-1, Hiyoshi, Kohoku, 2238522, Yokohama, Japan, masuda@ae.keio.ac.jp, *Sho Deguchi*

We examine the monotonicity properties of expected revenue in revenue management with respect to consumers' choice behavior. Considered are two types of consumer behavior: a simple choice model and a general discrete choice model. An example shows that the usual stochastic order relation in consumers' preference over the set of fare products is not sufficient for monotonicity under a general discrete choice model. We provide sufficient conditions for the monotonicity under these two choice models.

2 - Multi-stage Decision Processes with Targets for Every Stage

Akifumi Kira, Graduate School of Mathematics, Kyushu University, 744 Motooka, Nishi-ku, 819-0395, Fukuoka, Japan, a-kira@math.kyushu-u.ac.jp

As a generalization of the standard threshold probability problem in finite horizon MDPs, we consider a class of problems consisting of three criteria concerned with achieving specified targets. The main criterion attempts to maximize the probability that, at all stages, the accumulation of rewards earned up to that point takes its value in a given interval. We may think of the criterion as being the model for minimizing liquidity risk. This class is shown to reduce to the case of the usual expectation criteria (additive, multiplicative and maximum) through an invariant imbedding technique.

3 - Threshold Probability and Expectation Criteria for Additive Reward System

Masahiko Sakaguchi, Graduate School of Integrated Arts and Sciences, Kochi University, 780-8520, 2-5-1 Akebono-cho, Kochi, Japan, b08d6a04@s.kochi-u.ac.jp, *Yoshio Ohtsubo*

There are several criteria for an additive reward system in Markov decision processes. In this talk, we are concerned with threshold probability and expectation criteria. By imbedding approach for the threshold probability criterion, an optimal recursive equation is given. We then show the existence of an optimal policy. Moreover, we contrast the expected value of the optimal threshold probability with the optimal one for the expectation criterion.

4 - Learning Algorithms for Uncertain Markov Decision Processes

Masayuki Horiguchi, Institute of Mathematics, Faculty of Engineering, Kanagawa University, 3-27-1 Rokkakubashi, Kanagawa-ku, 221-8686, Yokohama, Japan, horiguchi@kanagawa-u.ac.jp

We consider adaptive models for finite MDPs with unknown transition matrices. We develop learning algorithms for the communicating case of multi-chain MDPs and for the regularly communicating case whose state space is decomposed into a single communicating class and an absolutely transient class. In the regularly communicating case, we can investigate the structure of unknown transition matrices and get an asymptotic sequence of adaptive policies. Also, under the minorization condition, we construct an adaptive policy based on the temporal difference method in neuro-dynamic programming.

■ FA-09

Friday, 9:00-10:30
Meeting Room 108

Public Sector Problems

Stream: Contributed Talks

Contributed session

Chair: *Stephen Starkey*, Management, University of Canterbury, Private Bag 4800, Ilam, 8140, Christchurch, Canterbury, New Zealand, stephenrstarkey@hotmail.com

1 - Divisor-Based Biproportional Apportionment in Electoral Systems

Martin Zachariasen, Dept. of Computer Science, University of Copenhagen, Universitetsparken 1, DK-2100, Copenhagen, Denmark, martinz@diku.dk

Biproportional apportionment methods provide two-way proportionality in electoral systems where the electoral region is subdivided into electoral districts. In a divisor-based method for biproportional apportionment, the problem is solved by computing appropriate row- and column-divisors, and by rounding the quotients. Divisor-based methods have received significant attention over the last years; in particular, a range of algorithms have been studied - both from a theoretical and experimental perspective. We give an overview of recent developments in the area.

2 - An Analysis of Diffusion Process of Emerging Infectious Disease

Yasufumi Saruwatari, Graduate School of Business Sciences, The University of Tsukuba, 3-29-1 Otsuka, Bunkyo-ku, 112-0012, Tokyo, Japan, saru@gssm.otsuka.tsukuba.ac.jp, *Tadahiko Sato*

A threat of infectious diseases is increasing according to fast changes in human demographics worldwide, increased mobility, and so on. A pandemic of A H1N1 influenza in 2009 showed that it is important to understand the mechanism of the diffusion of such event. We propose a mathematical model for describing the diffusion process of emerging infectious disease based on time-series SIR (Susceptible-Infectious-Recovered) model. Our model identifies the characteristics of the propagation process from a geographical aspect, and shows the possibility of predicting the evolution of such event.

3 - Climatic Regionalization through Data Mining Techniques: A Case Study for Michoacan, Mexico

Guillermo Molero Castillo, Doctorado en Tecnologías de Información, UdeG, Periferico Norte 799, 45150, Zapopan, Jalisco, Mexico, dtigmolero@gmail.com

This paper presents the use of Data Mining to provide similar climatologically zones or regions in the state of Michoacan, Mexico. Hydrologically, the availability of homogeneous regions allows to count on necessary data to establish a reliable water balance to assist in decision making aimed at to protect and to take advantage of rational way the water resources. Data sets used correspond to the climate records CLICOM stations. The analysis of climate variability in the region is important given the differences in climate, topography, vegetative and socio-economic of a region (Michoacan).

4 - Enhancing Water Allocation with Price Based Mechanisms

Stephen Starkey, Management, University of Canterbury, Private Bag 4800, Ilam, 8140, Christchurch, Canterbury, New Zealand, stephenrstarkey@hotmail.com

We present insights into an LP formulation which is intended to enhance wholesale urban water allocation with price based mechanisms. The model features many practical implementation challenges that have been successfully overcome in well-established electricity and natural gas markets. We allude to key aspects of the water utility network, giving insight into ways in which participants could interface, and benefit, from such a market type system.

■ FA-10

Friday, 9:00-10:30
Meeting Room 111

Stochastic Programming Models and Methods

Stream: Stochastic Programming

Invited session

Chair: *Abdel Lisser*, LRI, Universite de Paris Sud, Bat. 490, 91405, Orsay, France, lisser@lri.fr

Chair: *Rüdiger Schultz*, Mathematics, University of Duisburg-Essen, Lotharstr. 65, D-47048, Duisburg, Germany, schultz@math.uni-duisburg.de

1 - Solving Stochastic MIPs using Column Generation

Andy Philpott, Engineering Science, The University of Auckland, 70 Symonds Street, 1022, Auckland, New Zealand, a.philpott@auckland.ac.nz, *Jonas Christoffer Villumsen*

Stochastic mixed integer programming (MIP) problems are very important in applications, but have proved difficult to solve in general cases. Often the quickest route to a solution in practice is to solve a large-scale deterministic equivalent MIP using a commercial solver. This limits the size and realism of problems that can be solved. We describe an approach to solving a quite general class of stochastic MIPs using Dantzig-Wolfe decomposition and column generation. Examples from capacity expansion and electricity transmission switching will be used to illustrate the methodology.

2 - Application of Sensitivity Analysis for Energy Power Management

Kengy Barty, OSIRIS/R35, EDF, 1 avenue du Général de Gaulle, 92141, Clamart, France, kengy.b@gmail.com

In energy power management we must cope with numerous difficulties in order to schedule efficiently the production. The mathematical counterpart of the opterationnal problem is a large scale optimization problem, involving both heterogenous decisions variables and random entries. We are going to focus on the specific dimension of this problem concerning nuclear stops for maintenance and refuelling. We are going to show how sensitivity analysis can help us in order to obtain the sensitivity of the optimal cost of the schedule with respect to the time of stop begining.

3 - Stochastic Maximum Weight Forest

Abdel Lisser, LRI, Universite de Paris Sud, Bat. 490, 91405, Orsay, France, lisser@lri.fr, *Rüdiger Schultz*, *Marc Letournel*

The maximum weight forest problem (MWFP) in a graph is solved by the famous greedy algorithm due to Edmonds (1971) where every edge has a known weight. In particular, the system of constraints on the set of edges is TDI (totally dual integral), since the set of independent edges, i.e., of acyclic subsets of edges, is a matroÃd. We extend this approach to the case of two-stage maximum weight forest problems. The set of edges is composed of first stage edges with known weights and second stage ones where the weights are known a priorily in terms of discrete random variables. As the probability distribution is discrete, we transform the stochastic problem into a deterministic equivalent problem. In this article, we prove TDIness for the two stage maximum weight forest problem in the following cases: Two scenarios with reduced number of first stage variables and we propose an efficient greedy algorithm for solving this problem. We provide a counter example to prove that the problem is not TDI for more than two scenarios.

4 - Stochastic Shape Optimization

Rüdiger Schultz, Mathematics, University of Duisburg-Essen, Lotharstr. 65, D-47048, Duisburg, Germany, schultz@math.uni-duisburg.de

Based on paradigms from finite-dimensional two-stage stochastic linear programming we propose infinite-dimensional, PDE-constrained models for shape optimization under linearized elasticity and stochastic loading. Both risk neutral and risk averse models are considered. Solution algorithms combine finite-element techniques with descent methods involving shape derivatives. Some illustrative computational results conclude the talk.

■ FA-11

Friday, 9:00-10:30
Meeting Room 112

Partitioning Problems

Stream: Integer Programming
Invited session

Chair: *Nezam Mahdavi-Amiri*, Mathematical Sciences, Sharif University of Technology, Azadi Avenue, 1458889694, Tehran, Iran, Islamic Republic Of, nezamm@sharif.edu

1 - Numerical Semigroups and Discrete Optimization

Victor Blanco, Departamento de Algebra, Universidad de Granada, Facultad de Ciencias, Campus Fuentenueva, 18071, Granada, Spain, vblanco@ugr.es, *Justo Puerto*

We present a mathematical programming approach for solving a problem that arises in the theory of numerical semigroups. It consists of decomposing a numerical semigroup into m-irreducible ones. We prove that finding a minimal m-irreducible decomposition is equivalent to solve a finite number of integer linear problems plus a set covering problem. Furthermore, we prove that there is a suitable transformation that reduces the original problem to find an optimal solution of a compact integer linear problem.

2 - Solving the Segmentation Problem for the 2010 Argentine Census with Integer Programming

Guillermo Duran, Ingenieria Industrial, University of Chile, Republica 701, 1000, Santiago, Chile, gduran@dii.uchile.cl, *Diego Delle Donne*, *Flavia Bonomo*, *Javier Marenco*

One of the most challenging tasks within the planning of a demographic census is to partition each census track into sets of homes such that each census taker visits exactly one set from this partition. In this work we introduce the home segmentation problem, which consists in designing such a partition subject to speci
fic constraints. We present an integer programming-based algorithm for this problem, and we report the application of this algorithm for the 2010 census in the main province in Argentina.

3 - Relative Errors of Strict Separating Systems

Xavier Molinero, Matemàtica Aplicada 3, UPC - ALBCOM, Av. Bases de Manresa, 61-73, 08242, Manresa, Barcelona, Spain, xavier.molinero@upc.edu, *Josep Freixas*

The sensitivity to weights and threshold in strict separating systems is applyed in neural networks. The tolerance and the greatest tolerance are two parameters to measure the relative errors in weights and threshold of strict separating systems. Given an arbitrary separating system, we study which is the equivalent separating system that provides maximum tolerance or/and maximum greatest tolerance. We also consider such systems for n variables of k distinguished types.
*This work was partially supported by Grant MTM 2009-08037, ALBCOM-SGR 2009-1137, SGR 2009-1029 and 9-INCREC-11.

■ FA-12

Friday, 9:00-10:30
Meeting Room 205

Stochastic Routing and Network Problems

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Faiz Ahyaningsih*, Mathematics, Unimed/Graduate School of Mathematics, University of Sumatera Utara, Jln Keruntung Gg. Famili No 1 Medan, 20222, Medan, Indonesia, Indonesia, faiz_ahyaningsih@yahoo.com

1 - On Solving the Capacitated Open Vehicle Routing Problems with Uncertainty Demand

Hotman Simbolon, Mathematics, University HKBP Nommensen/Mathematics Graduate program, University of Sumatera Utara, FMIPA USU, 20155, Medan, Indonesia, simbolonh45@yahoo.com

In open vehicle routing problems, the vehicles are not required to return to the depot after completing service. In this paper, we extend the problem to be more realistic by including the uncertainty of customer demands. We solve the stochastic model using a strategy of releasing nonbasic variables from their bounds, combined with the "active constraint' method. This strategy is used to force the appropriate non-integer basic variables to move to their neighborhood integer points.

2 - Stochastic Programming Model for a Water Network Problem

Asrin Lubis, Mathematics, Unimed/Graduate School of Mathematics, University of Sumatera Utara, FMIPA USU, 20155, Medan, Sumatra Utara, Indonesia, lubis.asrin@yahoo.com, *Herman Mawengkang*

The optimal design of a Water Distribution Network (WDN) consists of the choice of a diameter for each pipe, the topology of the design, and the pipe length. In this paper we propose a new approach for tackling a WDN optimization model under the consideration of reliability in water flows.

3 - Developing a Combined Strategy for Solving Quadratic Assignment Problems

Faiz Ahyaningsih, Mathematics, Unimed/Graduate School of Mathematics, University of Sumatera Utara, Jln Keruntung Gg. Famili No 1 Medan, 20222, Medan, Indonesia, Indonesia, faiz_ahyaningsih@yahoo.com

The quadratic assigment problem is a combinatorial problem of deciding the placement of facilities in specified locations in such a way as to minimize a nonconvex objective function expressed in terms of distance between location and flows between facilities. In this paper. We propose a random point strategy to get a starting point, and then we use a combined strategy to get 'optimal' solution. As a computational experience we solve 42 x 42 backboard wiring problem.

■ FA-13

Friday, 9:00-10:30
Meeting Room 206

Mathematical Programming III

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Andrew Eberhard*, Mathematical and Geospatial Sciences Dept., RMIT University, GPO Box 2476V, 3001, Melbourne, Victoria, Australia, andy.eb@rmit.edu.au

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Shunsuke Hayashi*, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp

1 - Calculation of Global Optimal Fundamental Matrix

Hiroshige Dan, Kansai University, 3-3-35, Yamate-cho, 564-8680, Suita-shi, Osaka, Japan, dan@kansai-u.ac.jp

In stereo vision, a fundamental matrix characterizes the relation between two cameras. We need it to reconstruct a 3D structure from two images taken by two cameras. When we do not know a fundamental matrix a priori, we will calculate it from the corresponding points in two images. However, since these points contain noise generally, parameter estimation is necessary. Also, this estimation is formulated as a constrained nonlinear programming problem. In this research, we propose a method for finding a global optimal solution of this problem, that is, a global optimal fundamental matrix.

2 - Successive Approximation Algorithms for Solving a Canonical DC Programming Problem

Syuuji Yamada, Graduate School of Science and Technology, Niigata University, 8050 IKarashi-2nocho, 9502181, Niigata, Japan, yamada@math.sc.niigata-u.ac.jp, *Tamaki Tanaka*, *Tetsuzo Tanino*

In this paper, we consider a canonical dc programming problem (CDC) whose feasible set is defined as the intersection of a compact convex set and the complement of a bounded open convex set. For (CDC), many global optimization algorithms have been proposed. However, since the data necessary for executing such algorithms increase in proportion to the number of iterations, such algorithms are inexecutable for large scale problems. Hence, to calculate an approximate solution of a large scale (CDC), we propose new successive approximation algorithms.

3 - On a Maxentropic Deformation of Logarithm, Exponential and Entropy

Alin Rusu, Faculty of Mathematics and Computer Science, University of Bucharest, Academiei Street, no. 14, sector 1, 010014, Bucuresti, Romania, rusualinmarian@yahoo.com

Applying the maximum entropy principle to a trace form entropy yields a class of generalized logarithms from which the k-entropy is obtained. The k-entropy's generalized algebra is obtained. The Lesche's stability property is described. A general condition under which the k-entropy becomes stable is presented.

4 - A New Approach to the Surrogate Dual in Integer Programming

Andrew Eberhard, Mathematical and Geospatial Sciences Dept., RMIT University, GPO Box 2476V, 3001, Melbourne, Victoria, Australia, andy.eb@rmit.edu.au, *Natashia Boland*

The theoretical properties of the surrogate dual (SD) are at least as strong as the Lagrangian dual (LD) and offers hope of improvements in bounds. Puzzlingly the SD has had much less impact on computational practice in integer programming. In this talk we give a summary of some aspects of the theory of SD and propose some new variations on numerical approaches to the solution of the SD. Its potential use in branch and bound algorithms has also been suggested over many decades and we provide some additional observations here as well. Numerical experiments will be discussed.

■ FA-14

Friday, 9:00-10:30
Meeting Room 207

Optimization Modeling and Equilibrium Problems I

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Hayri Önal*, Agricultural and Consumer Economics, University of Illinois, 305 Mumford Hall, 1301 W. Gregory Dr., 61801, Urbana, Illinois, United States, h-onal@illinois.edu

Chair: *Jon Borwein*, Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, jon.borwein@gmail.com

1 - Complex System Modelling Using Belief Rule Based (BRB) Systems

Dong-Ling Xu, Manchester Business School, The University of Manchester, F37 MBSE, Booth Street West, M15 6PB, Manchester, England, United Kingdom, L.Xu@mbs.ac.uk, *Yu-Wang Chen*, *Shan-Lin Yang*, *Jian-Bo Yang*

Belief rule based (BRB) system provides a generic inference framework for approximating complicated nonlinear causal relationships between inputs and output. In this paper, the approximation properties of BRB systems are analysed, which reveals the underlying inference mechanisms that enable BRB systems to have superior approximation performances. It is proved that BRB systems can approximate any continuous function on a compact set with arbitrary accuracy. A numerical study is conducted to demonstrate the validity of a BRB system and its approximation capability.

2 - Configuration Optimization of the Soldier System

Yixing Shan, School of Business and Economics, Loughborough University, 9 Coniston Crescent, LE11 3RQ, Loughborough, United Kingdom, Y.Shan@lboro.ac.uk, *Lili Yang*, *Roy S.Kalawsky*

Along with the increasing of new equipment based capabilities, the physiological burden on the dismounted soldier keeps on growing, which leads to the limitation in the quality and types of missions that can be carried out. In this research, a methodology is developed to solve the burden problem from the operational optimization point of view. Comparing with other relevant research, the new methodology provides the high fidelity evaluation with the capability of handling incomplete data with hybrid format in nature, and at the same time restrains the model complexity to an acceptable level.

3 - Optimal Frequency Design Problem for Multi-modal Transportation Systems

Younes Hamdouch, Dept. of Business Administration, UAE University, P.O. Box 17555, Al Ain, United Arab Emirates, younes.hamdouch@uaeu.ac.ae

In this paper, we study the optimal frequency design problem for multi-modal transportation systems. We assume that users adopt strategies or hyperpaths to travel between each origin-destination pair. However, the choice between driving and using public transportation is determined by binomial logit function. The optimal frequency design problem is formulated as a bilevel optimization problem where the response from users to the frequencies of transit lines is assumed to follow a user equilibrium. We provide a numerical example to illustrate our approach.

4 - A Mathematical Programming Approach to Political Redistricting with Compactness and Community Integrity Considerations

Hayri Önal, Agricultural and Consumer Economics, University of Illinois, 305 Mumford Hall, 1301 W. Gregory Dr., 61801, Urbana, Illinois, United States, h-onal@illinois.edu, *Kevin Patrick*

We present a linear integer programming approach to partition indivisible spatial units and configure a specified number of political districts around selected district centers such that all districts have almost equal populations; each district is contiguous and compact; and communities are divided minimally. We also present empirical applications to legislative districting cases for the states of Illinois and Kentucky in US. The results show that the model-generated districts are considerably more compact than the actual district plans while dividing jurisdictional boundaries much less.

■ FA-15

Friday, 9:00-10:30
Meeting Room 208

Fuzzy Optimization

Stream: Fuzzy Logic
Invited session

Chair: *Jaroslav Ramik*, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz

Chair: *Martin Gavalec*, Department of Information Technologies, Faculty of Informatics and Management, University of Hradec Králové, Rokitanského 62, 50003 , Hradec Králové, Czech Republic, Martin.Gavalec@uhk.cz

1 - Measuring Inconsistency of Pair-wise Comparison Matrix with Fuzzy Elements

Petr Korviny, Center of Information Technology, Silesian University in Opava, Univerzitni Namesti 1934/3, 73340, Karvina, Czech Republic, petr.korviny@slu.cz, *Jaroslav Ramik*

In this paper, we deal with inconsistency of pair-wise comparison matrix with triangular fuzzy elements. Inconsistency is based on the distance of the matrix to a special matrix measured by a particular metric. In the other approach we use a fuzzy pair-wise comparison matrix as a way of specifying fuzzy restrictions on the possible values of the ratio judgments. A specific consistency index corresponding to the degree of satisfaction is defined. Simple illustrating examples for comparing the new index with other approaches are presented.

2 - Aggregation of Generalized Concave Functions in Fuzzy Optimization and Decision Making

Jaroslav Ramik, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz, *Milan Vlach*

In this paper aggregation functions and their basic properties are defined. The averaging aggregation operators are defined and some interesting properties are derived. Moreover, we have extended concave and quasiconcave functions introducing t-quasiconcave and upper and lower starshaped functions. The main results concerning aggregation of generalized concave functions are presented and some extremal properties of compromise decisions by adopting aggregation operators are derived and discussed.

3 - Fuzzy Games Against Nature

Josef Vícha, Mathematical Institute in Opava, Silesian University in Opava, Na rybničku 1, 74601, Opava, Czech Republic, Josef.Vicha@math.slu.cz

It has been shown that a fuzzy two person games can be solved by optimistic and pessimistic approach. A two person game with the first player as the decision maker and second as the Nature is very special type of the zero-sum person games. Solving these games can be used for the decision making in finance, crisis management and other disciplines. In this paper we introduce an approach based on optimistic and pessimistic approach to this problem. An illustrative example is presented and discussed.

4 - A Residential Consumer Payment Capability Index Based on Fuzzy Logic Inference

Fernando Luiz Cyrino Oliveira, Pontifical Catholic University of Rio de Janeiro, Brazil, fcyrino@ele.puc-rio.br, *Reinaldo Souza*

The lack of payment of electricity bills has been one of the main problems faced by the distributing utilities of electrical energy in Brazil. It is therefore essential that the utilities are provided by a tool to assess the ability to advance payment by the consumer units in order to formulate strategies to mitigate the lack of payment. This paper presents an approach based on Fuzzy Logic to develop an index that reflects this real capability of payment for any individual consumer unit or any kind of geographical aggregation, allowing, this way, a graphical display with the help of GIS tools.

■ FA-16

Friday, 9:00-10:30
Meeting Room 209

OR for Health Policy Decisions II

Stream: Health Care Applications

Invited session

Chair: *James Benneyan*, Center for Health Organization Transformation, Northeastern University, 334 Snell Engineering Center, 360 Huntington Avenue, 02115, Boston, MA, United States, benneyan@coe.neu.edu

1 - Robust Dynamic Kidney Exchange

Kristiaan Glorie, Econometric Institute, Erasmus University Rotterdam, Postbus 1738, 3000 DR, Rotterdam, Netherlands, glorie@ese.eur.nl

Kidney exchanges have recently emerged as a way to alleviate the worldwide shortage of kidney donors. We study the centralized organization of kidney exchanges in a dynamic setting, where the timing of exchange is fixed but the arrival of patient-donor pairs is uncertain. Using robust optimization techniques, we derive optimal dynamic matching policies that are protected against this uncertainty. We make policy recommendations using simulations based on kidney exchange data from the US and the Netherlands.

2 - Specialty Care Service Location within the U.S. Veterans Health Administration

James Benneyan, Center for Health Organization Transformation, Northeastern University, 334 Snell Engineering Center, 360 Huntington Avenue, 02115, Boston, MA, United States, benneyan@coe.neu.edu, *Seda Sinangil*, *Hande Musdal*, *Mehmet Ceyhan*, *Brian Shiner*, *Bradley Watts*

Several medical care location-allocation optimization models are developed to support macro capacity planning across geographic regions of the U.S. Veterans Affairs integrated service networks. Given the current U.S. healthcare reform debate, significant cost and access improvements are shown possible by simultaneous optimization of the locations and capacities of primary and tertiary specialty care services. Results, modeling issues, and ramifications are discussed. Correlated care needs, demand uncertainty, population trends, and telemedicine introduction are considered.

3 - The Role of Air Travel in the Worldwide Spread of Vector Borne Diseases

Travis Waller, University of Texas, 78712-0273, Austin, TX, United States, S.Travis.Waller@engr.utexas.edu, *Lauren Gardner*, *David Fajardo*, *Sahotra Sarkar*

Increased passenger air traffic has lead to an increased risk of importation and establishment of vector-borne diseases, such as dengue and malaria. As such, it is critical to be able to identify the risk associated with air travel routes between vector-compatible environments. This problem requires modeling the interaction between three overlapping networks: a vector survivability network, a social network and an airport network. We study the interaction between these networks; in particular the role of the airport network in connecting the vector-survivability network.

4 - Multivariate Discrete Statistical Models for Disease Occurrence

Mulalo Annah Managa, Statistics Dept., UNISA, 15 Breekhout Street, Karenpark, P.O BOX 59035, Pretoria, South Africa, managma@unisa.ac.za

Prevention and control of tuberculosis diseases and other sexually transmitted diseases (STDs), present complex public health challenges. Understanding the interconnection between diseases epidemics is crucial in guiding the best intervention and control strategies that are cost effective. These types of diseases are known to share similar risk associated with lower socio-economic status and sexual behaviour. This paper uses multivariate discrete distribution to model the three diseases outcomes. We also control for both subject specific factors, both observed and unobserved. In this way, we will be able to determine the relative importance of the modelled factors.

■ FA-17

Friday, 9:00-10:30
Meeting Room 214

Investment Strategies and Valuation I

Stream: Finance

Invited session

Chair: *Thomas Burkhardt*, Campus Koblenz, IfM, Universitaet Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, tburkha@uni-koblenz.de

Chair: *Heinz Eckart Klingelhöfer*, Knopfstraße 1, 17489, Greifswald, Germany, hekling@web.de

Chair: *Ulla Hofmann*, Institute for Management, University Koblenz, Universitätsstraße 1, 50670, Koblenz, Germany, uhofmann@uni-koblenz.de

1 - Optimal Capital Growth with Convex Loss Penalties

Leonard MacLean, School of Business Administration, Dalhousie University, 6100 University Avenue, B3H 3J5, Halifax, Nova Scotia, Canada, l.c.maclean@dal.ca, *William Ziemba*, *Yonggan Zhao*

In capital growth under uncertainty, an investor must determine how much capital to invest in riskless and risky instruments at each point in time, with a focus on the trajectory of accumulated capital to a planning horizon. Assuming that prices are not affected by individual investments but rather aggregate investments, individual decisions are made based on the projected price process given the history of prices to date.

2 - The Trend is not Your Friend! Demystifying the Empirical Track Record of Techn. Trading Rules and its Interrelation with Market Efficiency by Asset Price Characteristics

Peter Scholz, Frankfurt School of Finance and Management, 60314, Frankfurt am Main, Germany, p.scholz@frankfurt-school.de, *Ursula Walther*

The empirical success of technical trading rules, contradicting the efficient market hypothesis, still seems puzzling. We contribute by showing that timing success can be explained by the statistical characteristics of the underlying asset price, where market efficiency does not play any role. Five impact factors are studied: return autocorrelation, trend, volatility and its clustering and market efficiency. Different simple moving average rules are applied to simulated and real asset price data to allow for systematic parameter variations. Evaluation is done on the entire return distribution.

3 - Rational Choice in IPD Games from an Investor's Perspective

Ulla Hofmann, Institute for Management, University Koblenz, Universitätsstraße 1, 50670, Koblenz, Germany, uhofmann@uni-koblenz.de, *Thomas Burkhardt*

We consider experimental results in an iterated prisoner's dilemma game from the perspective of a rational investor. We describe observed behavior using a stochastic Markov model and analyze the properties of the return distribution from the investor's perspective. Some first theoretical considerations regarding optimal choice are discussed.

■ FA-18

Friday, 9:00-10:30
Meeting Room 215

Applications of DEA in Health Sector

Stream: Data Envelopment Analysis
Invited session

Chair: *Ana Camanho*, Faculdade de Engenharia, Universidade do Porto, DEMEGI - GEIN, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, acamanho@fe.up.pt

1 - Estimating Technical Efficiency of Social Security Hospitals in Iran by Data Envelopment Analysis

Nahid Hatam, Health Service Administration, Shiraz University of Medical Sciences(SUMS) -Shiraz - Iran, School of Management & Medical Information Sciences, 0098, Shiraz, Fars, Iran, Islamic Republic Of, hatamn@sums.ac.ir, *Kimia Purmohamadi*, *Ali Keshtkaran*, *Mehdi Javanbakht*

This study examines the technical and scale efficiency of 64 public hospitals affiliated to social security organization in Iran, between 2006-2008, by estimating a deterministic frontier production function and the variable return to scale (VRS), and input-oriented DEA model.

2 - Evaluating Relative Efficiency of Regulatory Departments in Pharmaceutical Companies in Iran

Seyed Hamid Mostafavi, Socioeconomic Research Center, Cardiff University, Welsh School of Pharmacy, Redwood Building, King Edward VII Ave, CF10 3NB, Cardiff, United Kingdom, seyedhamid.mostafavi@gmail.com, *Sam Salek*

This study applies DEA to determine the technical efficiency of DMUs based on technical, operational and financial inputs and outputs, and identify key performance indicators of the regulatory departments in pharmaceutical companies and evaluate their relative efficiencies. The results give efficiency scores of 11 companies and show that 3 were efficient. It is concluded that the existence of an independent regulatory department can create and sustain superior performance for companies to reach competitive advantage by exploiting new opportunities vis-à-vis new products' time to market.

3 - Assessing Efficiency of Primary Healthcare: Comparing DEA and SFA

Sergio Maturana, Ingenieria Industrial y de Sistemas, P. Universidad Catolica de Chile, Casilla 306 Correo 22, Santiago, Chile, smaturan@ing.puc.cl, *Martha Ramirez-Valdivia*

This article uses the same data set and compares the efficiency ranking and index by applying Data Envelopment Analysis and Stochastic Frontier Analysis to 259 nationwide municipalities that administer Chilean primary healthcare. The SFA efficiency value reaches 79.34% whilst the DEA value is 82.07%. Up to 67% decision making units found to be "better' under DEA were also classified as "better' under SFA. The results show that both methods provide efficiency measures that are similar enough to conclude that there are no statistically significant differences between them.

4 - Benchmarking Countries Environmental Performance

Andreia Zanella, FEUP - Faculdade de Engenharia da Universidade do Porto, Portugal, andreia.zanella@fe.up.pt, *Ana Camanho*, *Teresa Galvão Dias*

Environmental performance assessments are often conducted using environmental indicators. These indicators provide a starting point for comparisons, although the identification of directions for improvement is difficult. The main contribution of this paper is the development of a DEA model with virtual weight restrictions that provides a summary measure of countries performance. It also enables the identification of the strengths and weaknesses of each country, as well as the peers and targets that inefficient countries should follow to improve environmental practices.

■ FA-19

Friday, 9:00-10:30
Meeting Room 216

Multiobjective Flows and Paths Problems

Stream: Network Optimisation and Telecommunications
Contributed session

Chair: *Bi Yu Chen*, Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, chen.biyu@gmail.com

1 - Algorithms for Biojective Shortest Path Problems in Fuzzy Networks

Iraj Mahdavi, Department of Industrial Engineering, Mazandaran University of Science & Technology, P.O.Box 734, 4716685635, Babol, Mazandaran, Iran, Islamic Republic Of, irajarash@rediffmail.com

We consider biobjective shortest path problems in networks with fuzzy arc lengths. Considering the available studies for single objective shortest path problems in fuzzy networks, using a distance function for comparison of fuzzy numbers, we propose three approaches for solving the biobjective problems. We propose a fuzzy number ranking method to determine a fuzzy shortest path. Illustrative examples are worked out to show the effectiveness of our algorithms.

2 - Multiobjective Shortest Paths in Multimodal Networks

Romain Billot, Smart Transport Research Centre, QUT, 2 George St GPO box 2434, 4101, Brisbane, QLD, Australia, billotro@gmail.com, *David Rey*

Computation of multimodal travel time has become a critical issue for the transportation specialists in order to provide the network users with an efficient information about their journey conditions. After a review of the different approaches for multimodal shortest paths computation and a practical example for the city of Lyon in France, we broad the topic by considering the multiobjective aspects. We present a method that combines the use of A* algorithms with genetic algorithms and conclude the paper with a discussion about the introduction of the stochasticity into theses solutions.

3 - A Return to the Traveling Salesman Model: The Network Branch and Bound Approach

Elias Munapo, Decision Sciences Dept., University of South Africa, Preller Street, Pretoria, P. O. Box 392, UNISA 0003, 27, Pretoria, Gauteng, South Africa, munape@unisa.ac.za

This paper presents a network branch and bound approach for solving the difficult traveling salesman (TSP) problem. A rooted tree is how the TSP is tackled, with the root representing the optimal solution, and lower levels representing sub-problems traversed using a combination of minimum spanning tree (MST), arc fixing and leaf removal. In that sense, the tree is optimized (in terms of size at lower levels) by starting with nodes having smallest degree. The strength of the method lies in that the MST is easier to solve than either the linear programming or assignment based algorithms.

4 - Reliable Shortest Path Problem in Stochastic Networks with Spatial Correlation

Bi Yu Chen, Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, chen.biyu@gmail.com, *William Lam*

This study investigates the reliable shortest path problem (RSPP) in stochastic networks with spatial correlation. Such reliable shortest paths can help travelers make their route choice under travel time uncertainty with a given on-time arrival certainty. The RSPP with spatial correlation is formulated and solved as a multi-objective shortest path approach. A new A* algorithm is proposed to exactly solve this problem. Computational results show that the proposed algorithm can determine the reliable shortest path in large scale networks within a very short computation time.

■ FA-20

Friday, 9:00-10:30
Meeting Room 217

Decision Theory

Stream: Contributed Talks

Contributed session

Chair: *Jae H. Min*, Sogang Business School, Sogang University, #1, Shinsu-dong, Mapo-ku, 121-742, Seoul, Korea, Republic Of, jaemin@sogang.ac.kr

1 - Forming a Stable Multipartner Alliance when Priorities Differ

Tom Blockmans, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussel, Belgium, tblockma@vub.ac.be, *Frank Plastria*

We extend a spatial alliance formation model by considering the relative importance that individual partners may attribute to separate policy dimensions. Both simultaneous and incremental negotiation procedures are used to determine the alliance positions. The similarity in policy priorities is shown to have a considerable impact on partners' preferences in terms of alliance composition. Demonstrated negotiating flexibility strongly influences the formation process. The stability of an alliance structure is compared between different formation procedures and distance functions.

2 - Sensitivity Analysis in PROMETHEE

Sándor Bozóki, Research Group of Operations Research and Decision Systems, Computer and Automation Research Institute, Hungarian Academy of Sciences, PO Box 63., H-1518, Budapest, Hungary, bozoki@sztaki.hu

Sensitivity analysis in multi-attribute decision making is of both theoretical and practical interest. In partial sensitivity analysis the weight of a given attribute is modified and the weights of the other attributes are fixed or rescaled in order to keep the sum of the weights. Changes of two weights have been also analysed. However, a more general model for sensitivity analysis is at least as important, especially when dealing with real-life decision situations, as partial one. In the model proposed an arbitrary set of the weights can change independently from each other.

3 - Multicriteria Model to Evaluate Indicators in Performance Measurements Instruments

Edilson Giffhorn, Production Engineering, Santa Catarina Federal University, Av. Iguaçú, 399, apt. 25, bairro Rebouças, 80230020, Curitiba, Paraná, Brazil, edilson.giffhorn@gmail.com, *Leonardo Ensslin*, *Sandra Ensslin*, *William Vianna*

This paper presents the construction of a Performance Indicators evaluation model. From the model it was possible:(i) identify 58 criteria that evaluate the performance of the indicators;(ii) to trace the impact profile of the indicators of published applications of performance evaluation;(iii) to propose improvement actions that increase the performance of the indicators; and (iv) to draw an Impact Profile to the Case Study indicators after the improvement actions. The results evidence the availability of a model that improves the operationalization of Performance Measurement instruments.

4 - Another Bound on Rational Decision Making

Jae H. Min, Sogang Business School, Sogang University, #1, Shinsu-dong, Mapo-ku, 121-742, Seoul, Korea, Republic Of, jaemin@sogang.ac.kr

Behavioral decision making deals with how ordinary people make decisions and behave. Several bounds such as bounded rationality, bounded willpower, bounded self-interest, bounded will-to-commit, bounded ethicality have provided rationale for people's irrational judgment and behavior. This paper suggest another bound on rational decisions from the perspective of Asian values.

■ FA-21

Friday, 9:00-10:30
Meeting Room 218

Deterministic Open Pit Mine Planning

Stream: Mining Applications

Invited session

Chair: *Andrés Weintraub*, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl

1 - A Library of Open Pit Block Sequencing Problems

Alexandra Newman, Division of Economics and Business, Colorado School of Mines, 1500 Illinois Street, 80401, Golden, CO, United States, newman@mines.edu, *Daniel Espinoza*, *Marcos Goycoolea*, *Eduardo Moreno*, *Thomas Prevost*

The open pit block sequencing problem seeks to determine when if ever, a notional three-dimensional block containing ore and/or waste material is extracted from an open pit mine. A typical objective is to maximize the net present value of the extracted ore; constraints include spatial precedence and lower and upper bounds on resources. We present a description of this problem, briefly mention some related literature, detail mathematical models for the problem, provide a structured guide to corresponding data sets, and conclude with directions for use of this newly established mining library.

2 - Cutting Planes, Separation and Experiments for the Open-pit Planning Problem

Daniel Espinoza, Industrial Engineering, Universidad de Chile, Av. Republica 701, 837-0439, Santiago, RM, Chile, daespino@dii.uchile.cl

We consider the problem of separating valid inequalities arising from lifted induced cover inequalities for the precedence constrained knapsack problem, which essentially is a generalization of the long term planning problem for open pit mining in the presence of capacity constraints. We study some complexity issues regarding the separation problem, polynomial separation algorithms for a sub-class of these inequalities, and extensive computational tests showing the impact of the separated inequalities. The separation algorithms in this work generalize and include results from previous works from Boyd 1993, Park and Park 1997, van de Leensel et al. 1999 and Boland et al. 2005.

3 - A Heuristic Approach for Short-term Production Planning in Open-pits

Michel Gamache, Mathematics and Industrial Engineering, École Polytechnique de Montréal, P.O. Box 6079, Station Centre-Ville, H3C 3A7, Montréal, Quebec, Canada, michel.gamache@polymtl.ca, *Gabriel L'Heureux*, *Francois Soumis*

This presentation focuses on solving the short-term (a horizon of 90 days) scheduling problem in open-pit mines. This problem consists of finding the mining sequence that will minimize production costs while taking into account the precedence constraints for the extraction of the blocks, the grouping of blocks for drilling and blasting, the blending constraints, the movement of shovels, etc. A heuristic approach, based on a mixed integer linear programming model, is presented.

4 - Tailoring a Lagrangian Relaxation to Reduce Solution Time of the Open Pit Block Sequencing Problem

William Lambert, Division of Economics and Business, Colorado School of Mines, 1500 Illinois St., 80401, Golden, CO, United States, wlambert@mines.edu, *Alexandra Newman*

An open pit mine optimizes profits by maximizing the extracted orebody's net present value. Solving an integer program (IP) with time-indexed binary variables for each block representing if, and when, the block is extracted, is an exact method to determine the block extraction sequence. We solve the IP with a modified Lagrangian relaxation, where constraints are dualized, and multipliers are initialized, in different periods depending on the expected difficulty of satisfying minimum and maximum resource constraints. To determine these periods a priori, we develop heuristics that estimate how challenging it will be to fulfill the resource requirements in each period.

Friday, 13:15-14:45

■ FB-01

Friday, 13:15-14:45
Plenary Hall 3

Design and Operation of Competitive and Environmentally Friendly Transportation Systems

Stream: OR Applications in Energy

Invited session

Chair: *Yudai Honma*, Waseda Institute for Advanced Study, Waseda University, 60-02-05A, Okubo 3-4-1, 169-8555, Shinjuku-ku, Tokyo, Japan, yudai@aoni.waseda.jp

1 - Tradable Credits Scheme for Vehicle Emissions Control

Wei Xu, School of Management and Engineering, Nanjing University, #22 Hankou Road, 210093, Nanjing, China, xuwei@nju.edu.cn

Emissions from motor vehicles are steadily increasing and have become the major source of air pollution. Various emissions trading schemes have been proposed and implemented in many industrial installations for emission reduction, but not transport. This study presents a potential tradable credits scheme to internalize traffic emission externality into road users cost. A multimodal traffic network equilibrium model with vehicle model-specific credit charges is established. The existence of a credit charging scheme for minimum emissions and the trading price of credits are investigated.

2 - What Affect Improving of Eco-drive Techniques?

Ryosuke Ando, Research Department, TTRI (Toyota Transportation Research Institute), Wakamiya-cho 1-1, 471-0026, Toyota, Aichi, Japan, ando@ttri.or.jp, *Yasuhide Nishihori*

In order to reduce CO2 emission of automobiles, promotion of eco-drive is considered being effective. As a tool of promoting the eco-drive, some driver assistance systems have been developed for improving the drivers' techniques by providing information after having evaluated the drivers' behavior. What can make the drivers improve their driving to be more economically and ecologically? In this paper, factors affecting drivers' improvement of eco-drive are reported on the basis of our analysis of the data collected from a social experiment undertaken around end of 2009 in Toyota City.

3 - An Analysis for the Required Number of EV Stations in Highway Networks Based on Z-transform

Yudai Honma, Waseda Institute for Advanced Study, Waseda University, 60-02-05A, Okubo 3-4-1, 169-8555, Shinjuku-ku, Tokyo, Japan, yudai@aoni.waseda.jp, *Shigeki Toriumi*

Electric vehicles (EV) have attracted attention for decades, but short battery life and limited range are pointed out. These defects will be a serious problem in highway networks, where vehicles make long-distance driving. Enough number of EV stations is required on the highway networks to make EVs recharge. In this study, we calculate the required number of EV stations in actual highway networks based on Z-transform. Then, we apply the model to Tomei highway network and discuss the theoretical relationship between the location of EV stations and the number of EV arrivals.

■ FB-02

Friday, 13:15-14:45
Meeting Room 101

Scheduling for Services

Stream: Scheduling

Contributed session

Chair: *Andrew J Mason*, Dept Engineering Science, University of Auckland, Private Bag 92019, 1020, Auckland, New Zealand, a.mason@auckland.ac.nz

1 - eClasSkeduler: A Course Scheduling System for the Executive Education Unit at the Universidad de Chile

Jaime Miranda, Department of Management Control and Information Systems, Universidad de Chile, Diagonal Paraguay 257, Chile, jmirandap@fen.uchile.cl

Each October, the Executive Education Unit at the Universidad de Chile develops its course schedules for the following year. Three characteristics distinguish the unit's situation from the classic university course timetabling problem. First, its courses vary in duration, ranging between 15 and 30 weeks. Second, its course start dates are spread over the academic year. Finally, each course's start date is flexible and must fall within a window defined by the earliest and latest start dates. This work presents an automated computational system that generates optimal timetables.

2 - Improving the Revenue of Self-storage Warehouses by Optimizing Storage Decisions

Yeming Gong, Emlyon Business School, 12 Rue Dunoir, 69003, Lyon, France, gong@em-lyon.com

We consider a self-storage warehouse, facing a set of reservations for homogeneous or heterogeneous storage units over a certain time horizon with revenue rewards. The warehouse operation manager has to decide which storage requests to accept and schedule them in different storage units to maximize the revenue. We model warehouse operations as scheduling n independent multiprocessor tasks, with an objective to maximize total revenue. Finally, we consider the application to self-storage warehouses in different countries, and show our algorithm can improve the revenue.

3 - A Multicriteria Real Time Scheduling Approach for Flexible Manufacturing Systems (FMS)

Carlos Ernani Fries, Department of Production and Systems Engineering, Federal University of Santa Catarina, Campus Trindade - CTC/EPS, C.P. 476, 88010-970, Florianópolis, Santa Catarina, Brazil, ernani@deps.ufsc.br, *Mônica M. M. Luna*, *Thomas Makuschewitz*

The complexity and highly dynamic behavior of FMS require real time scheduling to ensure high productivity and flexibility. A multicriteria approach for the context dependent use of Dispatching Rules (DR) is suggested, where context is established by the FMS status as well as user defined preferences regarding manufacturing criteria. Several steady states of a typical FMS were simulated to provide a data base with the performance of DR for the most common contexts. Results for a wide range of preferences show that this approach leads to better results than the steady use of a single DR.

4 - A Generalised Staff Scheduling System using Neighbourhood-Constrained Nested Column Generation and Compile Time Customisation

Andrew J Mason, Dept Engineering Science, University of Auckland, Private Bag 92019, 1020, Auckland, New Zealand, a.mason@auckland.ac.nz

A challenge in staff scheduling is the diverse range of different rules. To handle this, we have developed a flexible rostering system that uses nested column generation whereby entities constructed by one generator form inputs to another generator. We use generic programming techniques to customise the system at compile time, giving substantial performance improvements. We also solve neighbourhood constrained sub-problems which construct columns that are neighbours to some current incumbent schedule. We report on tests conducted using problems from a recent nurse rostering competition.

■ FB-03

Friday, 13:15-14:45
Meeting Room 102

Meta-heuristics

Stream: Contributed Talks

Contributed session

Chair: *Pedro Steiner Neto*, Business, Federal University at Paraná, R. Pe. Anchieta, 1231, 80730-000, Curitiba, Pr., Brazil, pedrosteiner@ufpr.br

1 - Accommodation Arrangements of Ships and Craft VIA Quadratic Assignment Problem Applying GRASP and VNS Meta-heuristics Methods

Valdir Melo, Production Engineering, Federal University of Rio de Janeiro - UFRJ, Ilha do Fundão - Cidade Universitária, Centro de Tecnologia - Bloco F - Sala 105, 21941-972, Rio de Janeiro, Brazil, vmelo@pep.ufrj.br, *Nair Abreu*, *Richard David Schachter*, *Eliane Maria Loiola*

This work presents an improvement for a 'Ships Deck Accommodation Arrangements' software, for automated graphical space allocations, to aid marine designers. Accommodations are selected and sized via interface and their optimum allocation is determined by a QAP model, using a hybrid meta-heuristic, for quicker feasible solutions and, was introduced in this work, two penalty functions to reduce symmetry and concentrate unit squares that compose an accommodation. This improved allocations, now considering their relative position to the ship, if forward, aft or sideways.

2 - Power Efficient Broadcast Routing in Static Wireless Ad-Hoc Network Using Swarm Intelligence

S. Mehdi Hashemi, Computer Science, Amirkabir University of Technology, Hafez Avenue, Tehran, Iran, Islamic Republic Of, hashemi@aut.ac.ir, *Ahmad Moradi*, *Mohsen Rezapour*

Given a network with an identified source node, any broadcast routing is considered as a directed tree rooted at the source node and spans all nodes. As the problem is NP-Hard, we try to tackle it heuristically. First we propose an efficient PSO based algorithm with different coding schema. Then we present the second algorithm combining the global search of the first algorithm with a local search strategy based on noising methods. Comprehensive experimental study is devoted to compare the behavior of the proposed algorithm and to show its priority over the best known previous results.

3 - Extracting Rules from Genetic Algorithms to Electrical Energy Classification

Pedro Steiner Neto, Business, Federal University at Paraná, R. Pe. Anchieta, 1231, 80730-000, Curitiba, Pr., Brazil, pedrosteiner@ufpr.br, *Anderson Roges Teixeira Goes*, *Maria Teresinha Arns Steiner*

The methodology presented in this work uses Genetic Algorithms in the rules extraction in order to analyse the Electrical Energy Quality (EEQ). In order to do that, it were used patterns and their classes which are related to the responsibilities related to the voltage sag: equipment manufacturer; consumer or electrical energy concessionaries, as it was done by Casteren et al., 2005.

■ FB-04

Friday, 13:15-14:45
Meeting Room 103

Optimization in Bulk Goods Supply Chains

Stream: Supply Chain Management
Invited session

Chair: *Natashia Boland*, School of Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, natashia.boland@newcastle.edu.au

Chair: *Gaurav Singh*, Mathematics, Informatics & Statistics, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Private Bag 33, 3169, South Clayton, Victoria, Australia, Gaurav.Singh@csiro.au

1 - A Branch-price-and-cut Algorithm for a Maritime Inventory Routing Problem

Henrik Andersson, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Gløshaugen, Alfred Getz vei 3, NO-7491, Trondheim, Norway, Henrik.Andersson@iot.ntnu.no, *Marielle Christiansen*, *Guy Desaulniers*

A maritime inventory routing problem from the liquefied natural gas (LNG) industry is presented. The LNG is produced at liquefaction plants and transported using a heterogeneous fleet of ship to regasification terminals where it is sold. Both plants and terminals have limited storage capacities and production and sale are variables. A branch-price-and-cut algorithm is developed for the problem where a ship's movement is described using voyages. The valid inequalities explore the heterogeneity of the fleet, only full loading and unloading of ship tanks and the variable production and sale.

2 - Rail Schedule Optimisation in the Hunter Valley Coal Chain

Andreas Ernst, Mathematics, Informatics and Statistics, CSIRO, Gate 5, Normanby Road, 3168, Clayton, Vic, Australia, Andreas.Ernst@csiro.au, *Gaurav Singh*, *David Sier*

The Hunter Valley Coal Chain is the largest coal export operation in the world with total exports of more than 100 mil tonnes in 2010. It contains 35 mines with over 1000 km of rail track. The movement of coal is scheduled by the HVCC Coordinator (HVCCC). We present models and algorithms for a decision support tool developed to assist the HVCCC planners create optimal rail schedules. The tool greatly reduces the time taken to develop these schedules, allowing the planners to test the outcomes of various railing strategies before finalising the schedule. We also present computational results.

3 - Optimisation Tool for Medium-term Planning at Rio Tinto Iron Ore

Gaurav Singh, Mathematics, Informatics & Statistics, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Private Bag 33, 3169, South Clayton, Victoria, Australia, Gaurav.Singh@csiro.au, *Andreas Ernst*, *Rodolfo Garcia-Flores*

In supply chains, medium term plans are used to maximise throughput, identify bottlenecks, production and maintenance planning. This plan needs to observe constraints like maintenance requirements, production plans, and capacities of fleet, dumping, loading and stockyard. The model also needs to consider the grade qualities, which introduces a non-linear objective as the quality depends on the mixing ratio of ore from different sources. We present an optimisation tool developed to assist the Rio Tinto planners create optimal plans and has greatly reduced the time taken to develop such plans.

4 - Maintenance Scheduling for the Hunter Valley Coal Chain

Thomas Kalinowski, University of Newcastle, Australia, thomas.kalinowski@newcastle.edu.au, *Natashia Boland*, *Hamish Waterer*, *Lanbo Zheng*

We present a problem motivated by the annual maintenance planning process for the Hunter Valley Coal Chain which constitutes mining companies, rail operators, rail track owners and terminal operators. By carefully aligning necessary maintenance on different infrastructure parts capacity losses can be reduced significantly. We describe a dynamic network flow model for optimizing this alignment, discuss some LP based heuristic approaches to solving the model, and present computational results on random and real world instances.

■ FB-05

Friday, 13:15-14:45
Meeting Room 104

OR and Sports 1

Stream: OR and Sports
Invited session

Chair: *Tristan Barnett*, School of Mathematics and Statistics, University of South Australia, 1/11 Findon St, Hawthorn, 3122, Melbourne, Victoria, Australia, strategicgames@hotmail.com

1 - Markov Modelling in Hierarchical Games with Reference to Tennis

Andrei Loukianov, School of Mathematics and Statistics, University of South Australia, 307/23 King William Street, 5000, Adelaide, South Australia, Australia, andrei.loukianov@postgrads.unisa.edu.au, *Vladimir Ejov*

We propose a model, analytical approach and numerical technique to determine a winning probability of 'a point played'. The fundamental idea is to include sport specific competition situations in the stochastic analysis of hierarchical games. Our model is effectively a perturbed Markov Chain equipped with Bayesian player performance profiles.

2 - Perils of the Advantage Set

Alan Brown, retired, 14 Rowell Street, Rosanna, 3084, Melbourne, Victoria, Australia, abrown@labyrinth.net.au

In tennis, the stopping rules for an advantage set are poorly designed, and the total number of games required to determine the winner is not well controlled. When the advantage set is played, the standard deviation of the number of games is a poor measure of risk of very long matches. Analysis of the distribution of the number of games in an advantage set provides a simple practical example where the Normal Power approximation fails. It is proposed that the advantage set be replaced by short tie-breaker sets in tournament matches.

3 - Analyzing Tennis Scoring Systems: From the Origins to Today

Tristan Barnett, School of Mathematics and Statistics, University of South Australia, 1/11 Findon St, Hawthorn, 3122, Melbourne, Victoria, Australia, strategicgames@hotmail.com

This paper investigates tennis scoring systems that have been used throughout history — from Royal Tennis in 1490 to the most recent change to doubles Lawn Tennis in 2006. By identifying how the game has changed (such as technology in equipment) this helps to establish "reasonable' scoring systems that could be used for today. Based on this information and obtaining mathematical results of scoring systems, recommendations are given for men's and women's singles and doubles events. Actual matches are given to demonstrate why changes in many scoring systems are necessary.

■ FB-06

Friday, 13:15-14:45
Meeting Room 105

Logistics

Stream: Transportation

Invited session

Chair: *Said Salhi*, Kent Business School, University of Kent, Centre for Heuristic Optimisation,, Canterbury, Kent, CT2 7PE, United Kingdom, s.salhi@kent.ac.uk

1 - Pricing for Production and Delivery Flexibility

Martin Savelsbergh, CSIRO, NSW 1670, North Ryde, Australia, Martin.Savelsbergh@csiro.au, *George Nemhauser*, *Yaxian Li*

Adjusting prices to influence demand to increase revenue has become common practice. We investigate adjusting prices to influence demand to reduce cost. We consider offering price discounts in return for delivery flexibility in a single-item uncapacitated lot-sizing context. Even though the resulting optimization problem has a nonlinear objective function it can still be solved in polynomial time under Wagner-Whitin cost conditions. Furthermore, we report results of a computational study analyzing the benefits of offering price discounts in return for delivery flexibility in various settings.

2 - Metaheuristics for Order Batching and Batch Sequencing in Manual Order Picking Systems

Sebastian Henn, Faculty of Economics and Management, Otto-von-Guericke University Magdeburg, Universitätsplatz 2, 39106, Magdeburg, Germany, sebastian.henn@ovgu.de

Order picking deals with the retrieval of articles from their storage locations in order to satisfy customer requests. Major issues in manual picking systems are the transformation of customer orders into picking orders and the determination of picking tours. In practice, customer orders have to be completed by certain due dates. The observance of these dates is influenced by the composition of the batches, their tour lengths and by the sequence according to which the batches are processed. It is presented, how metaheuristics can be used to minimize the tardiness for given customer orders.

■ FB-07

Friday, 13:15-14:45
Meeting Room 106

Healthcare Systems and Queues

Stream: Applied Probability

Invited session

Chair: *Ilze Ziedins*, University of Auckland, 1010, Auckland, New Zealand, i.ziedins@auckland.ac.nz

1 - Some Observations Concerning Priority Queues

Mark Fackrell, Mathematics and Statistics, The University of Melbourne, 3010, Melbourne, Victoria, Australia, fackrell@unimelb.edu.au

We consider a single server queue with two types of customers, each type arriving according to a Poisson process, with possibly different rates. One type of customer is labelled "high priority", the other "low priority". Once a customer arrives to the queue they begin accumulating priority at a fixed rate, depending on their priority class. We present some theoretical and simulation results for the nonpreemptive priority queue mentioned above, and extend the analysis to queues with more than two priority classes of customers.

2 - A New Paradigm for Priority Patient Selection

David Stanford, Dept. of Statistical & Actuarial Sciences, The University of Western Ontario, WSC 262, 1151 Richmond Street N., N6A 5B7, London, Ontario, Canada, stanford@stats.uwo.ca, *Peter Taylor*, *Ilze Ziedins*

In many health care systems: 1) Key Performance Indicators (KPIs) specify the fraction of patients needing to be seen by some key time point. 2) Patient classes present themselves for care in a fashion that is totally independent of the KPIs. There is no reason to expect the resulting system performance will adhere to the specified KPIs. The present work presents a new paradigm for priority assignment that enables one to fine-tune the system in order to achieve the delay targets, assuming sufficient capacity exists for at least one such arrangement.

3 - Modelling Patient Flow through a Cardio-vascular Intensive Care Unit

Ilze Ziedins, University of Auckland, 1010, Auckland, New Zealand, i.ziedins@auckland.ac.nz

We describe a simulation model of an intensive care unit, and an associated optimization routine, that were developed for the Cardiovascular Intensive Care Unit at Auckland City Hospital. Acute patients arrive as a time varying Poisson process, while elective patients are modelled as deterministic arrivals. Lengths of stay are drawn from the empirical distributions for different types of patients. The model has been used to determine the number of beds that are needed in the unit, and to explore the benefits of flexible rostering.

■ FB-08

Friday, 13:15-14:45
Meeting Room 107

Natural Resource Management

Stream: Dynamic Programming

Invited session

Chair: *Julia Piantadosi*, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, Mawson Lakes Boulevard, Mawson Lakes, 5095, Adelaide, South Australia, julia.piantadosi@unisa.edu.au

1 - Time Series Analysis of Daily Rainfall

John Boland, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd., 5095, Mawson Lakes, South Australia, Australia, john.boland@unisa.edu.au

How correlated is daily rainfall? It is common to model daily rainfall totals as a Markov Chain. However, we conjecture that dependence at longer time scales, typically of the order of one week, can be important. Standard procedures do not capture this longer range dependence. We show the use of multiple regression and principal component analysis in this problem.

2 - Effective Decision Making Polices for Multi-reservoir Systems

Sara Browning, Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, Mawson Lakes, 5095, Adelaide, SA, Australia, sara.browning@mymail.unisa.edu.au

We are interested in developing more effective decision making polices for multi-reservoir systems using a variety of mathematical processes such as stochastic dynamic programming (SDP) and decomposition. We have developed an SDP formulation for the major storage areas of the Murray-Darling basin using a decomposition procedure which compares favourably to SDP solutions of the whole system. By incorporating methods of risk management we aim to develop an efficient and comprehensible model to determine economic water management policies whilst avoiding environmental damage to the water system.

3 - Mathematical Models for Management of Water Supply and Distribution

Julia Piantadosi, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, Mawson Lakes Boulevard, Mawson Lakes, 5095, Adelaide, South Australia, julia.piantadosi@unisa.edu.au

For a given (stochastic) level of supply it is important to manage water distribution in an optimal and sustainable way. We discuss applications of stochastic dynamic programming (SDP) using Conditional Value-at-Risk (CVaR) rather than Expected Monetary Value as an objective. It may be preferable to minimize environmental impact when untoward events occur rather than maximizing financial returns. By valuation of environmental assets one may quantify CVaR and hence SDP can be used to select a risk-averse policy. By adjusting key parameters we can investigate a range of climate-change scenarios.

■ FB-09

Friday, 13:15-14:45
Meeting Room 108

Data Mining

Stream: Contributed Talks

Contributed session

Chair: *Jung Ha Seo*, Global Production Technology Center, Samsung Electronics, 416, Maetan-3Dong, Yeongtong-Gu, 443-742, Suwon, Gyeonggi-Do, Korea, Republic Of, jung2010@korea.ac.kr

1 - Spam Filtering with Generalized Additive Neural Networks

Tiny Du Toit, Computer Science and Information Systems, North-West University, 11 Hoffman Street, 2531, Potchefstroom, North-West, South Africa, Tiny.DuToit@nwu.ac.za

The number of spam messages sent has increased significantly during the last decade. These unsolicited emails place a heavy burden on end users and email service providers. For this presentation a Generalized Additive Neural Network (GANN) is utilized to detect spam. GANNs have a number of strengths that makes them a suitable classifier of spam. An automated GANN construction algorithm is applied to a spam data set. Results obtained compare favourable to other classifiers found in the literature and can be interpreted by graphical methods.

2 - Spatial Data Mining in Municipal Content Management Systems

Ronny Weinkauf, Informatik und Kommunikationssysteme, Hochschule Merseburg, Geusaer Str., 06217, Merseburg, Germany, ronny.weinkauf@hs-merseburg.de

Target of this project is a recommendation system as a module of a content management system. It can be used to improve the usability of online platforms by offer content cross references. In a first step the enhanced content management system logs user and content interactions of municipal online platforms and storing it. Before the data is processed by common association algorithms, it will be enriched with geographical information and content categories. The association algorithms will produce rules which can be used to create automatically a list of recommendations.

3 - Design of Customized Promotions Supported by Data Mining Techniques Applied to a Loyalty Card Database

Vera Miguéis, DEIG, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal, vera.migueis@fe.up.pt, *Ana Camanho*, *João Cunha*

A good relationship between companies and customers is a critical factor of competitiveness. The design of customized promotions has gained prominence as a marketing tool to enforce loyalty relationships. In this context, we propose a method to support customer-oriented marketing policies, based on transaction records stored in a loyalty card database of a European retailing company used as case study. The data mining techniques used include cluster analysis and decision trees to segment customers and market basket analysis to identify the product subcategories usually purchased together.

4 - Time-invariant Feature Selection for Multivariate Time-series Data

Jung Ha Seo, Global Production Technology Center, Samsung Electronics, 416, Maetan-3Dong, Yeongtong-Gu, 443-742, Suwon, Gyeonggi-Do, Korea, Republic Of, jung2010@korea.ac.kr, *Cheong Sool Park*, *Sung-Shick Kim*, *Jun-Geol Baek*

For Multivariate time-series (MTS) data analysis, multivariate auto-regressive and moving average (ARMA) was applied. But multivariate ARMA is not appropriate to detect the time point to match with time-invariant feature. The time point of time-invariant feature can figure out faults or start of class-to-class change of classification problems in real-time process. So, we propose an algorithm for detecting time-invariant feature in MTS. The algorithm consists of feature generation using wavelets, extraction important feature vector from MTS and matching time point with time-invariant feature.

■ FB-10

Friday, 13:15-14:45
Meeting Room 111

Stochastic Optimisation

Stream: Contributed Talks

Contributed session

Chair: *Marlin Thomas*, Grad School of Engr & Mgmt, Air Force Institute of Technology, 2950 Hobson Way, 45433-7765, Wright-Paterson AFB, OH, United States, marlin.thomas@afit.edu

1 - Local Convergence of Interior Point Methods on Semi-definite Programs using a Path-Based Approach

Chee Khian Sim, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, macksim@inet.polyu.edu.hk

We first define a semi-definite program (SDP), and state a global convergence result using an interior point algorithm to solve it. Then we define certain paths which can be used to analyze the local convergence behavior of the algorithm when solving the SDP. Using the path-based approach, we give a sufficient condition for superlinear convergence of such an algorithm when solving an SDP. Based on this sufficient condition, we derive a condition for superlinear convergence on the class of semi-definite linear feasibility problems using the algorithm.

2 - Solving Two-stage Stochastic Quadratic Problems using the TNF Strategy

Eugenio Mijangos, Applied Mathematics and Statistics and Operations Research, UPV/EHU, P.O. Box 644 – Dept. Matematica Aplicada y E.I.O. (UPV/EHU), 48080, Bilbao, Spain, eugenio.mijangos@ehu.es

We present an algorithm to solve two-stage stochastic quadratic (TSSQ) problems. It is based on the Twin Node Family (TNF) concept involved in the Branch-and-Fix Coordination method. These problems have continuous and binary variables in the first stage and only continuous variables in the second stage. The objective function is quadratic and the constraints are linear. On the basis that the nonanticipativity constraints are fulfilled by TNF strategy, an algorithm to solve TSSQ problems is designed and implemented using Cplex to solve the QP subproblems. Numerical results are reported.

3 - Dynamic Choice Theory and Dynamic Consistency of Risk Measures

Jean-Philippe Chancelier, CERMICS Ecole des Ponts et Chaussées, Université Paris Est, 6 et 8 Av Blaise Pascal,Cite Descartes |, Champs sur Marne, 77455, Marne La vallee cedex 02, France, jpc@cermics.enpc.fr

In a seminal article Kreps and Porteus study three axioms on preferences and show that these axioms are equivalent to the existence of a utility function. They also study, in a dynamic choice framework, how to tie together preferences at different times by giving a temporal consistency axiom. They derive from the consistency axiom a representation theorem for dynamic utility functions. We make links between their original work and temporal consistency axioms found in risk measure theory and to derive the representation for dynamic risk measures.

4 - Data Driven versus Structure Driven Markov Chain Modeling

Marlin Thomas, Grad School of Engr & Mgmt, Air Force Institute of Technology, 2950 Hobson Way, 45433-7765,

Wright-Paterson AFB, OH, United States, marlin.thomas@afit.edu

Markov chains are fundamental in modeling operational systems due to the rational appeal and computational convenience gained by the Markov property. Under certain lumpability conditions the state space of a Markov chain can be partitioned into selected sets of states to form a smaller chain that retains the Markov property. This can simplify computations and sometimes provide desirable structural properties such as special subclasses of states that are peculiar to manpower planning models, selected DNA markers, and supply chain networks. Methods exist for examining alternative lumping options for given transition probabilities but identifying these alternatives can be quite difficult. With data however, one can postulate desired partitions and examine their statistical validity using standard inference procedures. The procedure for applying this method will be summarized along with examples.

■ FB-11

Friday, 13:15-14:45
Meeting Room 112

Network Design

Stream: Integer Programming
Invited session

Chair: *Haifei Yu*, Department of Management Science and Engineering, Northeastern University, No.11, Lane 3, Wen Hua Road, He Ping District, 110819, Shenyang, Liaoning, China, yuhaifei@gmail.com

1 - Solving a Network Flow Model using an Extended Tree Knapsack Approach

Hennie Kruger, School of Computer, Statistical and Mathematical Sciences, North-West University, Private Bag X6001, 2520, Potchefstroom, South Africa, Hennie.Kruger@nwu.ac.za, *Giel Hattingh*, *Tumo Baitshenyetsi*

There are many practical decision problems that fall into the category of network flow problems and numerous examples of applications can be found in areas such as telecommunications, logistics, engineering, computer science etc. In this paper, the feasibility of representing a network flow model in a tree network model and subsequently solving it using an extended tree knapsack approach is investigated. To compare and validate the proposed technique, a specific case study (an oil pipeline design problem) was chosen from the literature that can be used as a basis for the research project.

2 - Single Allocation Problem in Hub-and-Spoke Networks on 2D Plane

Ryuta Ando, Faculty of Science and Engineering, Department of Information and System Engineering, Chuo University, Kasuga, Bunkyo-ku,, 112-8551, Tokyo, Japan, r.ando.1201+lab@gmail.com, *Tomomi Matsui*

Hub-and-spoke network arises in the airline industry and postal delivery systems. The hub-and-spoke structure is based on the situation when some nodes, called non-hub nodes, can interact only via a set of completely interconnected nodes, called hub nodes. We consider a single allocation problem defined by nodes on 2-dimensional plane, which allocates each non-hub node to one of hub nodes, and minimizes the total transportation cost. We formulate the problem to a mixed integer programming problem and propose 1.6367-approximation algorithm based on randomized rounding technique.

3 - Optimizing the Deployment of a Multilevel Optical FTTH Network

Faye Alain, CEDRIC - ENSIIE, 91025, Evry, France, alain.faye@ensiie.fr, *Matthieu Chardy*, *Marie-Christine Costa*, *Mathieu Trampont*

Due to the emergence of bandwidth-requiring services, telecommunication operators are being compelled to renew their fix access network, most of them favoring the Fiber To The Home (FTTH) technology. This presentation focuses on the optimization of FTTH deployment, which is of prime importance due to the economic stakes. First we propose a mixed integer formulation for this decision problem. Then, valid inequalities and problem size reduction schemes are presented. Finally efficiency of solving approaches is assessed through extensive numerical tests performed on Orange real-life data.

4 - Optimization of Tree-structured Gas Distribution Network using Ant Colony Optimization: A Case Study

Amir Mohajeri, Industrial Engineering, Mazandaran University of Science and Technology, Tabarsi Street, 4716698563, Babol, Mazandaran, Iran, Islamic Republic Of, mohajeri.amir@gmail.com, *Iraj Mahdavi*, *Nezam Mahdavi-Amiri*

Here, a mixed integer programming model is formulated to minimize the total cost in the gas network. The aim is to optimize pipe diameter sizes so that the location-allocation cost is minimized. We apply the Minimum Spanning Tree technique to obtain a network with no cycles, spanning all the nodes. The problem being NP- hard, we propose an ant colony optimization algorithm and compare its performance with an exact method. A case study in Mazandaran gas company in Iran is conducted to illustrate the validity and effectiveness of the proposed model and the ant colony algorithm.

■ FB-12

Friday, 13:15-14:45
Meeting Room 205

Robust Optimization, Planning and Control

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Christian Gahm*, Chair Of Business Administration, Production & Supply Chain Management, Augsburg University, Universitätsstraße 16, 86159, Augsburg, Germany, christian.gahm@wiwi.uni-augsburg.de

1 - A Robust Optimization Approach to the Optimization of Airline Employee Scheduling

Yi Gao, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, PO Box 218, 3122, Hawthorn, Victoria, Australia, ygao@swin.edu.au

Successful manpower scheduling is vital for airport operations. Stochastic flight delays make airline employees scheduling challenging. The study aims to mitigate the impact of flight delays. With the simulated manpower demand distribution as inputs, the study used mixed integer programming and robust optimization to generate working schedules for the employees. The comparison between the robust scheduling model proposed in this study and the traditional model used by a major US airline suggested that the robust model saved more on the overall cost, and had less manpower demand violations.

2 - Using Supervised Learning to Improve Monte Carlo Integral Estimation

Brendan Tracey, Aeronautics and Astronautics, Stanford University, Durand Building, 496 Lomita Mall, 94305, Stanford, CA, United States, btracey@stanford.edu, *David Wolpert*, *Juan Alonso*

In uncertainty quantification and robust optimization calculating expected values is important. We present Stacked Monte Carlo (StackMC), a new method for post-processing a given set of any Monte-Carlo-generated samples (simple sampling, importance sampling, etc.) to improve the integral estimate, and in theory StackMC reduces variance without adding bias. We present a set of experiments confirming that the StackMC estimate of an integral is more accurate than both the associated pre-processing Monte Carlo estimate and an estimate based on a functional fit to the MC samples.

3 - Robust Models for Dynamic Multilevel Capacitated Facility Location

Marina Gebhard, Chair of Business Administration and Logistics, University Erlangen-Nuremberg, Lange Gasse 20, 90403, Nürnberg, Germany, marina.gebhard@wiso.uni-erlangen.de, *Vincenzo De Rosa*, *Jens Wollenweber*

We study a strategic facility location problem for distribution systems, where demand is served by a network of multiple supply stages. We show a new formulation for the robust multi-level capacitated facility location model that minimizes the expectation of the relative regrets over a multi-period planning horizon. Uncertainty in future demand and transportation costs is modeled by a set of scenarios. We compare our robust model to deterministic and alpha-reliable mean-excess model formulations and analyze the results for differences in total cost, sites, robustness and effectiveness.

4 - A Robust Planning Approach for Final Assembly in Special Purpose Machinery

Christian Gahm, Chair Of Business Administration, Production & Supply Chain Management, Augsburg University, Universitätsstraße 16, 86159, Augsburg, Germany, christian.gahm@wiwi.uni-augsburg.de, *Bastian Dünnwald*

Planning the final assembly of special purpose machinery is marked by high uncertainty. Against this background we developed an integrated optimization-simulation planning approach calculating a robust production plan, which minimizes lead times (WIP) and assures deadlines. The approach comprises a planning method that considers uncertainty by correction factors and an algorithm to solve the hybrid-flow-shop problem with variable-intensity and preemptive tasks. The implemented DSS focuses usability as well as adaptability and its application in an aerospace company shows impressive results.

■ FB-13

Friday, 13:15-14:45
Meeting Room 206

Mathematical Programming IV

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Xiaoqi Yang*, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, mayangxq@polyu.edu.hk

Chair: *Regina Burachik*, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, 5095, Adelaide, South Australia, Australia, regina.burachik@unisa.edu.au

1 - Continued Iterations on Interior Point Methods

Aurelio Oliveira, Computational & Applied Mathematics, State University Of Campinas, DMA IMECC Unicamp, C. P. 6065, 13081-970, Campinas, SP, Brazil, aurelio@ime.unicamp.br, *Lilian Berti*

The search directions on interior point methods are projected along the blocking constraint in order to continue the iteration. The process can be repeated while the projected direction is a good one in some measure. Since the such direction is as easy to compute as the corrector one, the approach can contribute to speed up convergence by reducing the total number of iterations. Numerical experiments show that the approach is promising when applied at the last interior point methods iterations.

2 - Implementation of a block-decomposition algorithm for solving large-scale conic semidefinite programming problems

Camilo Ortiz, School of Industrial & Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, NW, 30332-0205, Atlanta, Georgia, United States, camiort@gatech.edu, *Renato D.C. Monteiro*, *Benar F. Svaiter*

We consider block-decomposition first-order methods for solving large-scale conic semidefinite programming problems. Several ingredients are introduced to speed-up the method in its pure form such as: an aggressive choice of step-size for performing the extragradient step; and the use of scaled inner products in the primal and dual spaces. Finally, we present computational results showing that our method outperforms the two most competitive codes for large-scale semidefinite programs, namely: the boundary point method by Povh et al. and the Newton-CG augmented Lagrangian method by Zhao et al.

3 - On a Polynomial Merit Function for Interior Point Methods

Luiz Rafael Santos, Computational & Applied Mathematics, University of Campinas, Rua Sérgio Buarque de Holanda, 651, Cidade Universitária, 13083-859, Campinas, São Paulo, Brazil, lrsantos@ime.unicamp.br, *Fernado Villas-Bôas*, *Aurelio Oliveira*, *Clovis Perin*

Predictor-corrector type interior point methods are largely used to solve linear programs. In this context, we develop a polynomial merit function that arises from predicting the next residue of each iterate and that depends on three variables: a centralizer weight, a corrector weight, and a step size. We also generalize Gondzio's symmetric neighborhood, and the merit function is subjected to this neighborhood. A constrained global optimization problem results from this method and its solution leads to a good direction. Numerical experiments and comparisons to PCx are performed.

4 - Semi-infinite Program with Infinitely Many Conic Constraints: Optimality Condition and Globally Convergent Algorithm

Shunsuke Hayashi, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp, *Takayuki Okuno*, *Masao Fukushima*

We focus on the semi-infinite conic program (SICP), which is to minimize a convex function subject to infinitely many conic constraints. We show that, under Robinson's constraint qualification, an optimum of the SICP satisfies the KKT conditions that can be represented only with a finite subset of the conic constraints. We also introduce an exchange type algorithm combined with a regularization technique, and show that it has global convergence. We also give some numerical results to see the efficiency of the proposed algorithm.

■ FB-14

Friday, 13:15-14:45
Meeting Room 207

Optimization Modeling and Equilibrium Problems II

Stream: Continuous and Non-Smooth Optimization

Invited session

Chair: *Larry LeBlanc*, Owen Graduate School of Management, Vanderbilt University, 401 21st Avenue South, 37203, Nashville, Tn, United States, larry.leblanc@owen.vanderbilt.edu

Chair: *Dominik Dorsch*, Dept. Mathematics, RWTH Aachen University, Templergraben 55, 52056, Aachen, NRW, Germany, dorsch@mathc.rwth-aachen.de

1 - Implementing Optimization Models: Organization Capability and Analytical Needs

Larry LeBlanc, Owen Graduate School of Management, Vanderbilt University, 401 21st Avenue South, 37203, Nashville, Tn, United States, larry.leblanc@owen.vanderbilt.edu, *Thomas Grossman*

We explain why recent technological advances have increased the value optimization for analytics and present approaches for bringing optimization to bear. These are applying optimization to a traditional manually-constructed spreadsheet, using Excel's built-in VBA prior to applying optimization, and a mathematical approach using Excel for input/output to special-purpose algebraic modeling language. We explain the relative strengths and weaknesses of each approach and guide analysts in selecting the approach that takes into consideration both organizational capability and analytical needs.

2 - Integrated Framework for Fuel Reduction and Fire Suppression Resource Allocation

James Minas, Mathematical and Geospatial Sciences Department, RMIT University, GPO Box 2476V, 3001, Melbourne, VIC, Australia, james.minas@rmit.edu.au, *John Hearne*

Wildfire-related destruction is a global problem that appears to be worsening. Wildfire management involves a complex mix of interrelated components including fuel management, fire weather forecasting, fire behaviour modelling, values-at-risk determination and fire suppression. We propose a mathematical programming model that provides an integrated risk-based framework for fuel management and fire suppression resource allocation.

3 - An Intelligent Model Using Excel Spread Sheet in a Manufacturing System

Kanthen K Harikrishnan, School of Applied Mathematics Faculty of Enggineering, Nottingham University Malaysia Campus, Jalan Broga,, 43500, Semenyih, Selangor, Malaysia, Harikrishnan.KK@nottingham.edu.my, *Ho Kok Hoe*, *Kanesan Muthusamy*

The research integrates the combination of mathematical modelling and intelligent modelling concept to represent a manufacturing system in the Excel spread sheet interface. The mathematical modelling uses two types of approaches, which use IE variables and the development of mathematical theorem using deduction methodology from the dynamic manufacturing system. Mathematical language and mathematical reasoning technique through programming in spread sheet are used to build an intelligent modelling system which optimises targeted inventory level in order to response without human involvement.

4 - On Structure and Computation of Generalized Nash Equilibria

Dominik Dorsch, Dept. Mathematics, RWTH Aachen University, Templergraben 55, 52056, Aachen, NRW, Germany, dorsch@mathc.rwth-aachen.de, *Hubertus Th. Jongen*, *Vladimir Shikhman*

In GNEP the players may share common constraints. Hence, the appearance of Fritz-John points which are not Karush-Kuhn-Tucker points cannot be avoided. FJ points are characterized as solutions of an underdetermined nonsmooth system of equations. For finding solutions a new nonsmooth projection method is introduced. It converges under the strong full-rank assumption and semismoothness. Applying this to GNEP, latter is satisfied for generic data functions. Linear convergence is proven. Quadradic convergence cannot be expected due to the nontrivial geometry of the solution sets.

■ FB-15

Friday, 13:15-14:45
Meeting Room 208

Fuzzy Sets

Stream: Fuzzy Logic
Invited session

Chair: *Beloslav Riecan*, Department of Mathematics, Matej Bel University, Tajovskeho 40, 974 01, Banska Bystrica, Slovakia, riecan@fpv.umb.sk

1 - On the Robustness of Interval Fuzzy Matrices

Ján Plavka, Department of Mathematics and Theoretical Informatics, Technical University in Kosice, Nemcovej 32, 04001, Kosice, Slovakia, Jan.Plavka@tuke.sk, *Martin Gavalec*

Robust interval matrices over (max,min)-algebra (fuzzy matrices) are studied and robustness properties are proved, similar to those of classical fuzzy matrices. It is shown that a robustness of an interval fuzzy matrix is well-defined using the definition of classical robustness. Characterization of robust interval fuzzy matrices is presented and an algorithm for checking the robustness of a given fuzzy matrix is described.

2 - Interval Eigenvectors in Fuzzy Algebra

Martin Gavalec, Department of Information Technologies, University of Hradec Kralove, Rokitanského 62, 50003, Hradec Kralove, Czech Republic, martin.gavalec@uhk.cz, *Ján Plavka*

The eigenproblem for matrices and vectors with interval coefficients in max-min (fuzzy) algebra is studied. A classification of interval eigen- vectors is introduced and six types of interval eigenvectors are considered. Two different approaches to the problem are presented and characterization of all six types is given. Relations between the eigenvector types in the form of implications and counter-examples are described.

3 - Fuzziness and Randomness in an Optimization Framework

Monga K Luhandjula, Decision Sciences, University of South Africa, Muckleneuk Campus, 0003, Pretoria, Gauteng, South Africa, luhanmk@unisa.ac.za

In this talk, we focus on three chosen models in the rich array of situations where fuzziness and randomness are under one roof in an optimization setting.Suitable approximate surrogates are crafted by exploiting to a great extent uncertainty principles. Numerical examples are also provided for the sake of illustration.

■ FB-17

Friday, 13:15-14:45
Meeting Room 214

Emerging Aspects in Finance, Supply Chains and Environment

Stream: Finance
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Tatiana Bouzdine Chameeva*, OM and IS, BEM Bordeaux Management School, 680 Cours de la Liberation, 33405, Talence, France, tatiana.chameeva@bem.edu

1 - Enhancing the Sustainability of Supply Chain in Crisis

Soni Umang, Industrial Engineering(Mechanical Engineering Department), Indian Institute of Technology Delhi, I Hauz Khas, 110 016, New Delhi, Delhi, India, mez108087@mech.iitd.ernet.in, *Vipul Jain*

Supply chains are under unprecedented pressure during recovery from crisis - driven by financial instability, globalization and demanding customers. In order to make the supply chains sustainable, a new framework addressing "Fit Supply Chain" is proposed in this paper, which will tune-up the business organizations with the global competition and facilitates them to accomplish economic sustainability. This framework incorporates the concepts of leanness, agility, information management and the risk involved. This framework is also validated using case studies for its better analysis

2 - Investing in Sustainable Supply Chain with Uncertain Remanufacturing Costs and Environmental Regulation

Mei-Ting Tsai, Department of Business Administration, National Chung Hsing University, 250, Kuo Kuang Road, 402, Taichung, Taiwan, mtsai@dragon.nchu.edu.tw, *Yang Cheng Shih*

Remanufacturing is a means of achieving environmental sustainability. However, uncertainties make remanufacturing investment decision more complex. This paper develops an investment model incorporating two uncertain factors: the uncertain remanufacturing cost which depends on the conditions of recycled products and is modeled as a Geometric Brownian Motion, and the uncertain environmental regulation which is modeled as a jump process with random jump size and arrival time. A numerical example is conducted to illustrate the impacts of the two uncertainties on business decision making.

3 - Two-period Pricing and Ordering Policy with Single-supplier-single-retailer and Coordination under Price Dependent Stochastic Demand

Tatiana Bouzdine Chameeva, OM and IS, BEM Bordeaux Management School, 680 Cours de la Liberation, 33405, Talence, France, tatiana.chameeva@bem.edu, *Tulika Chakraborty*, *Satyaveer S. Chauhan*

A two-period SC model is developed for the pricing and ordering policies. The customer demand faced by the retailer is assumed to be price sensitive and stochastic. We construct Model I (double ordering policy) where ordering products from the retailer takes place twice during a complete cycle depending on the customer demand size, and Model II (single ordering policy) with replenishment done at the beginning of the cycle, which is extended by considering return policy. A comparison between models is carried out analytically. Numerical experiments draw key insights for managerial implications

■ FB-18

Friday, 13:15-14:45
Meeting Room 215

DEA Theoretical Development - 3

Stream: Data Envelopment Analysis
Invited session

Chair: *Vahid Behbood*, Information Technology, University of Technology Sydney, 2007, Sydney, NSW, Australia, vbehbood@it.uts.edu.au

1 - Alpha-returns to Scale in Production Technology with Variable Returns to Scale

Sara Zeidani, Mathematics Dept., Science and Research Branch, Islamic Azad University, Tehran-Sadeghieh-Bolvar Ferdos-Shirpur Street- Unit 20, 1477893855, Tehran, Iran, Islamic Republic Of, sara.zeidani@gmail.com, *Mohsen Rostamy-Malkhalifeh*, *Farhad Hosseinzadeh Lotfi*

In this paper, we discuss about strictly increasing and decreasing returns to scale then homogeneous production technology and its relationship with alpha-returns to scale was introduced. The definition of alpha-returns to scale with variable returns to scale has been evaluated (BCC model). After that new assumption and theorems are proposed and proved.

2 - A New Mixed Integer Linear Model for Technology Selection

Ali Asghar Foroughi, Mathematics Dept., Qom University, 3716146611, Qom, Iran, Islamic Republic Of, aa_foroughi@yahoo.com

In many applications of data envelopment analysis, it is desirable to select the best decision making units. In this paper a new mixed integer linear model is proposed to provide a single efficient decision making unit for technology selection. The relation between the approach and some existing methods are discussed, and it is shown that the proposed approach can overcome some drawbacks of the other methods. The contents of the paper are illustrated by several numerical examples

3 - Cost Efficiency by Data Envelopment Analysis with Nonlinear Virtual Input and Output

Razieh Mehrjoo, Science and Research Branch, Islamic Azad University, 1477893855, Tehran, Iran, Islamic Republic Of, mikhakf@yahoo.com, *Gholam Reza Jahanshahloo*, *Mohsen Rostamy-Malkhalifeh*

A method for measuring the efficiency of decision making units (DMUs) is Data Envelopment Analysis (DEA). An underlying assumption in DEA is that the weights coupled with the ratio scales of the inputs and outputs imply linear value functions. In this paper we represent a model to measure cost efficiency for these models. To this end we give minimal cost modelfor nonlinear virtual outputs and inputs in a piece-wise linear fashion. The applicability of the proposed model is in the some real evaluating programs that are with nonlinear virtual outputs and inputs.

4 - Efficiency Prediction in Decision Making Units Merger using Data Envelopment Analysis and Neural Network

Vahid Behbood, Information Technology, University of Technology Sydney, 2007, Sydney, NSW, Australia, vbehbood@it.uts.edu.au, *Jie Lu*

Overall efficiency of the system is one of the most important factors which determines the success of merging Decision Making Units (DMUs) in the system. In a successful merger, the inputs of DMUs are mixed together to produce enhanced outputs which improve the system efficiency. Hence, prediction the system efficiency prior to merger can significantly support policy makers to decide and judge appropriately. This study develops an approach to predict the system efficiency which will be changed as result of merger. The proposed approach applies Data Envelopment Analysis (DEA) to compute the efficiency of DMUs in the system based on their inputs and outputs. Afterward the Neural Network is used to learn the relationship between the inputs, outputs and efficiency of DMUs and consequently predicts the overall system efficiency. The prediction approach is validated using commercial banks data and the empirical results indicate its outstanding performance and its ability as an effective and accurate approach for finance industry.

■ FB-19

Friday, 13:15-14:45
Meeting Room 216

Telecommunications

Stream: Network Optimisation and Telecommunications

Contributed session

Chair: *Raymundo Oliveira*, Mathematics Institute, Federal University of Rio de Janeiro, Rua Leopoldo Miguez, 144 apt 901, Copacabana, 22060-020, Rio de Janeiro, RJ, Brazil, raymundo.oliveira2010@gmail.com

1 - Optimization Algorithms for the Automatic Planning of Hybrid Access Telecommunication Networks

Anderson Parreira, DSSO, Fund. CPqD, 13086902, Campinas, SP, Brazil, parreira@cpqd.com.br, *Sandro Gatti*, *Guilherme Telles*, *Rivael Penze*

Network access planning can be stated as the problem of finding minimal cost sets of equipments and cables connecting offer and demand points in order to provide services (video, data and voice). As literature shows, this kind of problems is NP-hard. Our approach combines shortest paths algorithms and heuristics in graphs and phylogenetic tree reconstruction to create a network. To evaluate the algorithm we performed a set of experiments on real infrastructure data. Data sets are georeferenced and offer and demand points include bandwidth. The experiments have shown that the algorithm builds good network concerning cost and also visual layout.

2 - Covering a Region in Telecommunication

Raymundo Oliveira, Mathematics Institute, Federal University of Rio de Janeiro, Rua Leopoldo Miguez, 144 apt 901, Copacabana, 22060-020, Rio de Janeiro, RJ, Brazil, raymundo.oliveira2010@gmail.com, *Angela Goncalvez*

We consider the problem of covering a region with circles. We seek to position m antennas in a flat region with n locations (X,Y) to be covered by the antennas. Each location will be covered by the nearest antenna. It is necessary to locate the m antennas in order to minimize the longest distance antenna-location. This reduces to a MinMaxMin problem. The paper presents a new methodology, using Nelder-Mead method, which solves a nonlinear problem in a space with dimensions 2m. A set of computational results illustrate its performance.

3 - Line Graph Tranformations for Minimum Cost Euler Tour with Movement Prohibition

Marcos José Negreiros, MESTRADO PROFISSIONAL EM COMPUTAÇÃO, UNIVERSIDADE ESTADUAL DO CEARÁ, Av Paranjana, 1700 - Campus do Itaperi, 60740-000, Fortaleza, CEARÁ, Brazil, negreiro@graphvs.com.br, *Augusto Palhano*

This work investigates a new procedure based on Line Graph Transformation, for solving the problem of performing Euler Tour with movement prohibitions. Previous literature consider the problem as a step forward to design comfortable Euler tours for garbage collection vehicles by using heuristics. We show new exact and metaheuristics methods for this problem and report results obtained from real life garbage collection networks.

■ FB-20

Friday, 13:15-14:45
Meeting Room 217

Multi-criteria Decision Analysis

Stream: Contributed Talks

Contributed session

Chair: *Pekka Leskinen*, Research Programme for Production and Consumption, Finnish Environment Institute, Joensuu, Finland, pekka.leskinen@ymparisto.fi

1 - An Integrated Mathematical Optimisation Framework for Suppliers Ranking and Demand Allocation

Shabnam Mojtahedzadeh Sarjami, Mathematics and Statistics, Curtin University of Technology, Kent St, Bentley WA, 6102, Perth, Western Australia, Australia, Shabnam.mojtahed@postgrad.curtin.edu.au, *Louis Caccetta*

The supplier selection problem is to determine a portfolio of suppliers from a set of candidates that best meets the requirement of an organisation. In this paper an integrated mathematical optimisation framework is developed to effectively rank the suppliers and allocate the demand. This framework ranks the suppliers under conflicting criteria with often varying criteria importance. Then, through an optimisation model the demand is allocated to the ranked suppliers.

2 - Integration of Multi-criteria Decision Analysis and Life-cycle Assessment to Measure Environmental Impacts of Biomass Production

Tanja Myllyviita, Finnish environment institute, P.O.Box 111, FI-80101, Joensuu, Finland, tanja.myllyviita@joensuu.fi, *Anne Holma*, *Riina Antikainen*, *Katja Lähtinen*, *Pekka Leskinen*

Life-cycle assessment (LCA) evaluates environmental impacts of a product from processing of raw-material to disposal with environmental impact categories. MCDA was applied to assess the importance of different LCA impact categories in biomass production. Experts valuated impact categories with a MCDA-application. The most important impact categories were natural land-use and climate change. Also biodiversity was considered important. The results indicate that MCDA can provide suitable tools for the weighting phase in LCA, which enables transforming the environmental impacts into one number.

3 - On Elicitation Techniques of Near-consistent Pairwise Comparison Matrices

Jozsef Temesi, Operations Research and Actuarial Studies, Corvinus University of Budapest, Fovam ter 8, 1093, Budapest, Hungary, jozsef.temesi@uni-corvinus.hu

Pairwise comparison matrices (PCMs) are frequently used in various multi-criteria decision-making methods. One of the most important properties of a PCM is consistency. My presentation will define the near-consistency of the PCM, and the error-free property of the decision-maker. Based on these definitions several methods can be generated to obtain the elements of a pairwise comparison matrix. Different elicitation techniques will be introduced, and — in case of non-consistent matrices — adjustment methods will be analyzed for both informed and uninformed decision-makers.

4 - An Analysis of the Major Drivers of Stock Market Prices-Case Study for the Zimbabwe Stock Exchange (2007-2008)

Kelvin T Chirenje, Applied Maths, National University of Science and Technology, 10 Rukumbati Rd, Zengeza 3, +263, Chitungwiza, Harare, Zimbabwe, kchirenje@gmail.com

This research is aimed at assessing the main factors that influenced the stock prices on the Zimbabwe Stock Exchange (ZSE) to be continuously bullish from 2007-2008, despite harsh economic conditions which prevailed in the country and explore the applicability of traditional theorist to the ZSE. Furthermore, the research will outline why the stock market was performing extraordinarily well in an economy down the drain with many corporations reporting subnormal profits and some shutting down

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■ FB-21

Friday, 13:15-14:45
Meeting Room 218

Stochastic Open Pit Mine Planning and Supply Chains

Stream: Mining Applications

Invited session

Chair: *Gary Froyland*, School of Mathematics and Statistics, University of New South Wales, 2052, Sydney, NSW, Australia, g.froyland@unsw.edu.au

1 - Open Pit Mine Planning with Uncertain Geology via Multi-stage Integer Stochastic Programming with Endogenous Uncertainty

Gary Froyland, School of Mathematics and Statistics, University of New South Wales, 2052, Sydney, NSW, Australia, g.froyland@unsw.edu.au, *Natashia Boland*, *Irina Dumitrescu*

Geological uncertainty is a major source of financial risk for mining projects. It is particularly difficult to handle as the timing of the resolution of the uncertainty is dependent upon earlier decisions made. We model the problem of NPV optimisation under geological uncertainty as a multi-stage integer stochastic programming under endogenous uncertainty. Our model allows mining and processing decisions to flexibly adapt over time, in response to observation of the geology of the material mined. We also discuss a number of model reductions to decrease computational effort.

2 - Dealing with Price Uncertainty in Mine Planning

Andrés Weintraub, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl, *Roger Wets*, *David Woodruff*, *Jean-Paul Watson*, *Rafael Epstein*, *Jaime Gacitua*

We consider the problem of uncertainty in future copper prices, reflected through scenarios with probabilites. Non-anticipativity constraints are imposed on the basic problem constraints. For larger problems solving the problem with the non-anticipativity constraints is very difficult computationally. We develop an approach for this problem based on Progressive Hedging, where the problem is decomposed by scenarios, and convergence to a feasible solution is attained through penalizing deviations from non-anticipativity. Positive results were obtained for an open pit mine problem.

3 - Effective Computational Models For Oil Refinery Operations

Juan Kuther, Maths and Stats, Curtin University, GPO BOX U1987, 6845, Perth, WA, Australia, juan.kok@postgrad.curtin.edu.au, *Louis Caccetta*

Petroleum refineries are very complex systems, giving rise to computationally difficult optimization models. Resolution of these problems is crucial for production planning and in particular in the evaluation and selection of crudes, feedstocks, products and processing options. These large-scale production planning models, which can are formulated as non-convex Mixed Integer Nonlinear Programming (MINLP) models, are very difficult to solve. Currently available tools are deficient and usually give rise to inconsistent predictions of refinery productivity and operation. Recent advances in a number of disciplines including computer science, mathematical programming, heuristics and complimentary disciplines like constraint programming and artificial intelligence motivate this research. These recent advances in technology will be utilised to formulate effective oil refinery production planning models.

4 - Collaborative Resource Constrained Scheduling : A Coal Industry Example

Anu Thomas, Industrial Engineering and Operations Research, IITB Monash Research Academy, IIT Bombay, Powai, 400076, Mumbai, MH, India, anuthomas@iitb.ac.in, *Gaurav Singh*, *Mohan Krishnamoorthy*, *Jayendran Venkateswaran*

We present a collaborative resource constrained scheduling problem motivated by the mining industry. In this model, there are several independent mines which have delivery jobs to be completed by certain due dates (ship arrival times). These jobs also require trains (of certain sizes) that are independently provided by a rail operator having a finite number of trains. We present MIP formulations, heuristic algorithms and computational results to compare centralised and decentralised decision making for minimising total weighted tardiness of all the jobs while maximising train utilisation.

Friday, 15:15-16:45

■ FC-01

Friday, 15:15-16:45
Plenary Hall 3

OR, Energy, and Africa

Stream: OR Applications in Energy
Invited session

Chair: *Caston Sigauke*, Statistics and Operations Research, University of Limpopo, Bag X1106, Sovenga, 0727, Polokwane, Limpopo, South Africa, csigauke@gmail.com

1 - Decision Support for Power Generator Maintenance Scheduling

Jan van Vuuren, Logistics, University of Stellenbosch, Private Bag X1, Matieland, 7602, Stellenbosch, Western Cape, South Africa, vuuren@sun.ac.za, *Bernard Schlunz*

Maintenance of power generating units has to be coordinated carefully within a power generating utility to ensure that power supply shortfalls do not occur due to too many units being out of service simultaneously. This maintenance scheduling problem is considered with scheduling objectives including cost minimisation and maintaining power generation safety margins (due to stochastic electricity demand), and with various practical constraints. A case study is included for the South African power generating utility, Eskom.

2 - Using Metaheuristic Modelling to Further Freight Transport Energy Management in South Africa

Tanya Visser, Industrial Engineering, Stellenbosch University, Privaatsak X1, Matieland, 7602, Stellenbosch, South Africa, tanyav@sun.ac.za

Transportation is a major sustainability engineering concern. The sector consumes vast amounts of non-renewable energy, expediting resource depletion and causing environmental harm. Improving sustainability within the sector is a daunting, highly complex and multi-faceted task. Planning authorities require decision support to enable decisions cognisant of all the intricacies surrounding the interaction between transport and energy management. This paper showcases how a purpose-built metaheuristic model aids in the formulation of freight transport energy management strategies for South Africa.

3 - Modeling Daily Peak Electricity Load Forecasting in South Africa using a Multivariate Non-parametric Regression Approach

Caston Sigauke, Statistics and Operations Research, University of Limpopo, Bag X1106, Sovenga, 0727, Polokwane, Limpopo, South Africa, csigauke@gmail.com, *Delson Chikobvu*

Accurate prediction of daily peak load demand is very important for decision makers in the energy sector. This helps in the determination of consistent and reliable supply schedules during peak periods. Accurate short term load forecasts enable effective load shifting between transmission substations, scheduling of startup times of peak stations, load flow analysis and power system security studies. A multivariate adaptive regression splines (MARS) modelling approach towards daily peak electricity load forecasting in South Africa is presented in this paper for the period 2000 to 2009. MARS is a non-parametric multivariate regression method which is used in high-dimensional problems with complex model structures, such as nonlinearities, interactions and missing data, in a straight forward manner and produces results which may easily be explained to management. The models developed in this paper consist of components that represent calendar and meteorological data. The performances of the models are evaluated by comparing them to a piecewise linear regression model. The results from the study show that the MARS models achieve better forecast accuracy.

■ FC-02

Friday, 15:15-16:45
Meeting Room 101

Scheduling

Stream: Scheduling
Contributed session

Chair: *Murari Lal Mittal*, Mechanical Engineering Department, Malaviya National Institute of Technology Jaipur, JLN Marg, 302017, Jaipur, Rajasthan, India, mlmittal.mnit@gmail.com

1 - Aircraft Rotation Problem: Is there a Problem?

Torsten Reiners, University of Hamburg, Institute of Information Systems, Von-Melle-Park 5, 20146, Hamburg, Germany, torsten.reiners@gmail.com, *Julia Pahl*

We survey the literature of airline scheduling regarding not only the isolated aircraft maintenance rotation problem, but also evaluate to what extend such (integrated) planning and scheduling problems can be solved to optimality especially regarding input data of real world problem sizes. In addition, we present an overview of algorithms and (meta-)heuristics.

2 - Cost Optimization: Case Studies from the Construction Industry

Miklos Hajdu, Department of Construction Management, Szent Istvan University Ybl Miklos Faculty, Budapest Thököly út 74, 1146, Budapest, Hungary, hajdu.miklos@ybl.szie.hu

Despite the fact that the official history of project management started with a cost optimization problem (Kelley & Walker 1958), these models have not become widespread in project management practice. In this paper the algorithms that operation research offers for project managers for project time-cost tradeoffs will be summarized. In addition, some case studies from the construction industry will be discussed, which — in our opinion — prove that cost optimization ought to be an essential part of project management practice.

3 - A New Weight Varying Scheme for Particle Swarm Optimization Algorithms

Murari Lal Mittal, Mechanical Engineering Department, Malaviya National Institute of Technology Jaipur, JLN Marg, 302017, Jaipur, Rajasthan, India, mlmittal.mnit@gmail.com, *Abhinav Mittal*

PSO is one of the recent metaheuristics successfully applied to a variety of OR problems. Inertia weight is an important parameter in PSO algorithms varied during iterations to effectively explore/exploit the search space. In most of the existing weight varying schemes it is either increased or decreased during successive iterations. In this paper we propose a scheme in which weight is increased form minimum to the maximum in half of the iterations and then decreased to the minimum in the rest half. The scheme is tested on instances of the resource constrained multiproject scheduling problem.

■ FC-03

Friday, 15:15-16:45
Meeting Room 102

AI and GameTheory

Stream: Contributed Talks
Contributed session

Chair: *Janny Leung*, Systems Engineering and Engineering Management Dept, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, jleung@se.cuhk.edu.hk

1 - Feature Extraction and Classification in Pattern Recognition and their Application in Economy

Pawel Blaszczyk, Institute of Mathematics, University of Silesia, Bankowa 14 Street, 40-007, Katowice, Poland, pblaszcz@math.us.edu.pl

Feature extraction and classification are the basic methods used to analyze and interpret economical data. The number of samples is often much smaller than the number of features. In this situation it makes impossible to estimate the classifier parameters properly and the classification results may be inadequate. In this case it is important to decrease the dimension of the feature space. This can be done by feature extraction. In this paper we present a new feature extraction method. Our method is an extension of the classical PLS algorithm. A new weighted separation criterions are applied.

2 - Proposal for a Strategic Planning for the Replacement of Products in Stores based on Sales Forecast

Maria Teresinha Arns Steiner, Production Engineering Dept., UFPR, R. Pe. Anchieta, 1231 - Ap. 31, 80730-000, Curitiba, Pr, Brazil, tere@ufpr.br, *Cassius Tadeu Scarpin*, *Pedro Steiner Neto*

This paper presents a proposal for strategic planning for the replacement of products in stores of a supermarket network. A quantitative method for forecasting time series is used for this, the Artificial Radial Basis Neural Networks (RBFs), and also a qualitative method to interpret the forecasting results and establish limits for each product stock for each store in the network.

3 - A Habitual Domain Approach to Coalition Formation in n-Person Games

Moussa Larbani, Business Administration, IIUM University, Jalan Gombak,, 53100, Kuala Lumpur, Kuala Lumpur, Malaysia, larbani61@hotmail.com, *Po-Lung Yu*

In this paper we present a new approach to n-person games based on Habitual Domain theory. The constructed game model captures the fact that the underlying changes in the psychological aspects and mind states of players over the arriving events are the key factors that determine the dynamic process of coalition formation.

4 - Game-Theoretic Models for Competition in Public Transit Services

Janny Leung, Systems Engineering and Engineering Management Dept, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, jleung@se.cuhk.edu.hk, *Eddie Chan*

We present game-theoretic models for investigating the competitive situation when several service providers offer public transit services, and study the impact on services offered to the public and the resultant ridership of the system. The competition among the operators can be modelled by a class of games called potential games. We discuss mathematical programmes that can be used to find the Nash equilibria. By analysing the equilibria solutions, we examine how different structures of the transit networks impact the services offered and the overall ridership of the system.

■ FC-05

Friday, 15:15-16:45
Meeting Room 104

Queuing and Simulation

Stream: Contributed Talks

Contributed session

Chair: *Michael Manitz*, Technology and Operations Management, Chair of Production and Supply Chain Management, University of Duisburg/Essen, Mercator School of Management, Lotharstr. 65, 47057, Duisburg, Germany, michael.manitz@uni-due.de

1 - The Cross-Entropy Method for Estimating Burr XII Parameters

Babak Abbasi, Mathematical and Geospatial Sciences, RMIT University, School of Mathematical and Geospatial Sciences, RMIT University, Melbourne, VIC, Australia, babak.abbasi@rmit.edu.au

This paper proposes a method in estimating parameters of Burr XII distribution which is widely used in practical applications such as lifetime data analysis. The Cross-Entropy (CE) method is developed in context of Maximum Likelihood Estimation (MLE) of Burr XII distribution for complete data or in presence of multiple censoring. A simulation study is conducted to assess the performance of the MLE via CE method for different parameter settings and sample sizes. The results are compared to other existing methods in both uncensored and censored situations.

2 - Efficient Procedures for Optimization via Simulation with Binary Variables

Shing Chih Tsai, Industrial and Information Management, National Cheng Kung University, No. 1, University Road,, Tainan, Taiwan, sctsai@mail.ncku.edu.tw

In the paper we propose a generic rapid screening procedure for zero-one optimization via simulation problem and then present the customized versions providing different statistical guarantees. Our optimization framework has several screening phases and one clean-up phase to select the best. Some strategies to construct the set of initial solutions and search for good solutions (in each screening phase) are also discussed. Experimental results are provided to compare the efficiency of our procedures with existing ones.

3 - Performance Evaluation of General Assembly/Disassembly Queueing Networks with Blocking

Michael Manitz, Technology and Operations Management, Chair of Production and Supply Chain Management, University of Duisburg/Essen, Mercator School of Management, Lotharstr. 65, 47057, Duisburg, Germany, michael.manitz@uni-due.de

In this presentation, A/D queueing networks with blocking, generally distributed service times, and synchronization constraints at assembly and disassembly stations are analyzed. A decomposition approach for the throughput and the variance of the inter-departure times is described. The subsystems are analyzed as G/G/1/N stopped-arrival queueing systems whose virtual arrival-process and service parameters are estimated via solving a system of so-called decomposition equations. The quality of the presented approximation procedure is tested against the results of various simulation experiments.

■ FC-06

Friday, 15:15-16:45
Meeting Room 105

Location and Facility Planning

Stream: Contributed Talks

Contributed session

Chair: *Tsutomu Suzuki*, Faculty of Systems and Information Engineering, University of Tsukuba, 1-1-1 Tennodai, 305 8573, Tsukuba, Ibaraki, Japan, tsutomu@risk.tsukuba.ac.jp

1 - Matching Warehouses with Auto Parts at a Motorcycle Assembler in Thailand

Sorawit Yaoyuenyong, Graduate School of Management and Innovation, King Mongkut's University of Technology Thonburi, Thailand, sorawit.yao@kmutt.ac.th, *Pakkanart Srimahasap*

When there is a new motorcycle model assembled at a plant, its engineers need to re-assign 8 different types of auto parts to 8 different warehouses in order to minimize the total daily distance in moving all parts. Parts are moved from 4 unloading locations outside the building to these warehouses, then to more than 100 locations inside assembly lines. Some parts are also moved among the warehouses. This problem formulation can be viewed as the Assignment Problem with a non-linear objective function. A computer program using Excel's Solver was successfully developed to solve this problem.

2 - A Comparison of Methods for Solving the Sensor Location Problem

Rodolfo Garcia-Flores, Mathematical and Information Sciences (CMIS), Commonwealth Scientific and Industrial Research Organisation (CSIRO), 71 Normanby Rd., Clayton, 3168, Melbourne, VIC, Australia, Rodolfo.Garcia-Flores@csiro.au, *Peter Toscas*, *Olena Gavriliouk*, *Geoff Robinson*

A problem that frequently arises in environmental surveillance is where to place a set of sensors in order to maximise collected information. In this article we compare two methods for solving this problem: a discrete approach based in the classical k-median location model, and a continuous approach based on the minimisation of the prediction error variance. Unlike conventional methods used by geo-statisticians like the Metropolis-Hastings algorithm, the methods proposed assume no prior knowledge of the spacial dependencies. We present an overview of both methods and a comparison of results.

3 - A Model for Dynamic Budget-constrained Capacitated Facility Location and Network Design Problem

Abdolsalam Ghaderi, School of Industrial Engineering, Iran University of Science & Technology, Khabgahe Khatam, Tehran, Iran, Islamic Republic Of, ab_ghaderi@iust.ac.ir, *Natashia Boland*, *Mohammad Saeed Jabalameli*

In this paper, a budget-constrained dynamic capacitated facility location-network design problem is investigated that minimize the total travel costs for customers and operating costs of capacitated facilities and network. This problem deals with the determination of the optimal time and location to open capacitated facilities and design of the underlying network, simultaneously when demand and cost parameters are time varying and there is a budget constraint on investment in facilities and links for each period during planning horizon. Also, an algorithm is proposed to solve some instances.

4 - Finding Critical Facility Location of Commercial Facilities in Demand-declining Urban Area

Yuran Choi, Systems and Information Engineering, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, 305-8537, Tsukuba, Japan, r1030173@risk.tsukuba.ac.jp, *Tsutomu Suzuki*

Our focus is on maximal covering of location preventing problem, which considers r interdictions due to disruption or management crisis. This study aims to identify the most important commercial facility for the demands of the system so the system can retain the highest coverage after the interdictions considering the social exclusion which its location could result. It is possible to discuss the necessity of the participation of governments for preventing critical shops from disruption based on the result of this study.

■ FC-07

Friday, 15:15-16:45
Meeting Room 106

Quality

Stream: Contributed Talks
Contributed session
Chair: *Lianjie Shu*, Faculty of Business Administration, University of Macau, Taipa, Macau, ljshu@umac.mo

1 - Evaluation of Average Run Lengths of Adaptive EWMA Procedures Under Linear Drifts

Lianjie Shu, Faculty of Business Administration, University of Macau, Taipa, Macau, ljshu@umac.mo, *Yan Su*, *Kowk-Leung Tsui*

This paper extends the adaptive exponentially weighted moving average (AEWMA) schemes to the monitoring of linear drifts in the mean from the monitoring of step mean changes. A numerical procedure based on the integral equation approach is presented for computing the average run length (ARL) of AEWMA charts under linear drifts in the mean. The comparison results show that AEWMA charts have better ARL performance than the other control charts in many situations. Some guidelines for designing AEWMA charts are presented.

2 - A Fault Detection of Multivariate Cyclic Signals using Kernel Regression Analysis

Seunghwan Park, School of Industrial Management Engineering, Korea University, Anam-dong Seongbuk-Gu, Jeonpagwan 101, Science Campus, 136-701, Seoul, Korea, Republic Of, udongpang@korea.ac.kr, *Jun Seok Kim*, *Rohae Myung*, *Sung-Shick Kim*, *Jun-Geol Baek*

To identify faults in the semiconductor manufacturing process, the analysis of univariate cyclic signals has been conducted. However, a profile process has a multivariate data structure that consists of time and variable axes, so it is hard to analyze of it. First, we conduct the adjustment of length and the unfolding of axes for reduction of the size of data. Second, we use kernel regression analysis in order to build a fault detection algorithm. Finally, we compare the performance of proposed algorithm with other.

3 - Proposal for Development of the Perceptual Map of Socio-environmental Risks using Multivariate Tools and Resampling Methods

Moacyr Machado Cardoso Junior, Production Department, Aeronautics Institute of Technology - ITA, R Licinio Rodrigues Alves 114, Chácara Jafet, 08730661, Mogi das Cruzes, São Paulo, Brazil, moacyr@ita.br, *Rodrigo Scarpel*

This work presents a new way to obtain perceptual map for environmental and social risks under psychometric paradigm and multivariate techniques. Perceptual map included Brazilian endemic diseases, climatic and geologic extreme events, technologies, transportation, environmental pollutants and habits in nine significant dimensions for risk perception studies. Multidimensional Scaling (MDS) was used with Procrustes analysis and resampling tests in order to obtain confidence regions. Results showed that the proposed perceptual map was efficient in portraying the risk perception.

4 - Reliability Analysis of N-policy, K-out-of-N: G Machining System with Warm and Cold Spares

Rekha Choudhary, Mathematics Dept., Govt. Engg. College, 110, Swarn Jayanti Nagar, 321001, Bharatpur, Rajasthan, India, rekhaparth2003@yahoo.co.in

The present investigation deals with a Markov model for analyzing the reliability of N-policy, K-out—of—N:G Machining system with warm and cold spares, which are provided to replace the failed machines. The machines are assumed to fail in M-modes. We have considered two cases for reliability analysis, with repair and without repair. An inverse Laplace transform is used to solve the simultaneous differential equations for nonrepairable case. A generalized analytic function for system reliability is obtained. We have used Runge-Kutta Method to analyze the reliability of repairable system.

■ FC-11

Friday, 15:15-16:45
Meeting Room 112

Integer Programming Models in Production, Inventory

Stream: Integer Programming
Invited session
Chair: *Rosklin Juliano Chagas*, CEFET - MG, Belo Horizonte, Minas Gerais, Brazil, rosklinjuliano@gmail.com

1 - The Integer Programming Model for Solving Inventory Routing Problem with Zone Based Objective Function

Pawel Hanczar, Department of Logistics, University of Economics, ul. Komandorska 118/122, 54-608, Wroclaw, pawel.hanczar@ae.wroc.pl

The paper presents a integer linear programming model for solving the problem of inventory routing. The situation where a manufacturer orders transportation services from an external company is taken into consideration. The transportation company is paid by the manufacturer, but only for the farthest location on the route plus a standing charge for every additional location visited. In the paper the practical application of the proposed model to planning inventory routes is described. Additionally, the integration of these model with the SAP ERP system is discussed.

2 - Petroleum Production Optimization - Formulated as a MINLP Problem with Call Back to State-of-the-art Simulators for Model Update

Vidar Gunnerud, Thomas Angellsgate 5, 7011, Trondheim, vidargu@ntnu.no

The purpose of this study is to develop a optimization algorithm, which will be included in a existing decision support tool available for daily production optimization by engineers at a Statoil operated oil and gas field. I present a MINLP problem, where the integer parts is related to on/off and routing of wells, and the nonlinearities origins from the well performance, pressure drop through the subsea pipes and the well routing. The two first of these nonlinearities will be approximated with quadratic functions, and these functions will be updated iteratively by callbacks to the simulators.

3 - Demand Driven Throughput Assessment for Hunter Valley Coal Chain

Mohsen Reisi, School of Mathematical and Physical Sciences, The University of Newcastle, Mathematics Building, 2308,

Callaghan, NSW, Australia, m.reisi@gmail.com, *Faramroze Engineer*, *Natashia Boland*

Newcastle, Australia, is home to the world's largest coal export operation that includes the transportation of coal from mines to stockyards, where cargoes are assembled in stockpiles before being conveyed to berthed ships. The throughput of this supply chain is determined by the capacity of resources such as load points, wagons, railroads, dumpers, stackers, reclaimers, shiploaders, and berths. Given demand for coal products, our aim is to assess the throughput of the supply chain. We discuss an IP model developed for this problem, including strategies to speed-up the solution process.

4 - Batching with Integrated Forward and Return Flows

Susanne Wruck, Distribution and Supply Chain Logistics, VU University Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, swruck@feweb.vu.nl, *Iris F.A. Vis*, *Jaap Boter*

High return product flows have become a well-known issue in warehouses of many retailers. To facilitate an economic inventory management and efficient capacity utilization, operations need to be designed such that return and forward flows are simultaneously taken into account. Batching is a major tool to increase order picking performance. Batching policies developed for forward flows appear to be unsuitable in settings with high return flows. We present an optimisation model and a solution approach to identify policies with integrated forward and return flows to obtain a higher efficiency.

■ FC-12

Friday, 15:15-16:45
Meeting Room 205

Computational Statistics with Optimization II

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Inci Batmaz*, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Exploring the Interrelationships among Operations Management Practices, Customer Perception of Service Quality, and Performance of Hotels in the Sultanate of Oman

Asma AlZaidi, Operations Managment and Business Statistics, Sultan Qaboos University, P.O Box: 20, CCE Postal Code:123, Muscat, Oman, alzidia@squ.edu.om, *Ramakrishnan Ramanathan*

The aim of this study is to build a holistic model linking customers' perception of service quality, management's perceptions of operations management practices, and performance. Our model has been tested on hotels in Oman. A twelve dimension model has been conceptualized based on literature. Two surveys have been developed one for hotels' customers and for hotel managers. Factor analysis and structural equation model have been used to test the conceptualized model. Our results support the need for efficient operations practices to ensure good service quality perceptions and performance.

2 - Investigating the Fitting Power and Variable Selection in the Fuzzy Regression Model

Chia-Jung Chang, Department of Industrial and Information Management, National Cheng Kung University, No.1, University Road, Tainan City 701, Taiwan, r38991028@mail.ncku.edu.tw, *Liang-Hsuan Chen*

This paper investigates the quality of fit and suitable variable selection procedure in the fuzzy regression model. Fuzzy regression is used to describe the contribution of the corresponding fuzzy input variables in explaining the fuzzy output variable. Based on the framework of statistical concepts and mathematical derivations, a determination coefficient and stepwise procedure are applied to the fuzzy environment to determine the best set of input variables, which can explain the most of explanatory proportions for a fuzzy regression model. A numerical example is provided for verification.

3 - A Robust Algorithm for Sequential ANOVA with Imprecise Observations: An Environmental Real Life Case

Carmen Anido, Economic Analysis: Quantitatve Economy, Autonoma University of Madrid, Faculty of Economics, Cantoblanco., 28049, Madrid, Spain, carmen.anido@uam.es, *Teofilo Valdes*

We present an ANOVA algorithm which is valid under the following robust conditions: the data is not received in batch but sequentially, and may be precise or imprecise; the error distribution may general; and the error variance is unknown. The algorithm updates the analysis as soon as a new data is received, is computationally efficient, yields the estimates of the effect parameters and ends up in estimating the asymptotic covariance matrix of the parameter estimates. The algorithm uses this matrix estimate to test the ANOVA hypotheses formulated as a linear combination of the effects.

4 - Parameter Estimation for the Truncated Model Using the Ordinary Differential Equation

Hideo Hirose, Systems Design & Informatics, Kyushu Institute of Technology, Iizuka 680-4, 820-8502, Fukuoka, Japan, hirose@ces.kyutech.ac.jp

In estimating the number of failures using the truncated data for a reliability distribution, we often encounter a case that the estimate is smaller than the true one when we use the likelihood principle. In infectious disease predictions, the SIR model described by simultaneous ordinary differential equations can predict the final stage condition well, even if the number of observed data is small. Thus, we propose to use the ordinary differential equation method to find the number of failures in the truncated model accurately. The positive results are shown.

■ FC-13

Friday, 15:15-16:45
Meeting Room 206

Mathematical Programming V

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Shunsuke Hayashi*, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Aurelio Oliveira*, Computational & Applied Mathematics, State University Of Campinas, DMA IMECC Unicamp, C. P. 6065, 13081-970, Campinas, SP, Brazil, aurelio@ime.unicamp.br

Chair: *Oliver Stein*, Institute of Operations Research, Karlsruhe Institute of Technology, 76131, Karlsruhe, Germany, stein@kit.edu

1 - Efficient Implementation of the Interior Point Methods for the Norm Lp Fitting Problems

Daniela Cantane, Computational & Applied Mathematics - IMECC, State University Of Campinas - UNICAMP, Rua Sérgio Buarque de Holanda, 651 — Cidade Universitária "Zeferino Vaz" — Distr. Barão Geraldo, 13083-859 , Campinas, São Paulo, Brazil, dcantane@gmail.com, *Aurelio Oliveira*, *Eliana Contharteze Grigoletto*

In this work the family of logarithmic barrier interior point methods previously developed is modified to achieve an efficient implementation for the Lp norm fitting problem. The matrix structure is exploited in order to have better performance. In particular, for polynomial fitting the constrainsts consist of a Vandermond matrix and the reduced linear system for finding the search directions has a positive definite Hankel matrix. The implementation of the interior point methods developed is compared to an implementation of the existing methods obtaining better computational performance.

2 - Semidefinite Optimization in Design of Composite Materials with Randomly Oriented Inclusions

Olesya Zhupanska, Mechanical and Industrial Engineering, University of Iowa, 3131 Seamans Center, 52242, Iowa City, IA, United States, olesya-zhupanska@uiowa.edu, *Pavlo Krokhmal*

We consider a problem of design of composite materials, namely optimizing the materials' elastic properties. The approach is based on constructing bounds on the tensor of elastic moduli of a composite material consisting of multiple phases of 'matrix' with randomly oriented 'inclusions'. Mathematically, the problem reduces to a nonlinear semidefinite optimization problem. A solution algorithm and computational studies are presented.

■ FC-14

Friday, 15:15-16:45
Meeting Room 207

Nonsmooth Optimization II

Stream: Continuous and Non-Smooth Optimization
Invited session

Chair: *Adil Bagirov*, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

Chair: *Jon Borwein*, Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, jon.borwein@gmail.com

1 - Kinds of Vector Invex

Bruce Craven, Mathematics & Statistics, University of Melbourne, University of Melbourne, Parkville, Victgoria, 3010, Melbourne, Victoria, Australia, bdc@labyrinth.net.au

Necessary Lagrangian conditions for a constrained minimum become sufficient under generalized convex assumptions, in particular invex, and duality results follow. Many classes of vector functions with properties related to invex have been studied, but It has not been clear how far these classes are distinct. Various inclusions between these classes are now established Some modifications of invex can be regarded as perturbations of invex. There is a stability criterion for when the invex property is preserved under small perturbations. Some results extend to nondifferentiable (Lipschitz) functions.

2 - Nonconvex Piecewise Linear Optimization: Numerical Algorithms

Julien Ugon, CIAO, University of Ballarat, P.O. Box 663, 3350, Ballarat, Victoria, j.ugon@ballarat.edu.au, *Adil Bagirov*

In this paper, an algorithm for global minimization of functions represented as a difference of two polyhedral functions is proposed. Since any continuous piecewise linear function can be represented as a maxima of minima of linear functions the new algorithm is applicable for global minimization of continuous piecewise linear functions. This algorithm is based on the concept of codifferential.The proposed algorithm is finite convergent.

3 - Continuous Models with Complementarity Equations for Scheduling Problems

Joao Lauro D. Faco', Dept. of Computer Science, Universidade Federal do Rio de Janeiro, Av. do PEPE, 1100 / 203, 22620-171, Rio de Janeiro, RJ, Brazil, jldfaco@ufrj.br, *Fabio Fagundez*, *Adilson Elias Xavier*

A novel nonlinear model for scheduling in the Oil and Gas industry is presented, where discrete variables are replaced by complementarity constraints on non-discrete variables, achieving a continuous model. We illustrate the approach with computational examples from the literature, which are solved to local optimality with NLP solvers in reasonable computational time. The problem is modeled as a dynamic system operating under certain constraints. Transfer operations are carried out by flows from source to destination equipments, changing the contents (volume and properties) of the destination.

4 - Nonconvex Piecewise Linear Optimization: Optimality Conditions

Adil Bagirov, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

We present necessary and sufficient local and global optimality conditions for continuous piecewise linear functions. These conditions are formulated using the concept of codifferential. Since any continuous piecewise linear function can be represented as a maxima of minima of affine functions we use this representation to demonstrate that in many practical situations these conditions can be efficiently checked.

■ FC-15

Friday, 15:15-16:45
Meeting Room 208

Fuzzy Decision Making

Stream: Contributed Talks
Contributed session

Chair: *Qiang Zhang*, Beijing Institute of Technology, School of Management and Economics, 100081, Beijing, China, qiangzhang@bit.edu.cn

1 - Fuzzy TOPSIS System Development Using Objective and Subjective Weights for the Assessment of Faculty Performance in University Campuses

Jamileh Ahmadzadeh Rad, Management Dept., Azad University of Tehran, Tehran, Iran, Islamic Republic Of, jamile_rad@yahoo.com, *Mahboube Khodabakhsh*, *Mohammad Ali Afshar Kazemi*

The process of selecting meritorious university faculty is a multi-criteria decision. The purpose of this paper is to present a model to identify worthy faculty and rank them using the Fuzzy TOPSIS model. This model comprises of seven main criteria such as teaching quality and creativity. In this paper, the subjective weight of criteria was measured using expert opinion from Wise-pair matrix, thereafter utilizing Fuzzy-Entropy technique; the objective weight of criteria was measured. Finally, utilizing the Fuzzy TOPSIS model ranking was carried out.

2 - An Application of the Fuzzy ELECTRE Method for Best Project Selection

Babak Daneshvar Rouyendegh(Babek Erdebilli), Department of Industrial Engineering, Atılım University, 06836 , Ankara, Turkey, babekd@atilim.edu.tr, *Serpil Erol*

There are various methods regarding best project selection in the different fields. Selecting projects is an important problem, yet often difficult task. It is complicated because there is usually more than one dimension for measuring the impact of each Project, when there is a more than one decision maker. This study consider an actual application of Project selection with selection using the opinion of experts to be applied into a model of by one of the group decision making, called Fuzzy ELECTRE (ELimination Et Choix Traduisant la REaite) method.

3 - Lattice-valued Sugeno Integral and its Application in Intuitionistic Fuzzy Multicriteria Analysis

Qiang Zhang, Beijing Institute of Technology, School of Management and Economics, 100081, Beijing, China, qiangzhang@bit.edu.cn, *Jian-Zhang Wu*

The componentwise decomposition theorem of lattice-valued Sugeno integral is extended. The concepts of the interval fuzzy-valued, interval intuitionistic fuzzy-valued Sugeno integral are introduced. The intuitionistic fuzzy-valued Sugeno integral and the interval fuzzy-valued Sugeno integral are mathematically equivalent. The interval intuitionistic fuzzy-valued Sugeno integral can be decomposed into the interval fuzzy-valued, the intuitionistic fuzzy-valued, or the original Sugeno integrals. The obtained results will be useful for multicriteria analysis, such as multicriteria decision making and image processing, under intuitionistic fuzzy environment.

■ FC-17

Friday, 15:15-16:45
Meeting Room 214

Investment Strategies and Valuation II

Stream: Finance
Invited session

Chair: *Heinz Eckart Klingelhöfer*, Knopfstraße 1, 17489, Greifswald, Germany, hekling@web.de

Chair: *Thomas Burkhardt*, Campus Koblenz, IfM, Universitaet Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, tburkha@uni-koblenz.de

Chair: *Peter Scholz*, Frankfurt School of Finance and Management, 60314, Frankfurt am Main, Germany, p.scholz@frankfurt-school.de

1 - Long-Term Investments in Technology, Make-to-Stock with Holdback and Make-to-Order Strategies

Liu Yang, The Hong Kong Polytechnic University, Department of Logistics and Maritime Studies, Hung Hom, Hong Kong, willow.yang@polyu.edu.hk, *Chi To Ng*, *T.C. Edwin Cheng*, *Michael Pinedo*

With development of various new technologies, firms are able to reduce their production costs by adopting the advanced technologies. On the other hand, choosing the appropriate capacity strategy is crucial to development of a firm in long run, i.e., make-to-stock with holdback or make-to-order. This paper addresses long-term investment in technology under strategies of make-to-stock with holdback and make-to-order, respectively. We find out the optimal technology levels under different capacity situations, and further identify the most appropriate environment for the technology investment.

2 - Financial Evaluation of Market Development and Investments into New Market Segments

Heinz Eckart Klingelhöfer, Knopfstraße 1, 17489, Greifswald, Germany, hekling@web.de

The paper offers an approach for the financial valuation of segment specific marketing activities, market development and ventures into new segments under the conditions of imperfect markets. Applying duality theory of linear programming allows to identify the determinants of the investments price ceiling and to interpret them as (corrected) net present values of the payments and the interdependencies arising from changes in the optimal programs. We use sensitivity analysis to support these findings and to get more information on the effects of these determinants.

3 - The Effects of Costly Exploration on Optimal Investment Timing

Michi Nishihara, Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka, 560-0043, Osaka, Japan, nishihara@econ.osaka-u.ac.jp, *Takashi Shibata*

We investigate a principal-agent model in which an owner optimizes a contract with a manager delegated to undertake an investment project. We explore the effects of costly exploration by which the manager learns the real value of development cost. We show that high exploration cost can lead to a pooling policy not contingent on project type. Notably, we show that, in the presence of asymmetric information, higher exploration cost leads to wealth transfer from owner to manager and can then play a positive role in preventing a greedy contract by the owner and improving social welfare.

■ FC-18

Friday, 15:15-16:45
Meeting Room 215

Applications of DEA

Stream: Data Envelopment Analysis

Invited session

Chair: *Chiun-Ming Liu*, Industrial Engineering and Systems Management, Feng Chia Univrsity, 100 Wenhwa Road, 407, Taichung, Taiwan, cmliu@fcu.edu.tw

1 - Cost Efficiency in Supply Chain with Imprecise Information Flow

Mani Shojaie, Young researcher Club, Islamic Azad University, North Tehran branch, Tehran, Iran, Islamic Republic Of, mani.shojaie@gmail.com, *Vahid Abbasi*, *Somayeh Mamizadeh-Chatghayeh*

To measure the Cost Efficiency (CE) of supply chain evaluates the ability to produce current outputs at minimal cost. However, the common price and cost assumption is not always valid in actual business for measuring and improving of productivity of a supply chain. On the other hand, Achieving a low cost position is critical for Supply Chain Management (SCM). Therefore, in this paper we propose application of Data Envelopment Analysis (DEA) and introduce cost efficiency with imprecise information flow under different unit prices for performance evaluation of supply chains.

2 - On the Relationship between Efficiency and Use of Information and Communication Technologies (ICT) in Logistics

Carlos Ernani Fries, Department of Production and Systems Engineering, Federal University of Santa Catarina, Campus Trindade - CTC/EPS, C.P. 476, 88010-970, Florianópolis, Santa Catarina, Brazil, ernani@deps.ufsc.br, *Mônica M. M. Luna*, *Antonio G.N. Novaes*

The impact of investment in ICT in the service sector has been the subject of several studies concerning the productivity paradox. The relationship between efficiency and use of ICT is examined here among a set of Brazilian logistics service providers from 2007 to 2010. DEA was applied to homogeneous groups of firms that operate mainly in the arcs, nodes, and networks of supply chains. The resulting weak relationship shows that the controversial productivity paradox has been confirmed for the Brazilian logistics sector.

3 - Multiple Time Periods Facilities of DEAOS; Malmquist Index and its Decompositions

Mohammad-Reza Alirezaee, School of Mathematics, Iran University of Science and Technology, Hengam St., Resalat Sq., 16846, Tehran, Iran, Islamic Republic Of, mralirez@yahoo.com, *Ali Niknejad*, *Nassrin Alirezaee*

The uses of Malmquist index- the prominent index for measuring the productivity change of decision making units (DMUs) in multiple time periods- are growing day by day. Fare, Grosskopf, Lindgren, and Roos (FGLR) (1992) identified the technological change and the change of technical efficiency as two components of the productivity change over time. Subsequently, Fare, Grosskopf, Norris, and Zhang (FGNZ) (1994) offered three components decomposition of the Malmquist index, capturing change in scale efficiency. Recently, Alirezaee and Afsharian (2010) presented four components decomposition of the Malmquist index in which the regulation efficiency change is calculated. Multiple time periods facilities of DEAOS are covered all necessary requirement of its users for calculation of the Malmquist index and its decompositions. DEAOS is available at www.DEAOS.com.

4 - Optimization of Multi-Response Quality Problems in IC Packaging Process Using Taguchi Method and DEA

Chiun-Ming Liu, Industrial Engineering and Systems Management, Feng Chia Univrsity, 100 Wenhwa Road, 407, Taichung, Taiwan, cmliu@fcu.edu.tw

In this study, a multi-response quality problem is analyzed for the IC packaging process and control factors and response variables are selected. Taguchi design method is then used to provide a robust experimental design. Then a super-efficiency DEA model is presented for completely ranking each parameter combination. The proposed approach is used to solve the multi-response quality problem and obtain an optimum parameter combination. Results from this study indicate that the developed approach provide a better parameter combination with highly quality level for multiple response variables.

■ FC-19

Friday, 15:15-16:45
Meeting Room 216

Telecommunications II

Stream: Network Optimisation and Telecommunications

Contributed session

Chair: *Cerasela Tanasescu*, ESSEC Business School, Bucharest, Romania, tanasescu@essec.edu

1 - Maximizing Survivability of Acyclic Multi-State Transmission Networks

Sanjay Chaudhary, Department of Mathematics, Dr. B.R.Ambedkar University, Institute of Basic Science, Khandari, 282002, AGRA, UP, India, scmibs@hotmail.com

In this research paper we evaluate the system survivability of acyclic multi-state transmission networks (AMTNs) using the universal generating technique. The AMTN survivability is defined as the probability that a signal from root node is transmitted to each leaf node. The AMTNs consists of a number of positions in which multi state elements (MEs) capable of receiving and /or sending a signal are allocated. The number of leaf position that can only receive a signal and a intermediate positions containing MEs capable of transmitting the received signal to some other nodes.

2 - Network Robustness in G-Graphs

Cerasela Tanasescu, ESSEC Business School, Bucharest, Romania, tanasescu@essec.edu, *Andreea Madalina Stancu*

G-graphs are graphs constructed from groups are. These graphs have highly-regular properties. Important recent trends in communications have been the increasing tendency to base operations around an internal network. This combination of factors makes it important to study the robustness of network topologies. We use graph-theoretic concepts and Laplacien spectrum of graphs in order to study G-Graphs connectivity. We examine the relationship between node connectivity and network symmetry, and characterize in what conditions G-Graphs are robust networks.

■ FC-20

Friday, 15:15-16:45
Meeting Room 217

Multi-criteria Decision Making

Stream: Contributed Talks

Contributed session

Chair: *Jacek Zak*, Department of Logistics, Poznan University of Technology, 3 Piotrowo Street, 60-965, Poznan, Wielkopolska, Poland, jacek.zak@put.poznan.pl

1 - Identifying Health Market Innovations in the Philippines Using Conjoint Analysis and Analytic Hierarchy Programming

Brian Canlas Gozun, De La Salle University Manila, 2401 Taft Avenue, 1004, Manila, Japan, bcgozun@gmail.com, *Rouselle Lavado*, *Oscar Picazo*, *Lizelle Lagrada*

This study aims to identify and to analyze health market innovations in the Philippines that are currently being undertaken by both public and private sectors. In general, the study will identify innovative health market programs that aim to address quality, affordability, equity, and/or availability of care. This study uses conjoint analysis and analytic hierarchy programming to identify features of health market innovations that can be used by providers of health services in the Philippines.

2 - The Promotion Effects for a Two-echelon Supply Chain System with Dominant Retailer

Tai-Yue Wang, Dept. of Industrial and Information Management, National Cheng Kung University, 1 University Road,, 70101, Tainan, Taiwan, tywang@mail.ncku.edu.tw, *Yi-Ho Chen*, *Tse-Ming Chen*

In this study, we investigate a two-echelon supply chain with two suppliers and three retailers among which one retailer dominates other retailers. A price competition demand function is used and the promotion strategies and negotiation schemes are integrated to form mathematical models under different scenarios. The decision variables such as promotional costs, retailer prices, wholesale price and order quantity are included in these models. Consequently, the distributions of promotion costs under different cost allocation strategies are discussed. Finally, a household paper market is used as an example to validate our models. The results from this empirical example show that the profit model will create the largest profit for the supply chain but with different profit-sharing results. At the same time, the more risk a member can take, the more profits are distributed to that member in the utility model.

3 - The Selection of the Logistics Center Location Based on MCDM/A Methodology

Jacek Zak, Department of Logistics, Poznan University of Technology, 3 Piotrowo Street, 60-965, Poznan, Wielkopolska, Poland, jacek.zak@put.poznan.pl, *Szymon Weglinski*

The paper presents the methodology of finding the most desirable (compromise) location of the logistics center for a certain area. A two-stage procedure based on MCDM/A methodology is proposed, including the macro analysis of sub-regions and the evaluation of concrete locations at a micro level. At both levels the decision problems are formulated as multiple criteria ranking problems. Different criteria: economical, social, technical, market-oriented and environmental are considered. The results of computational experiments with the use of MCDM/A ranking methods are presented.

■ FC-21

Friday, 15:15-16:45
Meeting Room 218

Underground Mine Planning, I

Stream: Mining Applications

Invited session

Chair: *Alexandra Newman*, Division of Economics and Business, Colorado School of Mines, 1500 Illinois Street, 80401, Golden, CO, United States, newman@mines.edu

1 - Extensions of Dubins-like Paths

Jose Ayala Hoffmann, Mathematics Dept., Unviersity of Melbourne, 801/466 Swanston St., 3053, Melbourne, Victoria, Australia, joseah@pgrad.unimelb.edu.au

The optimal decline design problem consists on finding a curve in $mathbb R3$ of minimum cost satisfying a condition of accessibility on each group of nodes. Such path has bounded turning circle at each point and satisfies a gradient constraint if and only if the length of the projected planar path reaches a certain lower bound. It may be the case that the desired length is not reached without violating the turning circle constrain. We analyze deformations of admissible paths via the concept of Dubins-like paths together with a characterization of the space when these paths lies.

2 - Optimal Underground Mine Access Design with Anisotropic Ground Support Costs

Alan Chang, Mechanical Engineering, University of Melbourne, 3010, Melbourne, VIC, Australia, a.chang5@pgrad.unimelb.edu.au, *Marcus Brazil*, *Joachim Rubinstein*, *Doreen Thomas*

Underground mine tunnels must satisfy vehicle navigability constraints of a minimum turning circle radius and maximum slope gradient. Existing software is able to produce such access designs while minimising haulage and development costs, assuming isotropic and homogeneous ground conditions. This assumption is inappropriate in regions of ground where the rock strength (and hence support required) is heavily dependent on the direction. This paper demonstrates how the approach can be modified to account for costs that are direction-dependent due to the anisotropic behaviour of the ground.

3 - Optimal Design of Level Access in Underground Mines

Peter Grossman, Mechanical Engineering Dept., University of Melbourne, 3010, Parkville, VIC, Australia, peterag@unimelb.edu.au

In underground mines where methods such as stoping and benching are used, a network of drives must be constructed on each level to provide access to the ore. Using the mathematical theory of Steiner trees, a software tool — the Planar Underground Network Optimiser (PUNO) — has been developed to aid mine planning engineers in generating optimal designs for the networks that minimise the construction and operational costs over the lifetime of the mine. We describe the current capabilities of PUNO including some recent enhancements and present the results of its application in a case study.

Friday, 17:00-18:30

■ FD-01

Friday, 17:00-18:30
Plenary Hall 3

OR Applications on Increasing Energy Efficiency in Complex Systems

Stream: OR Applications in Energy
Invited session
Chair: *Caroline Mota*, Industrial Engineering, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil, carol3m@gmail.com

1 - Genetic algorithm for Reducing Power Consumption of MRT Railways in Timetabling

KyungMin Kim, Korea Railroad Research Institute, Korea, Republic Of, kmkim@krri.re.kr, *Moonseob Han*, *Kwang Tae Kim*, *Soon-Heum Hong*, *Cheul-Ky Lee*

As regenerative energy produced when train braked can be used by other accelerating trains, it is possible to reduce energy consumption. This paper considers the problem of adjusting train departure time to reduce power consumption of mass rapid transit (MRT) railways. We formulate the problem as mixed integer program and developed genetic algorithm (GA) to solve the problem. To validate the suggested GA, a computational experiment was conducted using real data. The test results show that heuristic algorithm suggested in this paper gives good solution within reasonable computation times

2 - A Model for Improving Energy Efficiency in Industrial Motor System using Multicriteria Analysis

Caroline Mota, Industrial Engineering, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil, carol3m@gmail.com, *Antonio Sola*

In the last years, several policies have been proposed by governments and global institutions in order to improve the efficient use of energy in industries worldwide. This paper proposes a multricriteria model for evaluate industrial motor systems, with the aim of ranking alternatives for induction motors replacement. A comparative analysis of the model, applied to a Brazilian industry, has shown that multicriteria analysis presents a better performance on energy saving as well as return on investments than single criterion in the context of electric motor systems.

■ FD-12

Friday, 17:00-18:30
Meeting Room 205

Optimization Methods and Stochastic Calculus in the Financial Sector II

Stream: Continuous and Non-Smooth Optimization
Invited session
Chair: *Ceren Vardar*, Department of Mathematics, TOBB Economy and Technology University, Sogutozu caddesi no: 43, 06560, Ankara, Turkey, cvardar@etu.edu.tr
Chair: *Miroslav Culik*, Finance, VSB-TUO, Sokolska tr. 33, 70121, Ostrava, Czech Republic, miroslav.culik@vsb.cz
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - The Impact of Compliance in Pension Funds Management Using Nonlinear Stochastic Optimization

Nelson Maculan Filho, COPPE / PESC, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br, *Diego Lages*, *Claudio Contador*

The traditional retirement income has changed. There are less entrants and, at the same time, people are
living longer. So, pension funds are becoming the best alternative, because it doesn't depend much on other participants. The ammount invested by the participants are managed by these funds, highly regulated in some countries, in order to reduce the risk of loss. This work aims to
demonstrate the impact that the regulation causes in Brazil using Mathematical programming models, based on
traditional Markowitz concepts and new models based in nonlinear stochastic programming.

2 - Ecological-Economical Optimization of Strategic Production and Supply Networks

Franz Homberger, Daimler AG, Germany, franz.homberger@daimler.com, *Joanna Schyroki*, *Stefan Flicke*

Besides having a huge environmental impact, global production and supply networks are extremely complex. Therefore some companies make use of mathematical optimization technologies. Unfortunately, these optimization models do not consider ecological factors like CO2 emissions or are not suitable for strategic network planning, as they only have a limited scope. In this paper we present a practical optimization approach for the strategic planning of sustainable production and supply networks being applied to real production and supply networks of a German premium automotive company.

■ FD-14

Friday, 17:00-18:30
Meeting Room 207

Nonsmooth Optimization III

Stream: Continuous and Non-Smooth Optimization
Invited session
Chair: *Adil Bagirov*, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au
Chair: *Regina Burachik*, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, 5095, Adelaide, South Australia, Australia, regina.burachik@unisa.edu.au

1 - A Generalized Subgradient Algorithm for Unconstrained Nonsmooth, Nonconvex Optimization

Alia Al Nuaimat, GSITMS, University of Ballarat, University Drive, Mt Helen, 3353, Ballarat, Victoria, Australia, alia_s2006@yahoo.com

In this talk we present an algorithm for minimizing locally Lipschitz functions. Descent directions in this algorithm are computed by solving a system of linear inequalities. We reduce this system to the minimization of the convex piecewise linear function over the unit ball and discuss algorithms for its solution. The results of numerical experiments with nonsmooth objective functions are presented. We also compare the proposed method with different versions of the bundle and subgradient methods.

2 - Generalized Weak Sharp Minima in Cone-Constrained Convex Optimization with Applications

Xuexiang Huang, Chongqing University, School of Economics and Business Administration, 400030, Chongqing, China, huangxuexiang@cqu.edu.cn

In this work, we consider convex optimization problems with cone constraints (CPC in short). We study generalized weak sharp minima properties for (CPC) in the Banach space and Hilbert space settings, respectively. Some criteria and characterizations for optimal set to be a set of generalized weak sharp minima for (CPC) are derived. As an application, we propose an algorithm for (CPC) in the Hilbert space setting. Convergence analysis of this algorithm is given.

3 - On Accelerated Quasisecant Method for Nonsmooth Nonconvex Optimization

Liping Jin, GSITMS, University of Ballarat, University Drive, 3350, Ballarat, VIC, Australia, smilelipingjin@gmail.com, *Adil Bagirov*

we develop a new version of the quasisecant method. We introduce a quasisecant locality condition. At each new iteration this condition allows us to identify quasisecants from past iterations. Such an approach leads to the reduction in the number of function and significant reduction in the number of quasisecant (subgradient) evaluations in comparison with the quasisecant method. We prove that the sequence of points generated by the algorithm converges to the set of Clarke stationary points. The preliminary results of numerical experiments are reported.

4 - A Dual-penalty Update Based on Epsilon Subgradients for Solving Nonconvex Optimization

Regina Burachik, School of Mathematics and Statistics, University of South Australia, Mawson Lakes, 5095, Adelaide, South Australia, Australia, regina.burachik@unisa.edu.au, *C Yalcin Kaya*

Given a general augmented Lagrangian approach for solving a nonconvex and nonsmooth optimization problem, we use an epsilon subgradient step for improving the dual function. We show how this dual update tantamount to a penalty scheme, which is numerically more stable than the classical penalty update used in the literature. More precisely, we show that as long as the dual problem has solutions, the penalty parameter remains bounded above. We establish for this update both primal and dual convergence for some specific stepsizes.

■ FD-15

Friday, 17:00-18:30
Meeting Room 208

Fuzzy Logic

Stream: Contributed Talks
Contributed session

Chair: *Jessica Naundorf*, Department of Economics & Management, Otto-von-Guericke-University Magdeburg, Chair of Strategic Management and Organisation, P.O. Box 41 20, 39 016, Magdeburg, Germany, jessica.naundorf@ovgu.de

1 - Development of a Fuzzy Rule-based System for the Appraisal of the Employer Attractiveness

Jessica Naundorf, Department of Economics & Management, Otto-von-Guericke-University Magdeburg, Chair of Strategic Management and Organisation, P.O. Box 41 20, 39 016, Magdeburg, Germany, jessica.naundorf@ovgu.de, *Thomas Spengler*

Employer Awards represent institutions in the economic sense, which establishment is rational especially in the case of information asymmetry. They are outcomes of corresponding signaling-strategies. To prevent possible alpha and beta errors, a simple rule-based system for the appraisal of the employer attractiveness considering the concept of fuzzy linguistic is developed. The proposed procedure represents an analytical assessment process based on a criterion hierarchy. Both the criteria values and the criteria weights can typically only be expressed in a fuzzy form. Therefore, we take into account fuzzy linguistic variables and fuzzy rules to avoid erroneous specifications of the system.

2 - Time Dependent Intuitionistic Fuzzy Set

Chien-Cheng Tu, Industrial and Information Management, National Cheng Kung University, No. 1, University Road, 701, Tainan, Taiwan, charvis.tw@gmail.com, *Liang-Hsuan Chen*

This paper investigates the time-dependent decision-making problem in the uncertain environment. The intuitionistic fuzzy set (IFS) is used to describe the information with the degrees of truth and false. A reasonable assumption, that the degrees of truth and false will change during the decision-making period, is made in this study. The decision making quality is related to the information quality during the decision-making horizon. This paper defines the time-domain problem, derives the mathematical equations, and provides an illustrative example.

3 - A Cutting Plane Algorithm for Solving Fuzzy Semi-infinite Linear Programming

Alireza Fakharzadeh, Mathematics Dept., Shiraz University of Technology,, 71555-313, Shiraz, Iran, Islamic Republic Of, a_fakharzadeh@sutech.ac.ir, *Somayeh Khosravi*

Linear fuzzy phenomena have better presentation if they are modeled as a semi-infinite linear programming. No identified solution method has been presented for them yet. We propose an algorithm for non-symmetric fuzzy semi—infinite linear programming problems (FSILP) with fuzzy order relations of constraints. A finite subproblem was solved by Zadeh Method and defining a membership functions. Then a finite LP is introduced instead of the subproblem and a cutting plane method. Convergence theorem was proved and algorithm efficiency shown by test examples.

■ FD-18

Friday, 17:00-18:30
Meeting Room 215

Applications of DEA

Stream: Data Envelopment Analysis
Invited session

Chair: *Mahnaz Maghbouli*, Math and Economy Dept., Azad University, No 22-3 Bahar Alley-Shahriyar Street-Etesami Blvd-Vali Asr, 5157675334, Tabriz, East Azerbaijan, Iran, Islamic Republic Of, mahnaz4143@yahoo.ca

1 - Ranking by Multi Component Efficiency with Shared Resources in Commercial Banks

Mohsen Vaez Ghasemi, Mathematics, Islamic Azad University, Science and Research Branch, Hesarak St., Poonak Sq., Tehran, Iran, Islamic Republic Of, mohsen.vaez@gmail.com, *Farhad Hosseinzadeh Lotfi*, *Mohsen Rostamy-Malkhalifeh*

In the most utilization of Data Envelopment Analysis, available models are obtaining a number of efficiency. Indeed, in old models, a Decision Making Unit had its own input and outputs, it can be only effective in its own rank and efficiency, but in this model we're examining, some inputs are used for some components in common and the whole components are used to make some outputs, and we rank these DMUs by this situation. In this article, the ranking of four Banks has been examined and indices in question.

2 - Efficiency After 10 Years of Liberalization: Performance Assesment of Indian Life Insurers

Subir Sen, TERI University, 10 Institutional Area, 110070, New Delhi, Delhi, India, subir.econ@gmail.com

A move towards growth of the Indian insurance sector was initiated via liberalization of the sector in 1999 and formation of Insurance Regulatory and Development Authority and in this paper we attempt to identify factors which were beneficial for growth of insurers following a decade of liberalization. Using DEA, efficiency and productivity of all registered life insurers for the period 1999-00 to 2009-10 is examined. We further investigate relationship of performance indicators with financial ratios. Results suggest that some ratios are significant for efficiency improvements.

3 - Sensitivity Analysis of University Libraries with DEA

Mahnaz Maghbouli, Math and Economy Dept., Azad University, No 22-3 Bahar Alley-Shahriyar Street-Etesami Blvd-Vali Asr, 5157675334, Tabriz, East Azerbaijan, Iran, Islamic Republic Of, mahnaz4143@yahoo.ca, *Monireh Zoriehhabib*

This paper proposes a sensitivy analysis for evaluating efficiency of university libraries from Iran. This flexible non-parametric approach will provide some guidance to managers for improving quality performance level. Data Envelopment Analysis has been suggested to analyze the best units to be benchmarked against as well as in providing actionable measures for improvement of libraries' performance. An illustration is provided to demonstrate DEA sensitivy as a benchmarking tool against two factors. The results can provide directions for future research.

■ FD-21

Friday, 17:00-18:30
Meeting Room 218

Underground Mine Planning, II

Stream: Mining Applications
Invited session

Chair: *Donal OSullivan*, Division of Economics and Business, Colorado School of Mines, 1500 Illinois Street, 80401, Golden, Colorado, United States, dosulliv@mines.edu

1 - Passing Bays and Vehicle Schedules for an Underground Mine

Hamideh Anjomshoa, School of Mathematics & Statistics, University of South Australia, 5095, Mawson Lakes, South Australia, Australia, Hamideh.anjomshoa@unisa.edu.au, *Peter Pudney*, *David Lee*, *Amie Albrecht*

Underground mines often use a single decline for loaded and unloaded vehicles. Strategically placed passing bays allow opposing vehicles to pass. The number and locations of bays influences the flow of vehicles, and hence mine productivity. The optimal spacing of bays is a function of the length of decline, number of vehicles, up speeds, down speeds, loading and unloading times. We present the results obtained from an MIP model which determines the spacing of bays that minimises the makespan of a fixed number of trips. The MIP also generates the corresponding vehicle schedule.

2 - Integrating Constructability of a Project into the Optimization of Production Plans and Scheduling

Nelson Morales, Mine Engineering, Universidad de Chile, Santiago, Chile, nmorales@ing.uchile.cl, *Winston Rocher*, *Enrique Rubio*, *Milivoj Smoljanovic*

Mine planning for underground mines is decoupled in a process that first determines the production plan and mining schedule (what to extract and in which order) and then designs and schedules the infrastructure required to achieve these production goals. While the production plan is calculated considering some elements of constructability, the actual construction schedules do not meet the production requirements, affecting early stages of the project and therefore the NPV. In this work we present two models that integrate these steps and show aggregation techniques and real applications.

3 - Long-Term Extraction and Backfill Scheduling in a Complex Underground Mine

Donal OSullivan, Division of Economics and Business, Colorado School of Mines, 1500 Illinois Street, 80401, Golden, Colorado, United States, dosulliv@mines.edu

We use an integer programming model to optimize production at a complex underground mining operation. Mine managers seek to maximize metal production while using a mixture of mining methods to extract the ore. We apply a sliding time window heuristic to solve for a four year schedule with weekly fidelity.

Airline Applications
Invited

Matthias Ehrgott
University of Auckland
m.ehrgott@auckland.ac.nz
Track(s): 21
4 sessions

Analytic Hierarchy/Network Process
Invited

Josef Jablonsky
University of Economics Prague
jablon@vse.cz
Track(s): 20
3 sessions

Applied Probability
Invited

Peter Taylor
University of Melbourne
p.taylor@ms.unimelb.edu.au
Track(s): 7
2 sessions

Bioinformatics
Invited

Ceyda Oguz
Koc University
coguz@ku.edu.tr
Track(s): 8
3 sessions

Combinatorial Optimization
Invited

Silvano Martello
University of Bologna
smartello@deis.unibo.it
Track(s): 7
5 sessions

Constraint programming (CP-AI)
Invited

Mark Wallace
Monash University
mark.wallace@infotech.monash.edu.au

Jimmy Lee
The Chinese University of Hong Kong
jlee@cse.cuhk.edu.hk
Track(s): 7
1 session

Continuous and Non-Smooth Optimization
Invited

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Andrew Eberhard
RMIT University
andy.eb@rmit.edu.au

Regina Burachik
University of South Australia
regina.burachik@unisa.edu.au

Jon Borwein
The University of Newcastle
jon.borwein@gmail.com
Track(s): 12 13 14
33 sessions

Contributed Talks
Contributed
Track(s): 3 5 6 7 9 10 12 15 20
25 sessions

Cutting and Packing
Invited

Jose Fernando Oliveira
Universidade do Porto
jfo@fe.up.pt

David Pisinger
DTU Management
pisinger@diku.dk
Track(s): 7
2 sessions

Data Envelopment Analysis
Invited

Ali Emrouznejad
Aston University
a.emrouznejad@aston.ac.uk
Track(s): 18
15 sessions

Discrete and Global Optimization
Invited

Duan Li
The Chinese University of Hong Kong
dli@se.cuhk.edu.hk

Xiaoling Sun
Fudan University
xls@fudan.edu.cn
Track(s): 19
2 sessions

Discrete Optimisation
Invited

Michael Juenger
Universitaet zu Koeln
mjuenger@informatik.uni-koeln.de

Gerhard Reinelt
University of Heidelberg
gerhard.reinelt@informatik.uni-heidelberg.de
Track(s): 7
2 sessions

Dynamic Programming
Invited

Thomas Archibald
University of Edinburgh
T.Archibald@ed.ac.uk

Lidija Zadnik Stirn
University of Ljubljana
lidija.zadnik@bf.uni-lj.si
Track(s): 8
8 sessions

Education and Operations Research
Invited

James Cochran
Louisiana Tech University
jcochran@cab.latech.edu
Track(s): 19
9 sessions

Emergency Evacuation and Response
Invited

Elise Miller-Hooks
University of Maryland
elisemh@umd.edu
Track(s): 9
4 sessions

Finance
Invited

Rita Decclesia
Sapienza University of Rome
rita.decclesia@uniroma1.it

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr
Track(s): 17
8 sessions

Forestry Applications
Invited

Andrés Weintraub
University of Chile
aweintra@dii.uchile.cl

Track(s): 21
2 sessions

Fuzzy Logic
Invited

Janos Fodor
Óbuda University
fodor@bmf.hu

Track(s): 15
3 sessions

Game Theory
Invited

Fouad El Ouardighi
ESSEC Business School
elouardighi@essec.fr

Track(s): 2
8 sessions

Health Care Applications
Invited

Leonid Churilov
The University of Melbourne
leonid.churilov@gmail.com

Track(s): 16
8 sessions

Integer Programming
Invited

Sungsoo Park
K A I S T
sspark@kaist.ac.kr

Track(s): 11
7 sessions

Intelligent Optimisation
Invited

Kate Smith-Miles
Monash University
kate.smith-miles@sci.monash.edu.au

Leo Lopes
Monash University
Leo.Lopes@monash.edu

Track(s): 3
1 session

Knowledge and Knowledge Organizations
Invited

A. D. Amar
Seton Hall University
amaramar@shu.edu

Track(s): 20
1 session

Knowledge Management
Invited

Jo Smedley
University of Wales, Newport
jo.smedley@newport.ac.uk

Track(s): 20
1 session

Maritime Transportation and Logistics
Invited

Harilaos Psaraftis
National Technical University of Athens
hnpsar@mail.ntua.gr

Heng-Soon Gan
University of Melbourne
hsg@unimelb.edu.au

Track(s): 21
2 sessions

Marketing and OM Interface
Invited

Kathryn E. Stecke
University of Texas at Dallas
KStecke@utdallas.edu

Track(s): 5
5 sessions

Meta-heuristics
Invited

Stefan Voss
University of Hamburg
stefan.voss@uni-hamburg.de

Celso Ribeiro
Universidade Federal Fluminense
celso@inf.puc-rio.br

Track(s): 3
7 sessions

Military, Defense and Security Applications
Invited

Greg Parlier
Institute for Defense Analysis
gparlier@ida.org

Brandon Pincombe
Defence Science and Technology Organisation
Brandon.Pincombe@dsto.defence.gov.au

Track(s): 15
10 sessions

Mining Applications
Invited

Alexandra Newman
Colorado School of Mines
newman@mines.edu

Lou Caccetta
Curtin University of Technology of Perth
caccetta@maths.curtin.edu.au

Track(s): 21
4 sessions

Multicriteria Decision Analysis and Multiobjective Optimisation
Invited

Jyrki Wallenius
Helsinki School of Economics
jyrki.wallenius@aalto.fi

Theodor Stewart
University of Cape Town
theodor.stewart@uct.ac.za

Roman Slowinski
Poznan University of Technology
roman.slowinski@cs.put.poznan.pl

Track(s): 17
4 sessions

Network Optimisation and Telecommunications
Invited

Luis Gouveia
University of Lisbon
legouveia@fc.ul.pt

Bernard Fortz
Université Libre de Bruxelles
bfortz@euro-online.org

Track(s): 17
2 sessions

Network Optimisation and Telecommunications
Contributed

Bernard Fortz
Université Libre de Bruxelles
bfortz@euro-online.org

Luis Gouveia
University of Lisbon
legouveia@fc.ul.pt

Track(s): 19
3 sessions

Non-linear Optimisation
Invited

Ya-Xiang Yuan
Chinese Academy of Sciences
yyx@lsec.cc.ac.cn

Track(s): 6
1 session

Operations Management
Invited

Candace Yano
University of California, Berkeley
yano@ieor.berkeley.edu

Track(s): 4
5 sessions

OR and Marketing
Invited

Christopher Tang
UCLA Anderson School
ctang@anderson.ucla.edu

Track(s): 5
4 sessions

OR and Real Implementation
Invited

Ben Lev
Drexel University
blev@drexel.edu

Track(s): 21
2 sessions

OR and Sports
Invited

Tristan Barnett
University of South Australia
strategicgames@hotmail.com

Track(s): 5
1 session

OR and Strategy
Invited

Martin Kunc
University of Warwick
martin.kunc@wbs.ac.uk

Track(s): 20
2 sessions

OR Applications in Energy
Invited

Ilhan Or
Bogazici University
or@boun.edu.tr

Track(s): 1
8 sessions

OR Development Prize
Invited

Subhash Datta
Niilm Cms
subhash.datta@gmail.com

Track(s): 1
3 sessions

OR in Agriculture
Invited

LluisM Pla
University of Lleida
lmpla@matematica.udl.es

Track(s): 21
1 session

OR Practice
Invited

John Ranyard
Lancaster University
jranyard@cix.co.uk

Track(s): 1
4 sessions

OR software
Invited

Bjarni Kristjansson
Maximal Software, Ltd.
bjarni@maximalsoftware.com

Track(s): 7
1 session

Plenaries
Invited

Track(s): 1
3 sessions

Public Transit
Invited

Dennis Huisman
Erasmus University
huisman@ese.eur.nl

Track(s): 10
6 sessions

Revenue Management and Dynamic Pricing
Invited

Luce Brotcorne
Inria
luce.brotcorne@inria.fr

Track(s): 4
2 sessions

Scheduling
Contributed

Wieslaw Kubiak
Memorial University
wkubiak@mun.ca

Track(s): 2
6 sessions

Scheduling
Invited

Wieslaw Kubiak
Memorial University
wkubiak@mun.ca

Track(s): 16
4 sessions

Service & Health Care Operations
Invited

Chon Goh
Rutgers University
cgoh@camden.rutgers.edu

Kumar Rajaram
UCLA Anderson School
krajaram@anderson.ucla.edu

Track(s): 8
2 sessions

Service Science and Sustainability
Invited

Chung-Yee Lee
Hong Kong University of Science and Technology
cylee@ust.hk

Grace Lin
WRO & Columbia University
gracelin.ny@gmail.com

Track(s): 5
3 sessions

Simulation - Sponsored by I-SIM
Invited

Bahar Biller
Carnegie Mellon University
billerb@andrew.cmu.edu

Track(s): 11
4 sessions

Soft OR and Problem Structuring
Invited

Leroy White
University of Bristol
leroy.white@bris.ac.uk

Vicky Mabin
Victoria University of Wellington
vicky.mabin@vuw.ac.nz

Track(s): 20
4 sessions

Stochastic Programming
Invited

Abdel Lisser
Universite de Paris Sud
lisser@lri.fr

Rüdiger Schultz
University of Duisburg-Essen
schultz@math.uni-duisburg.de

Track(s): 10
3 sessions

Submodular Structures and Optimization
Invited

Satoru Fujishige
Kyoto University
fujishig@kurims.kyoto-u.ac.jp

Track(s): 11
3 sessions

Supply Chain Management
Invited

Tava Olsen
University of Auckland
t.olsen@auckland.ac.nz

Nesim Erkip
Bilkent University
nesim@bilkent.edu.tr

Track(s): 4
6 sessions

Time-Definite Logistics
Invited

Richard Wong
United Parcel Service
rtwong@ups.com

Track(s): 10
3 sessions

Transportation
Invited

M. Grazia Speranza
University of Brescia
speranza@eco.unibs.it

Michel Gendreau
École Polytechnique
michel.gendreau@cirrelt.ca

Track(s): 6
12 sessions

Travel Behaviour
Invited

Michel Bierlaire
École Polytechnique Fédérale de Lausanne (EPFL)
michel.bierlaire@epfl.ch

Track(s): 3 12
3 sessions

Vehicle Routing
Invited

Richard Eglese
Lancaster University
R.Eglese@lancaster.ac.uk

Arne Lokketangen
Molde College
Arne.Lokketangen@hiMolde.no

Track(s): 9
7 sessions

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Tuesday, 11:00-12:30

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Thursday, 9:00-10:30

Thursday, 11:00-12:30

Thursday, 13:30-15:00

Thursday, 15:30-17:00

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Friday, 13:15-14:45

Friday, 15:15-16:45

Friday, 17:00-18:30