42nd Annual Conference of the
Italian Operational Research Society

AIRO 2011 Conference

Operational Research in
Transportation and Logistics

September 6 – 9, 2011, Brescia, Italy

ABSTRACT BOOK

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Abstract Book

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Foreword

The AIRO 2011 conference is a special occasion for the Italian OR community, as AIRO was founded in 1961 and turns 50 in 2011. The conference will mark in several ways the 50th anniversary of AIRO. A special session will go back to the roots, will tell the history of AIRO and will look ahead to its future. The session will also feature a lecture by Paolo Toth. Moreover, during the social dinner, in the beautiful setting of Villa Baiana, we will have the opportunity to thank the past presidents of AIRO.

The program of the AIRO 2011 conference offers a broad spectrum of contributions covering the variety of OR topics and research areas. A large number of sessions are focused on the theme "Operational Research in Transportation and Logistics" that we have decided to highlight. In addition, three invited plenary lectures, by Ángel Corberán, Martine Labbé and Dimitris Bertsimas, will gather us together.

The AIRO 2011 conference will bring to life the two historical complexes of the Faculty of Economics, that we familiarly call Santa Chiara and San Faustino. The plenary sessions and the lunches will take place in San Faustino and the parallel sessions in Santa Chiara. The coffee breaks will take place in either of the complexes, depending on the program.

The conference would not have been possible without the support of several institutions and the commitment of a large number of people who have worked for the AIRO 2011 conference to match the occasion. On behalf of the organizing committee, I wish you a fruitful and pleasant attendance.

M. Grazia Speranza

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(Almost) 50 Years of Arc Routing

Ángel Corberán

Dpto. de Estadística e Investigación Operativa, Universidad de Valencia

Chair: M. Grazia Speranza
Tuesday, 14.30-15.30
Room: Aula Magna - San Faustino

About 50 years ago, a Chinese mathematician, Meigu Guan stated the problem of finding a least cost traversal of the edges of an undirected graph. Guan sought to minimize the length of a closed walk passing through each edge of the graph at least once and, hence, to find a least cost route for a postman who must traverse each edge in order to deliver his/her mail. Guan's paper (1962) on what was later known as the Chinese Postman Problem was the first of a long series of contributions to the arc routing area. Basically, arc routing problems consist of determining a minimum cost traversal of some or all the arcs or/and edges of a graph, possibly subject to some side constraints. They define an exciting area because, on the one hand, most of these problems are challenging problems from the point of view of its study and resolution and, on the other hand, because they can be found in many practical situations such as garbage collection, street cleaning, road maintenance and school bus routing, and, since the money involved on arc routing operations represents millions of Euro, there exists a considerable potential for savings. This talk is about arc (and edge) traversal, arc routing problems and their applications to real-life problems.

Bilevel Programming and Price Optimization Problems

Martine Labbé

Département d'Informatique, Université Libre de Bruxelles

Chair: Ángel Corberán
Wednesday, 12.00-13.00
Room: Aula Magna - San Faustino

Consider a general pricing model involving two levels of decision-making. The upper level (leader) imposes prices on a specified set of goods or services while the lower level (follower) optimizes its own objective function, taking into account the pricing scheme of the leader. This model belongs to the class of bilevel optimization problems where both objective functions are bilinear. In this talk, we review this class of hierarchical problems from both theoretical and algorithmic points of view and then focus on some special cases. Among others, we present complexity results, identify some polynomial cases and propose mixed integer linear formulations for those pricing problem. In the first problem considered, tolls must be determined on a specified subset of arcs of a multicommodity transportation network. In this context the leader corresponds to the profit-maximizing owner of the network, and the follower to users travelling between nodes of the network. The users are assigned to shortest paths with respect to a generalized cost equal to the sum of the actual cost of travel plus a money equivalent of travel time. An extension of the Network Pricing Problem is obtained by optimizing the design of the network and the set of tolls on a subset of open arcs, given that users travel on shortest paths. The third problem is a special case of the Network Pricing Problem in which the taxable arcs are connected and form a path, as occurred in toll highways. When users travel on at most one taxable subpath, the problem can be reformulated in a Network Pricing Problem on an auxiliary clique graph. Interestingly this problem is also equivalent to that of determining optimal prices for bundles of products given that each customer will buy the bundle that maximizes her/his own utility function.

A Computationally Tractable Theory of Performance Analysis in Stochastic Systems

Dimitris Bertsimas

MIT - Co-director, Operations Research Center

Chair: Martine Labbé
Thursday, 11.00-12.00
Room: Aula Magna - San Faustino

Modern probability theory, whose foundation is based on the axioms set forth by Kolmogorov, is currently the major tool for performance analysis in stochastic systems. While it offers insights in understanding such systems, probability theory is really not a computationally tractable theory. Correspondingly, some of its major areas of application remain unsolved when the underlying systems become multidimensional: Queueing networks, network information theory, pricing multi-dimensional financial contracts, auction design in multi-item, multi-bidder auctions among others. We propose a new approach to analyze stochastic systems based on robust optimization. The key idea is to replace the Kolmogorov axioms as primitives of probability theory, with some of the asymptotic implications of probability theory: the central limit theorem and law of large numbers and to define appropriate robust optimization problems to perform performance analysis. In this way, the performance analysis questions become highly structured optimization problems (linear, conic, mixed integer) for which there exist efficient, practical algorithms that are capable of solving truly large scale systems. We demonstrate that the proposed approach achieves computationally tractable methods for (a) analyzing multiclass queueing networks, (b) characterizing the capacity region of network information theory and associated coding and decoding methods generalizing the work of Shannon, (c) pricing multi-dimensional financial contracts generalizing the work of Black, Scholes and Merton, (d) designing multi-item, multi-bidder auctions generalizing the work of Myerson.

This is joint work with my doctoral student at MIT Chaitanya Bandi.

Parallel Sessions

TuA1 - Logistics I

Session organized by Roberto Musmanno

Tuesday, 16.00-17.15
Room B3

The Skill VRP Problem

Maria Grazia Scutellà[1], *Paola Cappanera*[2], *Luis Gouveia*[3]

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[2] Dipartimento di Sistemi e Informatica, Università degli Studi di Firenze

[3] Departamento de Estatistica e Investigacao Operacional, Universidade de Lisboa, Lisboa, Portugal

Consider a directed network where each node other than the depot represents a service requirement, and let s_j denote the skill level required by node j for the associated service call. Assume to have a set of available technicians, each one operating at a certain skill level, and assume also that the service requirement at node j can be operated by any technician having a skill level at least s_j. Given skill dependent travelling costs, we study the problem of defining a set of tours for the technicians, each one starting and ending at the depot, in such a way that each service requirement is fulfilled by exactly one technician, and the skill level constraints are satisfied. This problem is referred to as Skill VRP. Skill VRP, for which mathematical models have never been proposed before to the best of our knowledge, originates from a real application context, referred to as field service [1], [5]. Furthermore, it specializes the Site Dependent VRP [2], [3]. Skill VRP is also strongly related to Home Care Scheduling problems (HCS), where coordinators have to assign the care of every client to an operator, considering his particular skills [4]. In this paper several ILP models and related valid inequalities are proposed for formulating and solving Skill VRP. The proposed models are based on flow variables and constraints, on increasing levels of variable and constraint disaggregation. The models have been tested on a large set of randomly generated instances. The results show that some of the proposed models, when enhanced with suitable valid inequalities, may produce LP bounds close to the optimum at a reasonable computational cost. The proposed models thus appear to be a very promising starting point for solving extensions of Skill VRP which incorporate operational constraints, for example related to the maximum length of the tours. Possible extensions in the context of Home Care Scheduling will be discussed.

Keywords: VRP, ILP Models, Valid Inequalities, Computational Analysis.

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Metaheuristics for the Traveling Salesman Problem with Pickups, Deliveries and Handling Costs

Daniele Vigo[1], *Gunes Erdogan*[2], *Maria Battarra*[3], *Gilbert Laporte*[4]

[1] DEIS - University of Bologna (Italy)

[2] Ozyegin University, Istanbul (Turkey)

[3] Kadir Has University Istanbul (Turkey)

[4] HEC Montréal (Canada)

The Traveling Salesman Problem with Pickups, Deliveries, and Handling Costs calls for the minimum cost tour visiting a set of customers while taking into account the handling costs associated with loading and unloading the items to be delivered and picked up. The problem was first proposed by Battarra et al. [1], who developed exact approaches for its solution, and is an extension of the Traveling Salesman Problem with Pickup and Delivery

(see Gendreau et al. [2] and Gribkovskaia and Laporte [3]). The subproblem of minimizing the handling cost for a fixed route is analyzed in detail and solved through an exact dynamic programming based approach which requires quadratic running time and by a linear-time approximate methods. These algorithms are used as a base for three metaheuristics approaches which are tested on instances adapted from the related literature. The results show that using a tabu search algorithm with the exact algorithm for the subproblem performs best, while using the approximate linear-time algorithm considerably decreases the CPU time at the cost of slightly worsening the solutions.

Keywords: Travelling Salesman Problem, Handling Cost, Pickup and Delivery, Metaheuristics.

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Modeling and Solving the Mixed Capacitated General Routing Problem

Demetrio Laganà[1], *Adamo Bosco*[1], *Roberto Musmanno*[1], *Francesca Vocaturo*[2]

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[2] Dipartimento di Economia e Statistica, Università della Calabria, 87036 Arcavacata di Rende (CS)

We tackle the Mixed Capacitated General Routing Problem (MCGRP) which generalizes many other routing problems. Very few papers have been devoted to this argument, in spite of interesting real-world applications. We

propose an integer programming model for the MCGRP and extend to its polyhedron inequalities valid for the Capacitated Arc Routing Problem (CARP) polyhedron. Identification procedures for these inequalities and for some relaxed constraints are also discussed in this paper. Finally, we describe a branch and cut algorithm including the identification procedures and present extensive computational experiments over instances derived from the undirected CARP and the mixed CARP.

Keywords: Routing Problem, Mixed Graph, Relaxations, Separation Algorithms.

TuA2 - Vehicle Routing

Session organized by Giovanni Righini

Tuesday, 16.00-17.15
Room C1

Column Generation and Dynamic Programming Bounds for the Double TSP with Multiple Stacks

Alberto Ceselli[1], *Roberto Wolfler Calvo*[2]

[1] Università degli Studi di Milano - D.T.I.

[2] Université Paris XIII - L.I.P.N.

The Double Traveling Salesman Problem with Multiple Stacks (DTSPMS) is one of the simplest examples of integrated routing and loading problems: two cities are given, in which N customers are placed. Items have to be collected from the customers through a tour in the first city, and then delivered through a tour in the second city. During the pickup tour, the items have to be organized in stacks on the back of the vehicle; the delivery operations can start only from the top of the stacks. The objective is to find a pair of tours whose overall length is minimum. In this talk we propose an exact combinatorial algorithm for the DTSPMS, in which a relaxation of the problem is computed using dynamic programming techniques. Its performances rely on strong completion bounds, and decremental relaxations of the state space. These procedures are embedded in a column and row generation framework. We compare the performances of our algorithms to those of other exact algorithms from the literature.

Keywords: TSP, LIFO, Column Generation, Dynamic Programming.

Location and Distribution Problems: A General Approach

Emanuele Tresoldi, Giovanni Righini, Alberto Ceselli

Università degli Studi di Milano

We present a general framework for solving mixed location and distribution problems belonging to the wide family of the profitable VRP and its variations like the team orienteering problem. The algorithmic approach proposed is based on the branch-and-price paradigm in which the master problem is solved via a stabilized column generation algorithm while different types of exact and heuristic algorithms are employed to solve the pricing subproblems. The framework considers both location and distribution levels and it is able to deal with problems that can incorporate a number of constraints and requirements like heterogeneous fleets of vehicles, mixed distribution strategies, selection among several locations to be used as depots, mandatory and optional clients, time limits and time windows. Moreover the algorithm can be easily modified and extended in order to include unusual requirements and distribution methodologies that can arise in real applications. In the talk we present a detailed description of the algorithmic aspects of the framework. Moreover a few examples of actual problems modeled and solved exploiting this approach are reported and analyzed. Computational results are provided.

Keywords: Profitable VRP, Column Generation, Location and Routing, Branch-and-Price, Team Orienteering.

Branch and Price for the Vehicle Routing Problem with Discrete Split Deliveries and Time Windows

Matteo Salani[1], *Ilaria Vacca*[2]

[1] IDSIA

[2] Transp-OR, EPFL

The Discrete Split Delivery Vehicle Routing Problem with Time Windows (DSDVRPTW) consists of designing the optimal set of routes to serve, at least

cost, a given set of customers while respecting constraints on vehicles' capacity and customer time windows. Each customer can be visited by more than one vehicle since each customer's demand, discretized in items, can be split in orders, i.e., feasible combinations of items. We introduce two important modeling features: discrete demands and splittings and quantity-dependent service times. These features have been added in order to model in a more realistic way applications where demand consists of items and the unloading time at customers location is not negligible [1]. The existing literature on split-delivery VRP often allows for continuous splitting and fixed service-times. In this context, the solution algorithms based on column generation are advantaged by the knapsack-like substructure of the pricing problem which does not hold in our case [2]. In this work, we model the DSDVRPTW assuming that feasible orders are known in advance. We study the properties of this new enhanced model and its impact on the optimization algorithms. We present a flow-based mixed integer program for the DSDVRPTW, we reformulate it via Dantzig-Wolfe and we apply column generation. The proposed branch-and-price algorithm largely outperforms a commercial solver, as shown by computational experiments on Solomon-based instances. A comparison in terms of complexity between constant service time vs delivery-dependent service time is presented and potential savings are discussed. We also show the application of a framework that we proposed recently, called two-stage column generation, to the DSDVRPTW [3].

Keywords: Vehicle Routing, Column Generation, Split-Delivery.

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TuA3 - Scheduling I

Tuesday, 16.00-17.15
Room B2

Sorting Common Operations to Minimize Tardy Jobs

Claudio Arbib[1], *Giovanni Felici*[2], *Mara Servilio*[1]

[1] Università degli Studi dell'Aquila

[2] Istituto di Analisi dei Sistemi ed Informatica - CNR

We consider the following NP-hard problem (P): given a discrete finite set J of jobs, each requiring a set of operations and associated with a due date, an assignment of the operations to indexes defines the completion time of any job as the largest index of one of its operations. We suppose that once any operation is completed, it is done for all the jobs that require it. The problem calls for finding an assignment that minimizes the number of jobs with completion time exceeding the due date. A practical application of (P) is pattern sequencing in stock cutting. We formulate (P) as a stable set problem on a special graph. We investigate the structure of the graph, and discuss facet-defining and valid inequalities (the former include some Chvàtal-Gomory lifted odd holes). A preliminary computational experience provides difficult instances to be tested in future research.

Keywords: Scheduling, Stable Set Problem, Integer Linear Programming.

On One-Dimensional Cutting Stock with Due Dates

Fabrizio Marinelli[1], *Claudio Arbib*[2]

[1] Università Politecnica delle Marche

[2] Università degli Studi dell'Aquila

Classical stock cutting calls for fulfilling a given demand of part types minimizing trim loss. With the production of each part type assimilated to a job

due by a specific date, a problem arises of scheduling cutting operations. The problem of minimizing a combination of trim-loss and weighted lateness of jobs recently received a synthetic integer linear programming formulation by Reinertsen and Vossen. As can be shown by examples, this formulation is not exact and thus provides in general approximate solutions. We here propose two exact formulations and analyse their properties. A computational study completes the talk.

Keywords: Cutting Stock, Scheduling, Integer Linear Programming.

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A Framework to Optimize the Activities of the Quality Test Function through Scheduling and Simulation

Alessandro Perolini[1], *Giovanni Righini*[2]

[1] Politecnico di Milano

[2] Università degli Studi di Milano

This study deals with the problem of optimizing the activities of the quality test function in manufacturing companies with respect to the international standards. Given a set of activities and the production plan, the goal consists of defining the quality test activities to perform and their sizes in terms of required time and accuracy of the tests. The objective is to minimize the overall quality tests time respecting the international standards and the resource constraints. The production of goods involves structural and organizational factors which have to be controlled because of their effects on the stability of the system. Moreover, customers' requirements and availability of resources have to be taken into account. To address these problems we propose a framework consisting of three parts. The simulation part emulates the production processes and defines the workload of the quality workers with respect to time and product types. The data monitoring part extracts the information about the performance of the production system and of the workers to estimate the

execution time of the test activities. The scheduling part assigns each agent the activities to perform.

Keywords: Scheduling, Quality, Simulation, Performance.

TuA4 - Modelling European Emission Trading Scheme for Energy and Industrial Sectors

Session organized by Elisabetta Allevi

Tuesday, 16.00-17.15
Room A2

Do Environmental Regulations Matter? Evidences from the World Cement Sector

Rossana Riccardi[1], *Giorgia Oggioni*[1], *Simona Pireddu*[2]

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Cement production is energy intensive and generate a considerable amount of greenhouse gas emissions. Cap and trade systems and efficiency based regulations have been introduced overall the world in order to monitor the emissions generated by industrial sectors. Cement industry is included in most of these programs. In this paper, we apply Data Envelopment Analysis techniques to investigate the environmental performance of cement industries operating in 21 among European and non-European countries. We consider both desirable and undesirable production outputs. We take as desirable outputs either cement or cement by-product (clinker) and as undesirable outputs several types of greenhouse gas emissions. The study is conducted over the time horizon 2005-2008 pointing out the changes in efficiency levels within these years and the regulation effects on global performances. Both a sensitivity analysis and a stochastic approach are introduced in order to test the stability of our results.

Keywords: DEA, Environmental Regulations, Cement Industry.

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Evaluating the Carbon Leakage Effect on the Italian Cement Sector

Giorgia Oggioni[1], *Elisabetta Allevi*[1], *Rossana Riccardi*[1], *Marco Rocco*[2]

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The high pollutant activity of power and industrial installations and the limits imposed by the Kyoto Protocol have induced Europe to introduce the Emission Trading Scheme (EU-ETS) in order to curb CO2 emissions. However, the application of this cap and trade system have caused both direct (cost of CO2 allowances) and indirect (increase of electricity price) costs for energy intensive industries participating in this program. Moreover, the absence of an international CO2 agreement may distort European international trades that are mainly represented by carbon-intensive exports. This may be an incentive for energy intensive industries to relocate their production activities in non-regulated countries. This phenomenon is referred to as the carbon-leakage effect (see Demailly and Quirion [1], Ponssard and Walker [3], Meunier and Ponssard [2]). In this paper we investigate the effects of EU-ETS directives on the cement industry with a particular focus on the Italian market, the second European cement producer. The Italian cement sector is analyzed through a Cournot oligopolistic equilibrium model. We adopt a technological representation of the market in order to have a direct control of the different sources of cost (energy, raw materials and CO2 allowances and transportation) and the factors (such as a partial allowance grandfathering as foreseen by Directive 2009/29/EC) that may induce or refrain companies to displace their emissions.

Italy has several coastal plants which are the most exposed to carbon leakage. For this reason, in this analysis, a key role is played by transportation costs that are particularly high in this sector.

Keywords: Carbon Leakage, Cement Sector, Complementarity Models, European Emission Trading Scheme.

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Oligopolistic Power System under CO2 Regime: an Example from the Italian Electricity Market

Francesca Bonenti, Elisabetta Allevi, Giorgia Oggioni

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Climate change is a global issue, but actions to mitigate its development are regional. Europe has taken the leadership in the carbon emission policy by introducing the Emission Trading Scheme (EU-ETS), regulated by the Directive 2003/87/EC, and afterwards by the new Directive 2009/29 that will enter in force at the beginning of 2013. This new Directive foresees the increase of the sectors covered by the EU-ETS, imposes a full and a progressive auctioning system for the allocation of the emission permits respectively to the energy and the industrial sectors and encourages the use of renewable energies. During the first two phases of its application, the EU-ETS has contributed to the increase of the electricity prices. With the current organization, generators are able to pass through a high proportion of their carbon costs in electricity prices leading to an important increase of their profits. The combination of these two effects has induced consumers to reduce their demand. In this paper we investigate the economic impacts of the EU-ETS on the Italian electricity

market by a power generation expansion model. In particular, we assume that generators make their capacity expansion decisions in a Cournot manner. We adopt a technological representation of the energy market and we assume that generators operate in different zones connected by interconnections with limited capacity. We first consider a scenario without CO2 regulation; we then move to the situation characterizing the current second EU-ETS phase. Finally, we take up the new setting of the third EU-ETS phase. The developed models are implemented as complementarity problems and solved in GAMS using the PATH solver.

Keywords: Oligopolistic Model, EU-ETS, Italian Electricity Market.

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TuA5 - Networks

Tuesday, 16.00-17.15
Room AM

A Cycle-Contraction Heuristic for Detecting an Embedded Reflected Network Matrix of Maximum Size

Angelo Parente, Fabrizio Marinelli

Università Politecnica delle Marche

The recognition of special structures in the coefficient matrix of (integer) linear programs speeds up the solution of large-scale LP models and helps in the strategic choice of constraints to be relaxed (convexified) in a Lagrangian relaxation (Dantzig-Wolfe decomposition). Well-known special structures are (reflected) networks. Given a $\{-1, 0, +1\}$-matrix A, an embedded reflected network is a subset of rows of A that can be transformed into a network matrix by multiplying by -1 some of its rows. The most effective heuristic [1] and an exact 0-1 linear programming model [2] for detecting an embedded reflected network of maximum size (DMERN) are both based on a reformulation of the problem as a maximum independent set on the signed graph associated to the coefficient matrix. In the present work, we propose a new heuristic approach for DMERN problem that progressively reduces the order of the signed graph by performing cycle-contraction operations. An extensive computational study on instances from Netlib and on randomly generated signed graphs shows that, in terms of effectiveness, the new approach outperforms the existing heuristics.

Keywords: Network Matrix, Signed Graph, Independent Set.

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Maximizing Lifetime and Handling Reliability in Wireless Sensor Networks Using Adjustable Sensing Ranges

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Wireless sensor networks are generally characterized by a large number of small sensing devices (sensors), randomly disposed all over an area of interest in order to perform a monitoring activity on a set of target points. In order to maximize the total time during which all targets are simultaneously monitored (i.e., the network lifetime), sensors can be opportunely scheduled in subsets able to cover the whole set of targets (covers) which can be sequentially turned on so that the limited battery power of the sensors is efficiently used. Many works in the literature are devoted to the study of the optimal organization of sensors into covers ([1],[2],[3]). Generally, these contributions do not take into account that one or more sensors could stop working with a certain probability. In such a case, indeed, the entire set of covers would be potentially compromised. To overcome such an issue, some authors propose to organize covers so that each target is covered by at least k sensors [4]; this approach can prevent coverage breaches in case of sensor failures. Of course, there is a trade-off between ensuring k-coverage and enlarging network lifetime: if none of the sensors fails, the redundant coverage of the targets would merely result in a shorter network lifetime. We propose an alternative approach that results in a shortage of network lifetime only when sensors actually fail. As considered for example in [5], it is realistic to assume that sensors have adjustable sensing radii. Indeed, in case of failure, the radii of the other sensors in the cover can be opportunely enlarged (increasing their energy consumption) to maintain coverage of all the targets. In this way, each target can be potentially k-covered, but network lifetime would be affected only in case of failures. Therefore, we address the problem of maximizing network lifetime by potentially ensuring k-coverage by means of adjustable sensing radii. Our preliminary analysis and results will be presented.

Keywords: Sensor Networks, Sensor Failure, Maximum Network Lifetime.

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New Consensus Algorithms Based on a Positive Splitting Approach

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The research related to the topic of networked systems has widely increased during the last years [1], [2], [3], [4]. In networks of agents, "consensus" means to reach an agreement on the value of a certain quantity of interest that depends on the state of all agents. A consensus algorithm is an interaction rule that specifies the information exchange between an agent and all of its neighbors on the network [4]. Moreover, such networks are intended to be large-scale, i.e., the number of connected devices can be large to be able to cover large surface areas. Hence, consensus protocols have to be scalable and decentralized algorithms able to solve problems addressing the topological communication of large networks. The consensus protocols with fixed and switching topologies are proposed mainly using concepts and tools taken from algebraic graph

theory [2], [3]. In particular, the network of agents is described by a directed or undirected graph and the associated graph Laplacian matrix L plays an important role in the convergence and alignment analysis [4]. In this contribution we consider a sensor network whose nominal state evolution is governed by a discrete time consensus equation. In particular, we start from the discrete time model of consensus networks defined by the equation x(k+1)=(I-eL)x(k), where I is the identity matrix and e>0 is a parameter. However, such standard protocols exhibit low speed of reaching a consensus for particular topologies of the digraph. In order to determine new and faster alignment protocols, we propose a class of consensus algorithms that are based on the positive splitting [5] of the matrix (I-eL). Moreover, in the framework of non-negative matrix theory some results are proved that guarantee the convergence of the proposed algorithms. In addition, for each network topology we determine the positive splitting that allows reaching the group decision value.

Keywords: Consensus Algorithms, Networked Systems, Non Negative Matrices.

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TuB1 - Logistics II

Session organized by Roberto Musmanno and Demetrio Laganà

Tuesday, 17.15-18.45
Room B3

Capacitated Location of Collection Sites in an Urban Waste Management System

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[2] University of Calabria

Urban waste management is becoming an increasingly complex task, absorbing a huge amount of resources and having a major environmental impact. The design of a waste management systems consists in various activities and one of these is related to the location of waste collection sites. In this talk, we propose an integer programming model that helps decision makers in choosing the sites where to locate the garbage collection bins in a residential town, as well as the capacities of the bins to be located at each collection site. This model includes operational constraints that force each collection area to be capacitated enough to fit the expected waste to be directed to that area, while taking into account Quality of Service constraints from the citizens' point of view. Moreover, we propose an effective constructive heuristic approach whose aim is the provide a good solution quality in an extremely reduced computational time. Computational results on data related to the city of Nardò, in the south of Italy, show that both exact and heuristic approaches provide consistently better solutions than that currently implemented, resulting in a lower number of activated collection sites and a lower number of bins.

Keywords: Urban Waste Management, Collection Sites, Location Problems.

The Product Allocation Problem in a Warehouse with Compatibility and Volume Balancing Constraints

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The organizations are interesting in adopting supply chain management policies for reducing the total costs. In this context, the improvement of each specific activity plays a crucial role: for example, managing efficiently the storage space in a warehouse. It arises to a specific problem, known as Product Allocation Problem (PAP). PAP influences many performance measures of a warehouse (order-picking time and cost, productivity, inventory accuracy and etc.) and thus this problem has attracted the attention of many researchers, interested in developing efficient models and approaches. The traditional solution strategy firstly groups the products in classes (considering their structure and characteristics) and, then, assigns each class to a slot of the storage space. In this work, we firstly present a mathematical model including both compatibility constraints (i.e., two classes could not be located in adjacent slots) and volume constraints for placing each class into the assigned slot. Since in realistic scenarios (many product classes and slots in the warehouse) the mathematical formulation could become computationally intractable, we also describe a two steps heuristic for solving the considered problem in a reasonable amount of time.

Keywords: Product Allocation Problem, Warehouse Management, Product Allocation Problem for Cross Docking, Decision Making on Product Allocation, Item Allocation.

Equity Measures for Location Problems: Shortcomings and Perspectives

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In recent years, a new class of location problems has arisen, considering as objective a measure of "equity" of the distances from the demand points to the set of facilities. In this context a wide spectrum of equity measures has been suggested and location models using these measures have been proposed in order to solve different practical problems in the field of logistics and supply chain management. However, given the quite large number of equity measures that have been introduced, there is a concern about their intrinsic meaning and ability in keeping track of equity issues. For this reason we propose an empirical analysis in order to underline properties and characteristics of a set of equity measures. In particular, we solve facility location problems on randomly generated benchmark problems and we calculate and compare a large set of popular equity measures. The obtained results are discussed and common and different behaviour characteristics are highlighted.

Keywords: Location Problem, Equity Measure, Optimization.

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Analysis of the Best Double Frequency Policy in the Single Link Problem with Discrete Shipping Times

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[2] USA

We study a transportation problem where one product has to be shipped from an origin to a destination by vehicles with given capacity. The product is made available at the origin and consumed at the destination at the same constant rate. The intershipment time must be not lower than a given minimum value. The problem is to decide when to make the shipments and how to load the vehicles with the objective of minimizing the long run average of the transportation and the inventory costs at the origin and at the destination over an infinite horizon. This problem without the minimum intershipment time requirement has been studied in [2]. In this case, the optimal solution is identified by a single number obtained in closed form and consists of shipping the product periodically with a vehicle which may be fully or only partially loaded. [3] studied the Zero Inventory Ordering (ZIO) policy with the additional minimum intershipment time requirement. In this policy, a shipment is performed only when the inventory level is down to zero. [1] showed that the best single frequency policy has a tight performance bound of 5/3, while the best double frequency policy, that is the best among the policies that use at most two frequencies, has a tight performance bound of about 1.286. We study the case in which the intershipment time is a multiple of the minimum value, i.e. the problem with discrete shipping times. The practical relevance of this problem has been pointed out by [4] and [5]. We show that in this case the best double frequency policy has a tight performance bound of about 1.160 with respect to the optimal policy and of about 1.154 with respect to the best frequency based policy. Moreover, we show that, from the worst-case point of view, the best double frequency policy cannot be improved by allowing more shipping frequencies.

Keywords: Logistics, Inventory, Transportation, Worst-Case Analysis.

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TuB2 - Rich Vehicle Routing

Session organized by Claudia Archetti and Manuel Iori

Tuesday, 17.15-18.45
Room C1

Optimization of a Real-World Auto-Carrier Transportation Problem

Manuel Iori, Mauro Dell'Amico, Simone Falavigna

University of Modena and Reggio Emilia

We study a real-world distribution problem arising in the automotive field, in which cars and other vehicles have to be loaded on auto-carriers and then delivered to dealers. The solution of the problem involves both the computation of the routing of the auto-carriers along the road network and the determination of a feasible loading for each auto-carrier. We solve the problem by means of an iterated local search algorithm, that makes use of several inner local search strategies for the routing part, and mathematical modeling and branch-and-bound techniques for the loading part. Extensive computational results on real-world instances show that good savings on the total cost can be obtained within small computational efforts.

Keywords: Vehicle Routing, Loading, Auto-Carrier, Iterated Local Search.

Dynamic NG-Path Relaxation

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In [1] we introduced a new state-space relaxation, called ng-path relaxation, to compute lower bounds to routing problems, such as the Capacitated Vehicle Routing Problem (CVRP) and the VRP with Time Windows (VRPTW). This relaxation consists of partitioning the set of all possible paths ending at a generic vertex according to a mapping function that associates with each

path a subset of the visited vertices that depends on the order in which such vertices are visited. The subset of vertices associated with each ng-path is used to impose partial elementarity. This relaxation proved to be particularly effective in computing lower bounds on the CVRP, the VRPTW and the Traveling Salesman Problem with Time Windows (TSPTW) [2]. In this talk, we propose a new dynamic method to improve the ng-path relaxation which consists of defining, iteratively, the mapping function of the ng-path relaxation using the results achieved at the previous iteration. This method is analogous to cutting plane methods, where the cuts violated by the ng-paths at a given iteration are incorporated in the new ng-path relaxation at the next iteration. The new technique has been used to solve the Traveling Salesman Problem with Cumulative Costs (CTSP) and to produce new benchmark results for the TSPTW. The results obtained show the effectiveness of the proposed method.

Keywords: Traveling Salesman Problem, Cumulative Costs, Time Windows, State-Space Relaxations, Dynamic Programming.

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The Orienteering Problem with Set Constraints

Claudia Archetti, Enrico Angelelli, Michele Vindigni

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The Orienteering Problem (OP) is a problem where a set of customer is given and a non-negative profit is associated to each customer. A single vehicle is available to serve these customers, and the profit of a customer is gained if the customer is served. The objective is to find the route that maximizes the profit collected satisfying a maximum duration limit. The Orienteering Problem with Set constraints (OPS) is a generalization of the OP where customers are clustered in groups. A non negative profit is associated to each group and

is gained only if all customers belonging to the cluster are served. We propose a formulation of OPS and a branch and cut algorithm for solving it to optimality. A set of valid inequalities are inserted to strengthen the formulation. Moreover, a branching rule is proposed based on the choice of group which can be feasibly visited. Computational experiments are carried out to show the efficiency of the valid inequalities and the branching rule.

Keywords: Traveling Salesman Problem, Profits, Orienteering.

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Solving the Traveling Deliveryman Problem through Benders Cuts

Elisa Stevanato[1], *Carlo Filippi*[1], *Juan-José Salazar-Gonzáles*[2]

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The Traveling Deliveryman Problem (TDP), also known in the literature as Traveling Repairman Problem, Minimum Latency Problem and Traveling Salesman Problem with Cumulative Costs, is a variant of the Traveling Salesman Problem (TSP). It arises in a number of applications and turns out to be surprisingly harder than the traveling salesman problem. It consists in finding a path that starts from a fixed node, called depot, and visits all graph nodes, in such a way that the sum of times needed to reach each node is minimum. The TDP was shown to be NP-hard for general metric spaces [1]. Further, even if most combinatorial optimization problem are trivial on trees, TDP is NP- hard also on trees [2] . The aim of this work is to describe a new procedure to solve exactly the problem. We start from a flow formulation of the problem and use Benders' decomposition to consider the high number of flow variables

only implicitly. Cut generation is made through the solution of auxiliary min cost flow problems. Computational results are presented and compared with results shown by Mendez et al. [3] and Abeledo et al. [4] for the same problem.

Keywords: Traveling Salesman Problem, Benders Cut, NP-Hard.

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TuB3 - Scheduling and Surroundings

Session organized by Alessandro Agnetis

Tuesday, 17.15-18.45
Room B2

Radio Resource Allocation in OFDMA Networks: Complexity Analysis and Algorithms

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University of Siena

In this work, the problem of allocating users to radio resources in the downlink of an OFDMA (Orthogonal Frequency-Division Multiple Access) network is addressed. OFDMA has been proposed for the implementation of WiMax networks, and is one of the most promising technologies for next generation wireless systems. The OFDMA technique provides a sub-channelization structure in which the overall frequency bandwidth of a block of transmission, i.e., a radio frame, is divided into a given set of orthogonal radio resources (each resource defined by a pair frequency/time), called subcarriers, the basic units of resource allocation. We consider a single cell environment with a realistic interference model and a margin adaptive approach, i.e., we aim at minimizing the total transmission power while maintaining a certain given rate for each user. In particular, the problem consists in assigning subcarriers to users on a radio frame basis and in determining the transmission-format (i.e., the bit rate) for each assigned subcarrier, in such a way that a given transmission rate is provided for each user. The computational complexity issues of the problem and its special cases are discussed, proving that the problem is NP-hard in the strong sense. An approximation analysis is also presented, showing that the problem does not admit a polynomial-time approximation algorithm with approximation ratio bounded by a constant. Moreover, an approximation tight result for a heuristic algorithm based on a graph model is provided. Heuristic approaches, based on rounding techniques and graph models, that find optima under suitable conditions, or "reasonably good" solutions are presented. Computational experiences show that, in a comparison with a commercial state-of-the-art optimization solver, the proposed algorithms are effective in

terms of solution quality and CPU times. Comparisons with alternatives proposed in the literature definitely assess the validity of the proposed approaches.

Keywords: Resource Allocation, Graph Models, Approximation and Heuristic Algorithms.

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Parallel Dedicated Machines Scheduling with Task-Precedence Constraints

Andrea Pacifici[1], *Alessandro Agnetis*[2], *Hans Kellerer*[3], *Gaia Nicosia*[4]

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[2] Università di Siena

[3] Karl-Franzens Universität Graz

[4] Università di Roma Tre

A set of n nonpreemptive tasks are to be scheduled on m parallel machines in such a way that a given regular function of tasks completion times is minimized. Precedence constraints among the tasks, deterministic processing times and processing machine of each task are given. No machine may process more than one task at a time. We present computational complexity results and solution algorithms for some classes of this problem, namely: When the precedence relations among the tasks are given by two chains, we provide efficient solution algorithms for the minimization of (1) the weighted sum of

task completion times and (2) the number of tardy jobs. Moreover, we show that minimizing (3) the weighted number of tardy jobs is NP-complete in the ordinary sense. For the latter case we also provide a pseudopolynomial time algorithm and a fully polynomial time approximation scheme. The case of chain precedences is closely related to the job shop problem, identifying the chains with the jobs. Indeed, all the above mentioned problems are NP-complete when we consider three or more chains. In addition, for general precedence constraints and makespan minimization, we give a computational complexity characterization depending on the structure of the precedence graph.

Keywords: Scheduling, Computational Complexity, Approximation.

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A Distributed Combinatorial Exchange to Allocate Air Traffic Flow Management Slots

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[3] ALG (Advanced Logistics Group), INDRA Group, Spain

Air Traffic Flow Management delays are often caused by multiple capacity constrained air traffic resources. In fact, if not all airline requests can be accommodated, the Network Manager imposes ATFM slots to flights following a First-Planned-First-Served (FPFS) policy. With respect to this FPFS slot

allocation, we assume that airlines are interested in paying for delay reductions or receiving compensations for delay increases and we propose a market mechanism that allows airlines to trade their FPFS-allocated slots. Our mechanism is distributed as a centralized policy based on the airlines' costs cannot be implemented, unless the Network Manager knows the delay costs for each flight, which are private information internal to airlines. This mechanism is individual rational and budget balanced, meaning that all participants and the Network Manager, are guaranteed to individually experience non negative benefits. We derive slot prices and their corresponding allocation by means of a primal heuristic using a distributed approach based on the Lagrangian relaxation. We apply our algorithm on a real instance considering approximately 500 flights and 60 sectors. Our results show that the market-based solution allows the participating airlines to decrease their overall ATFM delay-related costs with respect to the FPFS allocation by tens of thousands Euros per day. Furthermore, by deriving slot prices, the mechanism allows to discover the real value of different resources to users.

Keywords: Air Transport, Air Traffic Flow Management, Combinatorial Exchange, Competitive Equilibrium.

Recent Advances in Multi-Agent Scheduling Problems

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In the multicriteria scheduling literature, several objective functions are used to measure the performance of a schedule, and all the jobs that are scheduled contribute to each performance measure. In a multiagent scheduling problem, there are several agents, each interested in a subset of jobs. Each agent has its own performance measure in mind, which depends on the schedule of her jobs only. However, all the jobs have to share common resources, so the problem is to find a schedule of the jobs of all agents, which constitutes a good compromise solution. Multiagent scheduling problems arise, for example, in manufacturing, project scheduling, aircraft conflict detection and resolution and railway traffic management. These problems are close to the field of combinatorial optimization and cooperative game theory and are receiving increasing interest in the literature due to the recent developments in collaborative decision making. The complexity of a multiagent scheduling

problem depends on the intersection structure of the job sets of all agents. In this talk, we introduce a classification of multiagent scheduling problems based on the relationship among these subsets and show complexity results for several relevant cases, including classical multicriteria scheduling problems as well as scheduling problems with interfering job sets or competing agents.

Keywords: Scheduling, Multi-Agent, Multicriteria, Interfering.

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TuB4 - Energy

Session organized by Maria Teresa Vespucci

Tuesday, 17.15-18.45
Room A2

Management of a Stochastic Electricity Portfolio with Forward Contracts

Rosella Giacometti, Marida Bertocchi, Maria Teresa Vespucci

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A stochastic multi-stage portfolio model for a hydropower producer operating in a competitive electricity market is proposed. The portfolio includes its own production and a set of forward contracts for future delivery or purchase of electricity to hedge against risks. The goal of using such a model is to maximise the profit of the producer and reduce the economic risks connected to the fact that energy spot and forward prices are highly volatile. Our findings show that the use of forward contracts for hedging purposes results in a risk reduction and in a more efficient use of the hydroplant, taking advantage of the possibility of pumping water and ending up with a higher final value of the reservoir.

Keywords: Electricity Forward Contracts, Electricity Spot Price, Portfolio.

Stochastic Models for the Investment Decision Problem of a Power Producer

Maria Teresa Vespucci, Stefano Zigrino, Marida Bertocchi, Mario Innorta

University of Bergamo

Stochastic models are developed for assessing the impact on capacity expansion decisions of generation companies of constraints imposed on CO2 emissions and on the ratio between the amount of energy produced using fossil-fuel and the amount produced from renewable energy sources. The impact of different scenarios of energy prices and fuel prices (gas, coal and nuclear fuel) are

also taken into account. The objective function is a combination of the total expected profit over the planning period and of a term representing risk. The constraints take into account the availability of plants locations for each new technology as well as budget and CO2 emission restrictions. A case study is presented related to the Italian electricity market.

Keywords: Power Generation Expansion Problem, Stochastic Programming, Risk, CVaR.

A Bilevel Programming Approach to Analyze Investment Decisions in a Zonal Electricity Market with a Dominant Producer

Paolo Pisciella[1], *Maria Teresa Vespucci*[1], *Mario Innorta*[1], *Guido Cervigni*[2]

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We introduce a mixed integer linear model for analyzing the behavior of spot prices in electricity markets composed of many small producers operating under a perfect competition market structure and a large dominant producer. The analysis focus on how such dominant producer can exert market power to influence both prices and amount of energy supplied by the involved producers to the end users. The market is supposed to be divided into zones interconnected by capacitated transmission lines. The model determines the optimal medium-term resource scheduling of a large dimensional producer who operates with the aim of maximizing her own market share while requiring a minimum threshold on profit. Market Operator clearing process is also modeled in order to obtain the hourly zonal electricity prices. The model can be used by investors as a simulation tool for analyzing the impact of investment decisions in the zonal electricity market on profitability.

Keywords: Electricity Markets Modeling, Market Power, Simulation.

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Modelling RES Intermittent Generation in an Electricity Market Simulator by Stochastic Programming

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The increasing amount of Renewable Energy Sources (RES) results in an increasing uncertainty in electricity generation, which has to be taken into account in energy market simulation models. This work, which is a collaboration between R.S.E. S.p.A (former Cesi Ricerca S.p.A.) and the University of Bergamo, deals with the implementation of Stochastic Programming techniques [5] into the MTSIM electricity market simulator in order to take into account wind generation uncertainty. Originally developed by R.S.E, MTSIM [1] is a medium term (time horizon spanning from some weeks to one year) zonal electricity market simulator, which calculates the optimal (in terms of minimization of generation costs) hourly Unit Commitment and Dispatching of thermal and hydro generation plants; moreover, it can also optimize the development of inter-zonal transmission capacity. MTSIM is used in scenario analyses for a wide range of applications: from the feasibility study of a single generation plant to the development of the cross-border European Transmission Network [2][3][4]. The newly introduced stochastic approach models the

day-ahead electricity market, where energy bids submitted for the day ahead are based on wind generation forecasts which will necessarily differ from the actual wind generation. From the hourly data of forecasted and actual wind generation (available on the web site of the Italian TSO TERNA) a statistical distribution of the forecasting error can be built. Then, by considering this error distribution around a mean wind generation profile, wind generation scenarios are created. Future developments of this work will be aimed to make MTSIM able to take into account uncertainty related to other kinds of RES intermittent generation as well as to demand.

Keywords: Stochastic Programming, Wind Generation, Intermittent Generation, Electricity Market.

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TuB5 - Models and Methods for Health-Care Management

Session organized by Edoardo Amaldi

Tuesday, 17.15-18.45
Room AM

A Probabilistic Multi-Period Optimization Model for the Ambulance Location Problem

Giuliana Carello, Edoardo Amaldi

Politecnico di Milano, Dipartimento di Elettronica ed Informazione

An Emergency Medical Service (EMS) is a service providing first care to patients with illnesses and injuries. A key performance issue for an EMS system is the early response, which substantially increases the probability of full recovery. Since the location of emergency vehicles across the considered area plays a fundamental role in EMS management, the problem has been extensively investigated in the optimization literature. A variety of models have been proposed, ranging from deterministic and static models to dynamic and probabilistic ones, see e.g. [1]. The aim is to capture the dynamic and probabilistic aspects of the problem while being able to solve real-life instances. In this work we propose a probabilistic multi-period ambulance location model based on a recent robust optimization model for the Uncertain Set Covering problem [2]. The model takes into account different demand scenarios (amount and distribution) which must be faced by the emergency vehicles and allows to relocate ambulances during the considered time horizon. We show that medium-size instances can be solved to optimality with state-of-the-art mixed integer programming solvers and propose a Lagrangian-based approach to tackle larger instances and to derive both lower and upper bounds. Tests are carried out on Milano and Lombardia real-life data. The model is also extended to take into account fleet dimensioning, as additional ambulances can be reserved through different types of contracts with volunteer associations (e.g., white cross, green cross, etc).

Keywords: Ambulance Location, Multi-Period Model, Probabilistic Model, Integer Linear Programming, Lagrangian Based Approach.

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Fast Algorithms for Supporting the Decisions in Ambulance Management

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Dealing with ambulance management, the standard approach is to assign a mission to the closest ambulance and to send back the unit to the starting location when the mission terminates. Managing the units in a different way may have a positive impact on the quality of the service. In this paper, we present a method rooted in the concept of marginal contributions that allows giving a fast and efficient answer to the problem of choosing which ambulance to send for a rescue mission when more than one may provide an equivalent service and to the problem of selecting the location where the ambulance returns at the end of the mission.

Keywords: Ambulance Management, Location Problem, Marginal Contribution.

Long Term Policies for Operating Room Planning

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This paper deals with the operating room planning problem. Given a Operating Theater composed of several (and possibly different) operating rooms, and given a waiting list of elective surgeries for each surgical discipline the aim is to assign Operating Room to surgical disciplines and allocate elective surgeries to Operating Room so to minimize delays and reduce waiting times. In this paper, we study different management policies for computing the weekly Master Surgical Schedule and for assigning surgical cases to be performed during the week. Mathematical formulations and heuristics are proposed to implement the different management policies. The evaluation is carried out on the basis of an annual simulation. Several indicators are computed for each simulation run including operating room utilization, throughput and lateness, and are used to assess the effectiveness of each policy. Computational results obtained by applying the proposed models to a medium size hospital in Tuscany are presented.

Keywords: Operating Room Planning, Healthcare, Elective Surgeries.

A Two Level Metaheuristics for the Operating Room Planning Problem

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In this paper we deal with the Operating Room (OR) planning and scheduling problem at a tactical level (i.e., weekly timetable and assignment among

OR, days and specialties and elective patients assignment to OR blocks), using a block scheduling approach. In particular, given a number n of patients belonging to m surgical specialties (wards) and a number v of OR block times available for elective surgery, we consider as input data the number of blocks assigned to each specialty, and we want to determine within a given planning horizon the specific OR and day of the week each block should be scheduled and which patients should to be operated on within each block. First, a Mixed Integer Linear Programming (MILP) model is proposed to solve in a concise framework the proposed problem with the aim of maximizing the overall societal cost of OR planning. Given the complexity of the problem we propose a metaheuristic solution approach based on Tabu Search methodology composed of a basic search and some intensification and diversification methods. The basic search starts from a feasible solution built by a greedy selection and patient exchange procedure and is continued until a pre-specified number of iterations without improvement is reached. Starting by the local optima at a patient level an intensification procedure is applied to improve the solution at an OR block level using ward swaps neighborhood within a Local Search framework. Then a diversification procedure is applied to the current solution in order to redirect the search towards a different region of the solution space. The algorithm has been tested on a set of benchmark instances based on real data collected from a large Italian teaching hospital. Results are really promising since the actual gap with best known solutions is about 0.63% and the optimality gap is about 1.39% for instances having 400 patients. Moreover the average running time required to compute the best solution is about 22 seconds on a standard laptop under Linux operating system.

Keywords: Operating Room Planning and Scheduling, MILP Model, Metaheuristics.

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WeA1 - Maritime Logistic I: Containers Handling and Distribution

Session organized by M. Flavia Monaco, Paola Zuddas and Daniela Ambrosino

Wednesday, 9.00-10.15
Room B3

Optimization Model for the Inland Distribution of Containers from a Port

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We study a problem faced by several maritime container shipping companies. They must deliver loaded containers to import customers, provide empties for export customers and determine the routes of trucks in order to serve both imports and exporters. The resulting routing problem exhibits several sources of complexity, due to precedence constraints between customers, trucks carrying more than one container and the need to wait for containers during pick-up and delivery operations. To address this problem, we propose an optimization model. We illustrate randomly generated experiments by a standard solver and show to which extent it can be used. Finally, a number of solution methods are illustrated.

Keywords: Intermodal Container Transportation, Vehicle Routing Problem with Full Truckload, Pickup and Delivery.

References

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Train Load Planning Problems in Seaport Container Terminals

Daniela Ambrosino, Simona Sacone, Silvia Siri

University of Genova

This work is devoted to landside transport optimization in a seaport and presents an optimization approach for the definition of loading plans for trains. A loading plan indicates on which wagon a container has to be placed; this decision generally depends on the destination, type and weight of the container, the maximum load of the wagon and the train composition. Also the container location in the storage area can influence the loading plan. We consider the case in which the loading plan is performed by the terminal operator with the aim of minimizing the re-handling operations in the stocking area where containers are waiting for being loaded on trains and maximizing the train utilization. More precisely, the problem under investigation is the train load planning of import containers on one track, i.e. only one train; in fact, we assume to plan the train loading operations for trains one by one. Furthermore, we suppose that the overhead travelling crane loads the train sequentially (starting from the first wagon onwards) and some re-handling operations in the stocking area are allowed. When dealing with real loading problems, the real weight constraints are stricter than simply considering a maximum weight capacity for each wagon and train. Thus, we assume that more than one container can be placed on board of a wagon and different weight restrictions have to be satisfied in accordance with the physical configurations of the wagon. We propose two mathematical formulations and a solution approach for solving the load planning problem in a seaport terminal that has to plan the train loading for shuttle trains directed to the inland port. We compare the solutions obtained by the heuristic approach with those obtained by solving up to optimality the

mathematical programming formulation. Preliminary computational results are reported.

Keywords: Seaport, Train Loading, Mathematical Programming, Heuristics.

References

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Management of Concurrent Operations in Two Container Vessels

M. Flavia Monaco, Manlio Gaudioso, Gregorio Sorrentino

Dipartimento di Elettronica, Informatica e Sistemistica - Università della Calabria

Transshipment operations at a maritime container terminal are usually implemented according to the ship-yard-ship cycle. The sojourn time of the container at the yard is in general sufficiently long to guarantee the possibility of independent scheduling of the download-upload operations. In recent times is getting more and more frequent the so called "live connection", in the sense that a downloaded container is immediately transshipped, completely skipping the yard storage phase. Live connection assumes at least partial overlapping of the berthing time windows of the involved ships, whose download-upload sequences can not be considered independent any longer. In the talk we survey several technical issues related to the handling of concurrent operations for two ships, and provide some guidelines to handle the problem in the scheduling theory framework.

Keywords: Maritime Container Terminal, Logistics, Live Connection, Scheduling.

WeA2 - PRIN 2008: Models and Algorithms for Combinatorial Optimization Problems in the Management of Transportation Systems

Session organized by Paolo Toth

Wednesday, 9.00-10.15
Room C1

Column Generation for a Rich Pickup and Delivery Problem

Andrea Bettinelli, Alberto Ceselli, Giovanni Righini

Università degli Studi di Milano

We present a rich pickup and delivery problem arising from a real project aiming at providing a platform that allows small distribution logistics companies to share their fleets and customers in order to exploit economies of scale. The problem we study involves: heterogeneous fleets, multiple depots (often corresponding to the house of the drivers), incompatibilities between goods, vehicles and customers, multiple (hard and soft) time windows and maximum route length. We present a column generation approach where the pricing problem is a particular resource-constrained elementary shortest-path problem, solved through a bounded bi-directional dynamic programming algorithm.

Keywords: Pickup and Delivery, Column Generation.

The Two-Echelon Capacitated Vehicle Routing Problem

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In the Two-Echelon Capacitated Vehicle Routing Problem (2E-CVRP) the delivery to customers from a central depot uses intermediate depots, called satellites. The 2E-CVRP involves two levels of routing problems. The first level requires to design the routes for a vehicle fleet located at the depot to transport the customer demands to a subset of the satellites. The second level concerns the routing of a vehicle fleet located at the satellites to supply all customers from those satellites which have been supplied from the central depot. The objective is to minimize the total routing cost. In this talk, we describe a new exact method for solving the 2E-CVRP based on a new mathematical formulation of the problem. The lower bounds produced by different bounding procedures, based on ng-path relaxation and dual ascent methods, are used by an algorithm that decomposes the 2E-CVRP into a limited set of subproblems. Computational results on benchmark instances from the literature show the effectiveness of the proposed method.

Keywords: Two-Echelon Vehicle Routing, Dual Ascent, Dynamic Programming.

Cutting Planes and a Separation Theorem for Convex Sets

Michele Conforti

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Four decades ago, Gomory introduced the corner polyhedron as a relaxation of a mixed integer set in tableau form and Balas introduced intersection cuts for the corner polyhedron. We introduce a general model that extends the concept of corner polyhedron and characterize minimal cuts in terms of Lattice-Free convex sets. This is joint work with G. Coruejols, A. Danilidis, C. Lemarechal and J. Malik.

Keywords: Integer Programming, Cutting Planes, Convex Analysis.

WeA3 - Regression and Multiple Criteria Decision Aid

Wednesday, 9.00-10.15
Room B2

Support Vector Machine for Robust Regression

Renato De Leone, *Sonia De Cosmis*

School of Science and Technology, University of Camerino

Support Vector Machines (SVMs) are a novel and extremely effective tool for classification and regression, belonging to the class of supervised learning methods. Similarly to Artificial Neural Networks, the study of learning machines grew up by the attempt to emulate the behavior of the human brain, especially for its flexibility and compactness, combined with a high level of parallelism. Robust optimization has received in these years particular attention for the ability of effectively addressing the issue of uncertainties and bounded variability in the data. The tradeoff is to accept a suboptimal solution in order to ensure that the solution remains feasible and near optimal in the case of changes in the data. In this talk we will discuss the main characteristics of Robust Support Vector Machines (RSVMs) and their capability of dealing with outliers and bounded perturbation of the value of the input data. In robust classification it is possible to deal with box-type uncertainty sets; here we propose to extend these robust methods to regression. Moreover, applications of RSVMs to the solution of regression problems will be presented.

Keywords: Support Vector Machine, Robust Optimization, Regression.

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New Approach to Estimate the Parameters of Electre Tri Model in the Ordinal Sorting Problem

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In Multi Criteria Decision Aid (MCDA) a set of alternatives are evaluated through a set of criteria which measures their performances. Among the four different problematics, that Roy distinguishes (ranking, sorting, choosing and describing), in this talk we are interested in the Multi Criteria Sorting Problem (MCSP). It belongs to grouping problems in which groups are defined a priori in order to determine the assignment of the alternatives to each predefined category (i.e. group). In this talk we focus our attention on the well-known method Electre Tri based on an outranking relation built upon the Decision Maker (DM) s preference information in terms of the Assignment Example (AE). This method requires the elicitation of preferential parameters (weights, thresholds, category limits, cutting level) in order to construct a preference model which the decision maker (DM) accepts as a working hypothesis in the decision aid study. Mousseau and Slowinski (1998) proposed an interactive approach that infers the parameters of an Electre Tri model from AEs; the determination of an Electre Tri model that best restitutes the AEs is formulated through an optimization (non-linear programming) problem in which veto thresholds are not considered. We propose instead a new approach to estimate the parameters of the Electre Tri model, taking into account that the core of the procedure is the profiles estimation. Two algorithms based on linear and integer programming problems are proposed and then their performances are compared through simulation.

Keywords: Multiple Criteria Decision Aid, Sorting Problem, Electre Tri Method.

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Integration of Soft and Hard OR Tools to Support Innovation Processes

Chiara Novello, Maria Franca Norese

DISPEA, Politecnico di Torino

Acquiring and organizing knowledge and information elements are essential activities in the innovation processes, to understand complexity and uncertainty elements and therefore to limit or control them. Not only technological, but also organizational complexities are present, together with uncertainties on the market that has to accept the innovation. An analysis of these elements was developed in relation to the SMAT project, an industrial project which aims to design unmanned aerial vehicles (equipped with sensors for specific data acquisition uses and data storage and communication systems), working together as an integrated monitoring system for a civil use and coordinated by a supervisory control station. Several enterprises and public organizations have to be involved in the conceptual phase of this design process and in the first phase of the SMAT project we worked in order to identify the potential users of the monitoring system and the characteristics of their needs and their constraints on the system implementation and use, and to analyze them from the points of view of the private and the public actors who should be involved in the innovation process. An integration of some soft (actor network analysis and cognitive mapping approach) and hard (multiple criteria decision aiding and mathematical programming) OR tools was proposed in the industrial project in order to acquire and structure information and knowledge elements and analyze them in formal models. All the acquired elements were organized in order to recognize roles and relationships of the focus organizations who have to be involved in the future phases of the project, define elementary and macro monitoring activities, create monitoring scenarios and plan monitoring missions. In the presentation, the potentialities of this integration will be described in relation to some specific activities that are above all oriented to identify and structure technological, organizational and economic constraints, that limit the generation of design alternatives, and criteria that should be used to orient the decisions in the global innovation process.

Keywords: Multiple Criteria Decision Aiding, Cognitive Mapping, Actor Network Analysis, Mathematical Programming.

WeA4 - Nonlinear Optimization and Applications I

Session organized by Gianni Di Pillo

Wednesday, 9.00-10.15
Room A2

A New Parameter Dependent Class of Preconditioners, for Large Scale Systems of Numerical Optimization

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We study and test a class of preconditioners, which are tailored for indefinite symmetric linear systems from non-convex nonlinear optimization. Our proposal is specifically tailored for large linear systems, and the preconditioners in our class are iteratively built as by-product of Krylov-based solvers. Indeed, the latter methods generate directions which can be used in order to provide approximate inverse preconditioners. Then, our proposal is easily combined with diagonal and block-diagonal preconditioning, in a general framework. Each preconditioner in our class is identified by specific values of parameters, which are user-dependent, and may be set according with the structure of the problem in hand. Several theoretical properties guarantee that the eigenvalues of the preconditioned matrices are clustered in some sense. Moreover, we are able to provide an estimation of the condition number for the preconditioned matrix. We have tested our proposal on a set of linear systems arising both from large scale optimization and linear algebra applications.

Keywords: Large Scale Optimization, Krylov Subspace Methods, Preconditioning, Approximate Inverse Preconditioners.

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A Unified Cutting Plane Model for both Convex and Nonconvex Optimization

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We describe an algorithm for the unconstrained minimization of both convex and nonconvex nosmooth functions of several variables, based on the construction of a piecewise affine model. In particular the model is of the affine minmax type and does not necessarily support the objective function from below. In addition, no translation of the affine pieces is required. Finite termination is proved at a point satisfying an approximate optimality condition. Some numerical results are also reported.

Keywords: Nonsmooth Optimization.

Generalized Nash Equilibria for the Service Provisioning Problem in Cloud Systems

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In recent years the evolution and the widespread adoption of virtualization, service-oriented architectures, autonomic, and utility computing have converged letting a new paradigm to emerge: the Cloud Computing. Clouds allow the on-demand delivering of software, hardware, and data as services. As Cloud-based services are more numerous and dynamic, the development of efficient service provisioning policies become increasingly challenging. In this paper we take the perspective of Software as a Service (SaaS) providers which host their applications at an Infrastructure as a Service (IaaS) provider. Each SaaS needs to comply with quality of service requirements, specified in Service Level Agreement (SLA) contracts with the end-users, which determine the revenues and penalties on the basis of the achieved performance level. SaaS providers want to maximize their revenues from SLAs, while minimizing the cost of use of resources supplied by the IaaS provider. Moreover, SaaS providers compete and bid for the use of infrastructural resources. On the other hand, the IaaS wants to maximize the revenues obtained providing virtualized resources. In this paper we model the service provisioning problem as a generalized Nash game and we show the existence of generalized Nash equilibria. Moreover, we propose two solution algorithms based on the best-reply dynamics and we prove their convergence in a finite number of iterations to a generalized Nash equilibrium. In particular, we develop an efficient distributed algorithm for the run-time allocation of IaaS resources among competing SaaS providers. We demonstrate the effectiveness of our approach by simulation and performing tests on a real prototype environment. Results show that, compared to other state-of-the-art solutions, our model can improve the efficiency of the Cloud system evaluated in term of Price of Anarchy by 50-70%.

Keywords: Cloud Computing, Resource Allocation, Game Theory, Generalized Nash Equilibrium.

WeA5 - Revenue Management

Wednesday, 9.00-10.15
Room AM

A Hybrid Approach for Forecasting the Demand for Hotel Rooms

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Forecasting the demand for hotel rooms is fundamental for applying any mechanism of revenue management [1]. In fact, for implementing pricing policies, a revenue manager needs first of all to know the expected level of the demand for each day. We propose a novel hybrid approach for producing demand forecasts. In the literature, several models have been developed. They estimate demand from historical data series in various ways and which model performs better depends at least on characteristics of the demand of each single hotel, arrival date and distance to arrival date. We propose an hybridization of eight of the most relevant models proposed in the literature [2]. The hybridization is based on the observation that the best model depends on the chosen hotel, arrival date and time to arrival. Looking at the problem from this novel perspective, we divide the time horizon for which we need to produce a forecast into weekly sub-periods. We propose an automatic procedure for selecting the best model for each week, and the best parameters for this model. We studied this approach in collaboration with GP Dati Hotel Service SpA, that is an Italian firm that designs and produces management solutions aiming at hotel companies. The flagship product of the firm is Scrigno, a modular, flexible and integrated suite for managing hotel chains and reservation centers using a market-oriented approach. Thanks to the collaboration with the firm, we could test the hybrid approach on real datasets coming from several Italian hotels. The results we obtained are very encouraging, up to the point that the firm is currently testing a forecasting module based on the hybrid approach. After this test phase, the firm will include the forecasting module as an optional feature of Scrigno.

Keywords: Forecasting, Revenue Management, Hybrid Approach.

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An O.R.-Based Proposal for Touristic Promotion of Small Cities and Territories

Adriana Novaes, Giovanni Righini

Università degli Studi di Milano

The aim of this work is to formulate a possible scientific approach to the problem of promoting the tourism in small cities, out of the classical touristic itineraries yet showing characteristics that make them potentially attractive for tourists and visitors. We consider the possibility to offer tourists and business travellers suitably predefined packages including for example: guided tours to artistic, historical and industrial sites, gourmet lunch and dinner alternatives, city-shopping, music concerts and other cultural events. The proposed model aims at coordinating the flow of tourists through the events, avoiding both crowd and empty situations at the several points of interest, reducing time uncertainty of the tourists' experience, helping them in their decisions about schedule, increasing economies of scale, improving service level, reducing costs and getting the maximum profit from the tourists' willingness to pay. This problem of profit maximization is formulated based on the theory and practice of Revenue Management [1]. Two complementary optimization methods are exploited: mathematical programming and simulation.

Keywords: Revenue Management, Mathematical Programming, Simulation.

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WeB1 - Maritime Logistic II: Resources Allocation and Management

Session organized by M. Flavia Monaco, Paola Zuddas and Daniela Ambrosino

Wednesday, 10.15-11.30
Room B3

Optimization and Simulation for Terminal Container Seaside

Elena Tànfani, Daniela Ambrosino

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In this work we present an integrated simulation and optimization approach for the analysis of a maritime container terminal. In particular we focus on the tactical and operational decision problems related to the organization of the seaside area. The study herein presented uses as operative scenario the Southern European Container Hub (SECH), sited in the Port of Genoa, Italy. The SECH is an import/export terminal actually involved in two major projects. The first one is related to investment on the quay cranes in order to make them able to operate vessels with capacity up to 8500 TEUs. The second pertains the expansion plan that will enlarge the current surface area and the annual throughput capacity. Due to these planned projects the terminal is facing new problems concerning the management of increasing traffic volumes and, as a consequence, implementing new operative policies, mainly related to the organization of the seaside area. With the aim of helping the terminal in the evaluation of tactical and operational choices, we propose a Discrete Event Simulation (DES) model that is able to implement and evaluate alternative scenarios pertaining to possible changes of the import/export flows, different operative rules, capacity and shift availability of the human and equipment resources. Moreover, we developed a 0-1 LP model to solve the Quay Crane Assignment Problem (QCAP), also including in the formulation the Gang Deployment Problem. The aim is to determine the assignment, on a shift basis, of QCs and gangs to each ship served by the terminal during a given planning horizon achieving cost savings related to a better use of handling and human resources. Simulation will be also used for evaluating the effects of different

operative decisions related to the scheduling of QCs and for understanding the improvement that can be obtained in the performance of the terminal when an optimal quay crane assignment is performed. Preliminary results will be given by analyzing some performance indices of interest, such as berthing time, net terminal performance index, quay crane and gang utilization rate.

Keywords: Discrete Event Simulation, 0-1 LP Model, Container Terminal, Performance Analysis.

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Robust Berth Allocation Problems at Transshipment Terminals

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Standard models for the berth allocation problem are commonly based on the assumption that arrival times are known in advance without uncertainty. Hence, as soon as some random disturbance occurs, delaying the arrival of some

critical vessel, the planned "optimal" schedule may easily result far from optimality or even infeasible and possibly difficult to recover. This has motivated the recent interest towards berth allocation models dealing with uncertainties. We particularly focus on models facing the uncertainty according to the robust paradigm, with the aim of constructing berth plans that are less sensitive to uncertainties, hence preventing propagation of possible delays to other ships in the schedule.

Keywords: Berth Allocation, Robust Optimization, Dynamic Programming.

References

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2. Moorthy R., Teo C.-P. (2006). Berth management in container terminal: the template design problem. OR Spectrum 28, 495-518.

An Optimization Model for Daily Manpower Allocation in Transshipment Container Terminals

Patrizia Serra[1], *Massimo Di Francesco*[2], *Paolo Fadda*[2], *Gianfranco Fancello*[2], *Paola Zuddas*[2]

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[2] Department of Land Engineering, University of Cagliari, Piazza d'Armi 16, 09123, Cagliari, Italy

This work is motivated by the manpower allocation problem arising at the Cagliari International Terminal Container. Generally speaking, human resources allocation plays a key role in terminals with high labor costs, in order to achieve high levels of productivity and quality services for customers. As a result, terminal containers exhibit a growing interest in advanced decision support systems, in which optimization methods play a crucial role. In this talk we present an optimization model for manpower allocation in transshipment container terminals. The objective is to determine the optimal daily allocation of crane operators and trailer drivers at an operational planning level, taking into account different requirements for permanent staff, external workers and

personnel shortfall. The model is exactly solved by a state-of-art solver within reasonable times for the needs of terminal containers.

Keywords: Human Resources Allocation, Transshipment Container Terminals, Manpower Planning.

References

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WeB2 - O.R. Teaching in Schools: Ideas, Proposals, Experiences

Session organized by Giovanni Righini

Wednesday, 10.15-11.30
Room C1

Operational Research: a Multifunctional Didactical Approach for Upper Middle School

Alberta Schettino

Istituto Tecnico Industriale "Galilei", Imperia (ind. Logistica e Trasporti); Università Telematica delle scienze Umane "Niccolò Cusano"

The main aim of this work is to show how Operational Research (OR) can be profitability used as a methodological and didactical approach for the study of mathematics through the entire second level of Secondary Education with a strong multipurpose vocation [1]. As it has been highlighted in international studies [2] the study of OR is very effective in stimulating motivation and could represent a concrete tool to improve the low mathematical performance of Italian students. Until today, OR received little attention in the mathematics syllabus in Italy. This trend has been confirmed by the guidelines of the "Gelmini" reform of secondary education (Licei), since OR concepts are almost absent in its specific learning aims [3]. In this work we firstly give some information on OR teaching in Italy and worldwide, afterwards we give a brief synthesis about the performance of Italian students reported by the OCSE-PISA survey during the period 2003-2009 [4] [5], explaining the present relation between the tested competence levels and the capacity of our students in modeling and problem-solving. OR is therefore suggested as an intervention tool, in this situation of "mathematical emergency". Moreover, could supply new and attractive instruments, inserting methods and elements derived from informatics into the working plans of mathematics. Personal experiences as teacher of mathematics involved in the AIRO games since 2009 (the 2011 session still going on) have also been reported.

Keywords: Mathematics Education, OCSE-PISA Survey, AIRO Games.

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Teaching O.R. at School: Ideas, Proposals, Experiences

Giovanni Righini, Alberto Ceselli

Università degli Studi di Milano

The aim of this presentation is to focus on some of the main misunderstandings that seem to forbid inserting O.R. into official syllabi in the Italian school system. In particular:

- "O.R: is a topic to be taught at a university level"
- "O.R. would be one more topic in the syllabi".

We will present some simple examples about teaching the very basic concepts of optimization, model and algorithm, starting from the fourth year of primary school up to the illustration of the format we have adopted for students' stages at university that we have proposed in the framework of the Programma Lauree Scientifiche and that allowed us reaching about 400 high school students in Lombardy during the last school year. In all these examples we will show how O.R. should not necessarily be conceived as one more topic but rather as a new way to teach mathematics.

Keywords: Operations Research, Operations Research!, Operations Research!!

A Teaching Strategy for Mathematics Based on Problem Solving. The Training Experience of LOGIMAT Courses in Campania Region

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In the last years Campania Region carried out several initiatives aimed to prepare Campania students to sustain PISA trials of OCSE (Organisation for Economic Co-operation and Development) ([1], [2]), with particular reference to Mathematic trials, based on the concept of "problem solving", which is not traditionally present in Mathematics teaching. In this context the Education Department of Campania Region promoted and supported two courses on the logical-mathematical learning with the scope to train mathematics teachers of Secondary School, within a deal between Public Education Ministry and Campania Region, which establishes to put in act initiatives aimed "to sustain the education of mathematics, science and technology in the school and to favor the didactic innovation". The two courses have been held in 2008/09 (LOGIMAT [3]) and in 2010 (LOGIMAT2 [4]) by the Department of Computer Science and Systems of the University "Federico II" of Naples, with the cooperation of professors of the Department of Mathematics and Applications. Each course has had a duration of 100 hours and has been based on seminars and frontal lessons on education methodologies and applicative themes aimed to make more captive the study of the mathematics, and on autonomous study, analysis and experimentation of the subjects and methodologies learned during the course. The seminars have been held by professors of University of Naples and other Italian Universities (University of Salerno, Polytechnic of Milan, University of Milan and University of Turin). School teachers who successfully attended the course performed a final presentation on a theme related to the logical-mathematical learning and received an attendance certificate by Campania Region, Regional Educational Directorate and University of Naples.

Keywords: Problem Solving, Logical-Mathematical Learning, Teaching Strategy.

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WeB3 - Learning Methods

Wednesday, 10.15-11.30
Room B2

Discovering the Gene-Drug Relationships for the Pharmacology of Cancer: A p-Median Approach

Elisabetta Fersini, Enza Messina, Francesco Archetti

University of Milano-Bicocca

The combined analysis of tissue micro array and drug response datasets has the potential of revealing valuable knowledge about the relationship between gene expression and the drug activity of tumour cells. Highlighting these relationships is of crucial importance for several objectives, among others: identification of mechanisms of the cancer development, design of new molecular targets for anticancer drugs and definition of an individual therapy driven by a specific gene profile. However, the amount and the complexity of biological data to be taken into account needs appropriate machine learning algorithms to uncover possible interesting patterns. We propose a relational clustering framework based on p-median problem formulation aimed at revealing the link between gene expression profiles and drug activity responses aimed at explaining the drug sensitivity/resistance. To this end a two phases approach has been developed and integrated with feature selection and probabilistic graphical models. The results obtained by this approach highlight two main facts: (1) the two phases clustering approach is able to create group of cell lines that are highly correlated both in terms of gene expression and drug response; (2) from a biological point of view, the gene selection performed on these clusters allows for the identification of a subset of genes that are strongly involved into several cancer processes. The final prediction of drug responses, by using the obtained clusters and the selected genes, represents an initial step for predicting potential useful drugs according to the gene expression level of tumour tissues.

Keywords: Clustering, p-Median, Pharmacology of Cancer.

Constrained Conditional Random Fields for Semantic Role Labeling

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This work investigates a method to infer a structured representation of contents from unstructured textual documents. Natural language documents are characterized by a significant level of ambiguity and often contain partial or imperfect information. The problem can be formalized as the assignment of a finite sequence of semantic labels to a set of interdependent variables associated with text fragments, and it is modeled through a stochastic process involving both hidden variables (semantic labels) and observed variables (textual cues). In this work we investigated one of the most recent and promising learning approach for semantic labeling, named Conditional Random Fields (CRFs) [1,2]. Standard CRFs are enhanced in a two stages approach, where the label assignment problem is modeled as an Integer Linear Programming; such specific modeling strategy makes it possible to include in the decision process both specific domain knowledge and context knowledge learned from data. The extra knowledge included in the model is in the form of logic rules learned from training data with ad hoc logic mining methods (as in [3]). Such modification makes it possible to improve the performances of the CRF inference procedure without significant increases in the complexity of the solution algorithm. The proposed approach has been validated by using a set of benchmark data and tested on real textual documents in the judicial domain.

Keywords: Conditional Random Fields, Logic Mining, Optimization.

References

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to the classification of biological data. International Symposium On Mathematical And Computational Biology

Leaks Localization within Water Supply Networks via Supervised and Unsupervised Learning H2OLEAK Project

Antonio Candelieri[1], *Valentina Carboni*[1], *Enza Messina*[1], *Ilaria Giordani*[2], *Leonardo Castiglioni*[3]

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[2] Consortium Milano Ricerche, Italy

[3] S.D.I. Automazione Industriale s.r.l., Italy

Water supply service is crucial for the citizens quality of life but distribution networks are usually complex making their management a challenging task. In particular, leaks entail management costs and unsatisfactory quality of service. Dispersions are difficult to be identified and detected: they can be due either to the progressive deterioration of pipes or to fraud and under-registration. In occasion of the World Water Day 2011, the Italian institute of statistics (ISTAT) provided a report about the service in 2008 stating that, at national level, dispersions amount at about 47%. The H2OLEAK project aims at designing and developing a tool for localizing leaks by providing a suitable clustering of the network into independent sub-sectors (District Meter Areas, DMA). Input data will be acquired by a Supervisory Control & Data Acquisition system (SCADA) deployed for continuous online monitoring of key features (pressure and flow) at crucial points of the net (e.g., at the entry and exit of districts). Within this project we propose a leak localization approach based on Supervised and Unsupervised Learning together with an intensive use of hydrologic simulation. First, several leaks (different for location and intensity) are simulated both on the entire network and on isolated districts; the related key measures obtained through simulation are compared to those obtained on the network without leaks. These data are used for training a classification model for a first-level localization aimed at identifying the district that is most probably affected by the leaks. At a second-level, clustering is applied for identifying which set of pipes, within the selected district, are most probably associated to the observed variations. The performances of the

proposed approach are validated on a set of artificially simulated data and tested on real data acquired from the water distribution network of Torbole, a little town on the shore of Lake Garda.

Keywords: Water Supply Service, Leaks Detection, Supervised and Unsupervised Learning.

WeB4 - Nonlinear Optimization and Applications II

Session organized by Gianni Di Pillo

Wednesday, 10.15-11.30
Room A2

On Solving the Quadratic Subproblem in Nonconvex Nonsmooth Minimization

Antonio Fuduli[1], *Manlio Gaudioso*[2], *Evgeni A. Nurminski*[3]

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[2] Dipartimento di Elettronica Informatica e Sistemistica - Università della Calabria - Rende (CS) - Italia

[3] Institute for Automation and Control Processes - Far East Branch, Russian Academy of Sciences - Vladivostok - Russia

We present a new bundle method for nonsmooth nonconvex minimization which is based on the construction of two local piecewise affine approximations, lower and upper, respectively, of the objective function. The main innovation in the proposed method is related to the quadratic subproblem to be solved at each iteration. In fact it is approximately reduced to the problem of finding the minimum norm vector in a convex combination of a finite set of points. In addition, inexact solution of the latter problem is also allowed without impairing convergence. Some numerical results are presented.

Keywords: Nonsmooth Optimization, Bundle Methods, Minimum Norm Vector.

A Derivative-Free Approach to Constrained Global Optimization Based on Exact Penalty Functions

Stefano Lucidi, Gianni Di Pillo, Francesco Rinaldi

Sapienza University of Rome

Constrained global optimization problems can be tackled by using exact penalty approaches. In a preceding paper [1], we proposed an exact penalty algorithm for constrained problems which combines an unconstrained global minimization technique for minimizing the penalty function for given values of the penalty parameter, and an automatic updating of the penalty parameter that occurs only a finite number of times. However, in [1] the updating of the penalty parameter requires the evaluation of the derivatives of the problem functions. In this work, we show that an efficient updating algorithm can be implemented also without using the problem derivatives. In addition, to improve the performance, the approach is enriched by resorting to local searches, in a multistart framework. A numerical experience is reported.

Keywords: Constrained Global Optimization, Exact Penalty Functions, Derivative Free Algorithm.

References

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Learning Machines for Circuit Design

Vittorio Latorre[1], *Gianni Di Pillo*[1], *Francesco Rinaldi*[1], *Angelo Cicazzo*[2], *Salvatore Rinaudo*[2]

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[2] ST Microelectronics, Catania

Any optimization procedure used to design complex electronic devices requires the availability of a circuit simulator, which takes into account the features of the circuit elements from an electro-magnetic point of view. However, each run of the simulator based on the physical laws may require a large amount of computing time. Therefore, we aim at developing surrogate models for the circuit behaviour based on a machine learning approach. In this work, we define a framework for suitable machine learning in circuit design and we report some numerical results on a real circuit design problem.

Keywords: Leaning Machines, Circuit Optimization, Surrogate Models.

WeB5 - Optimization

Wednesday, 10.15-11.30
Room AM

Functional Optimization in OR Problems with Very Large Numbers of Variables

Giorgio Gnecco, Marcello Sanguineti, Riccardo Zoppoli

University of Genoa

Functional optimization, or "infinite-dimensional programming", investigates the minimization (or maximization) of functionals with respect to admissible solutions belonging to infinite-dimensional spaces of functions. In OR applications, such functions may express, e.g.,

-releasing policies in water-resources management;

-exploration strategies stochastic graphs;

-routing strategies in telecommunication networks;

-input/output mappings in learning from data, etc.

Infinite dimension makes inapplicable many tools used in mathematical programming, and variational methods provide closed-form solutions only in particular cases. Suboptimal solutions can be sought via "linear approximation schemes",i.e., linear combinations of fixed basis functions (e.g., polynomial expansions): the functional problem is reduced to optimization of the coefficients of the linear combinations ("Ritz method"). Most often, admissible solutions are functions dependent on many variables, related, e.g., to

-reservoirs in water-resources management;

-nodes of a communication network;

-items in inventory problems;

-freeway sections in traffic management.

Unfortunately, linear schemes may be computationally inefficient because of the "curse of dimensionality": the number of basis functions, necessary to obtain a desired accuracy, may grow "very fast" with the number of variables. This motivates the "Extended Ritz Method"(ERIM), based on nonlinear approximation schemes formed by linear combinations of computational units containing "inner" parameters which make the schemes nonlinear to be optimized (together with the coefficients of the combinations) via nonlinear programming algorithms. Experimental results show that this approach obtains surprisingly good performances. We present recent theoretical results that

give insights into the possibility to cope with the curse of dimensionality in functional optimization via the ERIM, when admissible solutions contain very large numbers of variables.

Keywords: Infinite-Dimensional Programming, Suboptimal Solutions, Approximation Schemes, Curse of Dimensionality, Extended Ritz Method (ERIM).

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Recent Advances in Standard (Bi-)Quadratic Optimization

Immanuel Bomze

University of Vienna

A standard quadratic optimization problem (StQP) consists in optimizing a quadratic form over a simplex. Likewise, the standard biquadratic optimization problem (StBQP) optimizes a biquadratic form over the product of two simplices. Both problem classes are NP-hard and have important applications,

from portfolio selection to reformulation of combinatorial optimization problems. This talk addresses two recent developments: different unconstrained formulations via exact penalization for both problems, and also, for a particular class, the separable StQPs, a parametric approach which solves even non-convex n-variable instances in O(n log n) time.

Keywords: Nonconvex Optimization, Polynomial Optimization, Reformulation.

A New Approach to the Stable Set Problem Based on Ellipsoids

Stefano Smriglio[1], *Monia Giandomenico*[1], *Adam Letchford*[2], *Fabrizio Rossi*[1]

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[2] University of Lancaster

A new exact approach to the stable set problem is presented, which attempts to avoids the pitfalls of existing approaches based on linear and semidefinite programming. The method begins by constructing an ellipsoid that contains the stable set polytope and has the property that the upper bound obtained by optimising over it is less than or equal to the Lovsàz theta number. This ellipsoid is then used to derive cutting planes, which can be used within a Linear Programming-based branch-and-cut algorithm. Preliminary computational results indicate that the cutting planes are strong and easy to generate.

Keywords: Stable Set Problem, Semidefinite Programming, Convex Quadratic Programming, Cutting Planes.

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WeC1 - Maritime Logistic III: Decision Problems

Session organized by M. Flavia Monaco, Paola Zuddas and Daniela Ambrosino

Wednesday, 14.15-15.45
Room B3

Models and Solution Approaches for the Groupage Problem

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The groupage consists in grouping goods to be shipped from several senders to different recipients in order to build up suitable batches to be efficiently shipped by means of containers. The containers are carried by a fleet of containerships each of which calls, during its service, a certain set of ports. The resulting transportation network can be represented by an oriented graph where each node corresponds to a port visited by a ship and the arcs of the graph indicate the ship routes. We consider a set of customers each of them being characterized by a source and a destination port. The set of customers is partitioned into two subset, "Prime Customers" and "Secondary customers". The first subset consists of customers for which is already known the associate ship and, consequently, the appropriate route. To each of them a container to be filled at the source node, to be opened at the destination node without any intermediate bulk breaking, is assigned as well. Any residual capacity of a prime customer-associate container can be used to accommodate the loads of one or more secondary customers for the appropriate trip leg. Solving the groupage problem consists in planning the transport of goods of as many as possible secondary customers appending them to the available prime customers. We present an integer linear programming formulation of the problem and discuss some possible numerical approaches such as Lagrangean relaxation and column generation.

Keywords: Groupage, Column Generation, Container, Linear Programming.

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A Data Mining Approach for Exploratory Data Analysis to a Forecasting Arrivals Models in a Transhipment Container Terminal

Claudia Pani[1], *Paolo Fadda*[2], *Gianfranco Fancello*[2], *Francesco Mola*[3]

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[3] Deparment of Economics, V.le S. Ignazio 17, 09123, Cagliari, Italy

One of the most important issues in Transhipment Container Terminal (TCT) management is controlling data involved in the estimation of delays of vessels. High-quality models must be adopted in a daily planning horizon to update forecasts timely, because delays affect the optimal allocation of resources in TCTs. Despite the contractual obligations to send the ETA (Estimated Time of Arrival) at least 24 hours before arrival, ports are often forced to send updates due to unexpected events. Many variables and constraints may affect this process and predictive models learning from data are typically adopted in this type of forecasts. The paper presents the first results deriving from data mining techniques, such as tree nonparametric regression and classification. Furthermore, it discusses both supervised and unsupervised classification techniques for an exploratory analysis of the data affecting reported delays in a TCT. One of the main results is a map, which classifies the factors affecting the estimated error in Estimated Time of Arrival. Many of these factors are not readily identifiable because of their role is not always detectable by traditional analysis techniques.

Keywords: Exploratory Data Analysis, Data Mining, Containership Arrivals Prediction.

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Multicriteria Analysis Procedure to Assess New Port Layout

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The choice of new port layout is not an easy task; factors influencing port structure are different and they often regards issues that belong different areas. A port is a complex structure: at the same time, it's is a transport node (different maritime lines come in), it's an intermodal node (passengers and freights change transport mode in yard port), it's a factory (because inside freight processing is allowed). So when decision makers and planning staff decide to design a new port, they have to consider different factors that influence the final layout choice: these factors involve building, operational, managing, environmental aspects and others. The paper discuss about the application of a Multicriteria Analysis to assess new port layout; a concordance analysis is tested, using different weight intervals: in this way it's possible to define the choice stability. During analysis, different versions of concordance and discordance indices are tested, so they can be allowed to assess sample numerosity.

Keywords: Multicriteria Analysis, Port Layout, Concordance Analysis.

An Efficient Metaheuristic for the Multi-Dimensional Knapsack Problem

Guido Perboli

DAUIN - Politecnico di Torino

The Multi-Dimensional Knapsack Problem consists in orthogonally packing a subset of multi-dimensional items into a knapsack in order to maximize the total profit of the loaded items, while the items do not overlap ([1], [2]). We assume that items cannot be rotated. In this paper, we present GASP - Greedy Adaptive Search Procedure, a metaheuristic able to efficiently address two and three-dimensional Knapsack Problems. GASP combines the simplicity of greedy algorithms with learning mechanisms aimed to guide the overall method towards good solutions. Extensive experiments indicate that GASP attains near-optimal solutions in very short computational times, and improves state-of-the-art results in comparable computational times.

Keywords: Multi-Dimensional Knapsack, Metaheuristics.

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WeC2 - PRIN 2008: Enhancing the European Air Transportation System

Session organized by Giovanni Andreatta

Wednesday, 14.15-15.45
Room C1

The Impact of Environmental Variables on Airport Efficiency

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Airport efficiency has been the subject of several studies. Input considered represent either the production factors (labor and capital) or the physical infrastructure of the airports while the outputs consists of the volumes of aircraft, passengers and cargos. Technically Efficient airports are those that maximize their outputs with their given inputs. However, besides numerous benefits to citizen and companies, airports efficiency also bring undesired and damaging side effects in terms of noise pollution and emission of pollutants. The aim of the present study is to reassess by a new perspective airports technical efficiency ranking, developing two indexes to describe the main environmental impacts of aircraft operations, noise and air pollution, produced at airports, as undesirable outputs, implementing a Stochastic Frontier Approach. This analysis is based on the design of an Hyperbolic Distance Function and an environmental database that provides for each aircraft which has operated at Italian airports in the 1999-2008 period, as recorded in the Official Airline Guide (OAG database), both noise level and pollutants emitted amount (CO, NOx, HC) for single arrival and departure. Noise level (SEL(dB)) and emission quantities (tons) are calculated from certified values available at EASA, European Aviation Safety Agency, and ICAO, International Civil Aviation Organization, websites. The next phase has consisted in the elaboration of two indexes, the Day Night Level index (DNL, internationally adopted) and the Weighted Local Air Pollution index (WLAP, expressly designed) to be calculated for each yearly scenario of the Italian airports. Preliminary results show that the efficiency assessment of the airports (for period 2005-2008) when

their undesirable outputs are ignored is totally different and can be misleading.

Keywords: Efficiency, Noise, Emission.

Robustness versus Efficiency in the Assignment of Service Vehicles at an Airport Apron: a Test Case

Giovanni Andreatta, Lorenzo Capanna, Luigi De Giovanni, Michele Monaci, Luca Righi

Università di Padova

The recently funded European Project "Integrated Airport Apron Safety Fleet Management (AAS)" [2] aims at setting a decision support system for an efficient and safe management of apron traffic, taking advantage of information gathered by "intelligent" vehicles (GSE) equipped with on-board positioning and monitoring systems. The AAS project has been tested and validated by using it in two European airports, including Berlin Tegel (TXL). In this project, the role of the Padova team is concerned with optimizing the assignment of vehicles to apron operations. The GSE Assignment Problem (GAP) is NP-hard [1] and, furthermore, it has a dynamic nature, meaning that its parameters vary over time, because of both planned and unforeseen events, like GSE breakdowns, apron routes modifications, flight delays etc. This imposes hard restrictions on the available computational time (order of a few seconds) and a fast sequential heuristic has been devised, named Generalized Assignment Sequential Procedure (GASP). GASP has been integrated into the AAS platform and provides the dispatcher with suggestions for task-GSE assignments. To this end, the proposed solutions should respond to two primary issues: efficiency and robustness. Efficiency refers to cost minimization (e.g., total distance traveled by the GSEs). Robustness refers to operational issues rising from disrupting events and can be defined as the ability of the proposed solutions to remain good and feasible under relatively small perturbations of the problem parameters. In particular, we focus on delays, which are among the most frequent disruptions in apron contexts. Robust assignments can be treated as hard constraints or soft constraints and we propose to forbid or penalize the assignments involving small "slack times", which would propagate delays to the following tasks. The instance data used for the tests are coming from Berlin Tegel airport but have been modified for confidentiality reasons.

Keywords: Airport Ground Traffic Management, Equipment Allocation, Robust Assignment.

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Metaheuristics for the Simultaneous Airport Slot Allocation Problem

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We propose six metaheuristic algorithms for the Simultaneous Airport Slot Allocation Problem (SASAP): for each flight, an airline obtains a departure/arrival slot at the origin/destination airport which is compatible with the flight duration. This allocation is performed under the assumption that an airline has an ideal pair of departure and arrival slots for each of its flights. When this ideal pair is not available, the airline has to advance or delay the departure and the corresponding arrival time and this shift induces an undesired (shift) cost. The SASAP minimizes the sum of shift costs of all flights. The six metaheuristics algorithms are, respectively, Ant Colony Optimization (ACO), Tabu Search, Simulated Annealing, Variable Neighborhood Search, Iterated Local Search, and Iterative Improvement. We compare their performance against an exact binary linear programming formulation [1]. First, we consider an instance that is solved exactly in 200 seconds, and for which 60 seconds are needed to return the first solution allocating slots to all flights (complete solution). We perform 100 runs for each algorithm and show that ACO is the worst algorithm, with an average relative error of 45% in 200 seconds, and the first complete solution found after 0.39 seconds. The average relative error for the other algorithms is between 20% and 25%, and the time needed for finding the first complete solution is between 0.1 and 0.12 seconds. Second, we consider

an instance of realistic size, that the exact formulation cannot deal with on the hardware used for the experiments. Instead, all metaheuristics allocate slots to 98% of the flights after a very short time (less than 2.5 seconds for ACO, and less than 0.21 seconds for all the others). These results show that, despite further work must be devoted for improving the algorithms, metaheuristics are suitable for dealing with stringent time constraints or with large size instances.

Keywords: Airport Slot Allocation, Metaheuristic, Air Transportation.

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Models and Algorithms for Aircraft Rescheduling and Rerouting in a Terminal Area

Marco Pistelli, Andrea D'Ariano, Dario Pacciarelli

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This talk addresses the real-time problem of Aircraft Conflict Detection and Resolution (ACDR) in a Terminal Maneuvering Area (TMA). The ACDR is the problem of taking real-time airborne decisions on take-off and landing operations at a congested airport in given time horizons of traffic prediction. The possible aircraft control actions at each air segment and runway in the TMA are speed control, sequencing, holding and routing. We consider the inclusion of rerouting decisions in the TMA to dynamically search for alternative air segments and to balance the load of each runway. The objective function is the minimization of delay propagation and the decision variables are the aircraft timing and routing decisions. This problem can be viewed as a job shop scheduling problem with additional real-world constraints. We study different models for this problem, with increasing level of detail, by using alternative graphs. To solve the scheduling problem within the short computation time allowed by real-time applications, we analyze simple scheduling rules, heuristic methods and a branch and bound algorithm using specific problem properties. We also investigate the effectiveness of several neighborhood structures for aircraft rerouting, incorporated in a state-of-the-art tabu search scheme based on

a generalized critical path method. The effectiveness of solution algorithms are evaluated on practical size instances from the Rome FCO and Milan MXP airports, in Italy. Disturbances regarding the entrance time of aircraft in the TMA are simulated for assessing the optimization models and procedures under congested traffic conditions. We show that our exact scheduling algorithm can compute near-optimal solutions within limited computation time. The computational results also demonstrate the effectiveness of the tabu search algorithm to reduce delays and travel times when compared with the heuristic and exact aircraft scheduling solutions.

Keywords: Air Traffic Control, Delay Minimization, Alternative Graph, Branch and Bound, Tabu Search.

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WeC3 - Matheuristics

Session organized by Marco Boschetti and Vittorio Maniezzo

Wednesday, 14.15-15.45
Room B2

Hybrid Algorithms for the Optimal Composition of Healthcare Teams

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The quality of the health care is directly connected to the effectiveness of the service delivered. Usually, the health care is delivered by teams composed of individuals working together sharing knowledge, experiences and skills. Therefore, teams having different individuals can directly affect the effectiveness of the whole system providing the health care service [1]. We can measure the efficiency of the teams and of the members involved using various metrics (such as the number of patient per hours they visits, or the probability of making an incorrect decision), and exploit such measures to forecast the overall performance of the team. The random nature of the problem however, requires the introduction of random variables, and the characterization of the overall team behaviour with some sort of stochastic process. We address the problem of the evaluation of the impact of different team composition through the following case study: we analyse the patient flow of an Emergency Medical Service (EMS) by using a detailed Generalized Stochastic Petri nets (GSPN) model [2]. A GSPN allows a direct mapping from a high level representation of the team and of the EMS, to a Continuous Time Markov Chain (CTMC) that can be analysed to evaluate the performance of a particular choice. With a careful simplification of the EMS process, the solution of the GSPN and the evaluation of the performance metrics can be performed at a speed high enough to consider the model as a black box for an upper level optimization procedure. We discuss some hybrid algorithms based on metaheuristics framework (especially Local Search methods) for determining the optimal team composition using GSPN as evaluation tool. Experimental evaluation on a real case study is also reported.

Keywords: Hybrid Metaheuristics, Local Search, Petri Nets, Performance Models, Patient Flow.

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A Matheuristic Recovering Beam Search for the Capacitated Plant Location Problem

Fabio Salassa, *Marco Ghirardi*

DAUIN - Politecnico di Torino

A solution approach exploiting both a well known tree search based heuristic and a mathematical programming refining procedure has been developed to cope with the Capacitated Plant Location Problem. The problem is characterized by a set of locations where facilities may be built/opened. For every location information about the cost of building or opening a facility at that location is given (fixed costs). A set of demand points (clients) that have to be assigned for service to facilities. For every client information regarding its demand and about the costs/profits incurred if he would be served by a certain facility are given (variable costs). The goal of the problem is to find the set of facilities to be opened in order to optimize the total of fixed and variable costs, fulfilling clients demand. A Recovering Beam Search procedure with the recovering phase realized by a matheuristic method (MathRBS) has been developed to solve the described problem. The re-optimization of taken decisions is performed by a local search step working on a smaller solution space defining neighborhoods of the current partial solution. These neighborhoods are modeled fixing some variables to values as in the current solution and leaving a subset of them free to be optimized by means of a MIP solver. We do not fall into the classical local search framework because the overguiding algorithm is based on trees exploration. The proposed procedure shows a very good behavior in terms of solutions quality with different time limits on different size instances as presented by the achieved results.

Keywords: Location, Matheuristic, Beam Search.

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A Matheuristic Approach for the Sequential Ordering Problem

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The Sequential Ordering Problem (SOP) is an optimization problem used to model many different real applications such as production planning, single vehicle routing problems with pick-up and delivery constraints and transportation problems in flexible manufacturing systems. Ant Colony System (ACS) is a well-known metaheuristic metaphor, and it has been successfully applied to many combinatorial optimization problems, among which the SOP. We present a study on the hybridization of a well-known adaptation of the ACS method to the SOP with a Mixed Integer Linear Programming (MILP) describing the problem, leading therefore to a Matheuristic framework. Different combination of the the ACS algorithm with the MILP are considered, critically analyzed and compared. Computational experiments on the set of benchmarks commonly adopted in the literature show the effectiveness of the novel Matheuristic approaches: the first lower bounds were produced for many instances, together with some new best-known upper bounds. The combination of the bounds also provided an optimality proof for many instances.

Keywords: Matheuristics, Sequential Ordering Problem, Ant Colony Optimization, Linear Programming.

Customer Clustering and Sales Area Design

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[3] University of Bologna - Department of Computer Science

A common problem in local distribution arises when a company, or an agency in the case of city logistics, has to plan recurrent delivery and collection activities over a certain, typically urban territory. Goods are available at one or more warehouses and have to be transported to customers located in the territory, where reverse logistics operations could also be needed. Visits at the customers must be made on different days, according to feasible, well-spread day combinations. Moreover, attempted sales could be tried by the vehicle driver along his route. The overall objective is the minimization of the transportation costs, as resulting from the sum of travel costs of all routes of the company vehicles during the planning period. One fundamental constraint for the plan is that each vehicle of the company fleet must operate always in one same area of the city, albeit possibly visiting different customers on different days. Conversely, each customer must be visited always by the same vehicle. A number of other operational constraints could then be superimposed. In this work, we set the stage for an integrated approach, which splits the overall problem in a clustering phase (Customer Clustering Problem, CCP) followed by a routing phase (Periodic Vehicle Routing Problem, PVRP), but retains cost elements related to routing also in the clustering objective function. Moreover, a requirement for the model is the possibility to include further constraints from operational practice, such as heterogeneous vehicle fleet or customer vehicle objections. The size of actual instances and the operational constraints impose severe burdens on the solution method, and forced us to derive new solution methodologies based on a matheuristic approach. Test have been made both on problems from the vehicle routing literature and on real world instances. The procedure was coded in c#, with an option to use Cplex or CoinOR as MIP solver.

Keywords: Customer Clustering, Sales Area Design, Periodic Vehicle Routing Problem, Matheuristics.

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WeC4 - Nonlinear Optimization and Applications III

Session organized by Gianni Di Pillo

Wednesday, 14.15-15.45
Room A2

Optimization Tool for a Shipboard Electrical Propulsion

Luca Gregorio Frigoli[1], *Alessandro Tassi*[1], *Gianni Di Pillo*[2], *Stefano Lucidi*[2]

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In this paper we describe a software tool for quick design of electric motors. In particular we describe the utilization of tool for the optimization of a shipboard electrical auxiliary propulsion. The main features of this tool are ease to use, intuitive and suitable for calculation. It based on an approach which follow the "Black Box" idea, where the design engineers defines the design variables, constraints and objectives, and a simulation tool, endowed with a suitable optimization algorithm, provides the optimal design results. The internal working between the simulation software and the optimization is automatically set, so no programming is requested by the user.

Keywords: Electrical Motors, Motor Design, Optimization Algorithm.

Simulation Based Optimization: a Comparison between Black-Box Optimization Systems

Enrico Procacci[1], *Stefano Lucidi*[2], *Francesco Rinaldi*[2], *Marcello Fabiano*[1]

[1] ACT Solutions

[2] Sapienza Università di Roma, Dipartimento di Informatica e Sistemistica A. Ruberti

Real world optimization problems are often difficult to be formalized within a given mathematical programming model. The stochastic nature of real systems and the complex relations between variables naturally leads to the formalization of the problem using simulation models. Having a simulation model is then necessary to implement a search for the optimal setting of all control variables, which is a problem proportional to the complexity of the modelled system. Simulation can allow to test several "what-if" scenario but it's often possible to evaluate only a small fraction of the eligible solutions. An optimization "black-box" process can be paired and interact with the simulation model in order to find an optimal set of control variables. This work is about a comparison between two different black box optimization algorithm tested on several simulation models:

- Optquest based on the metaheuristic framework known as scatter search;
- OptBlackBox based on a sequential penalty derivative-free search.

Keywords: Black Box Optimization, Discrete Event Simulation.

Fast Algorithms for Solving Practical Black-Box Global Optimization Problems

Dmitri Kvasov, *Yaroslav Sergeyev*

DEIS, Università della Calabria

Many real-life global optimization problems are characterized by multi-extremal objective functions that are black-box. This means that there are black-boxes associated with the functions that, given the values of the parameters in input, return the corresponding functions values and nothing is

known to the optimizer about the way these values are obtained. For example, a single simulation performed to evaluate such costly functions can be performed by running a computationally expensive numerical model (as solving large systems of partial differential equations), by executing a set of experiments, etc., and hence, may take a few minutes to many hours depending on a particular application. One may refer, for instance, to various decision-making problems in control theory, electrical engineering and telecommunications, environmental sciences and seismology, etc. Global optimization of continuous black-box functions that are costly to evaluate is a really computationally challenging problem that often cannot be solved by traditional optimization techniques making strong suppositions about the problem (convexity, differentiability, etc.). This explains the growing interest of researchers in developing numerical methods able to efficiently tackle this difficult class of problems. Because of the enormous computational cost involved, a researcher is typically willing to perform only a small number of functions evaluations when optimizing such costly functions. Thus, the main goal is to develop fast global optimization algorithms that produce reasonably good solutions with a limited number of function (and constraints) evaluations. In this talk, various approaches for constructing efficient numerical methods for solving the mentioned problems based on the Lipschitz continuity assumption are discussed and their application to studying several real-life decision-making problems is shown.

Keywords: Global Optimization, Black-Box Functions, Lipschitz Condition, Applied Problems.

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WeC5 - Uncertainty

Session organized by Paola Zuddas

Wednesday, 14.15-15.45
Room AM

A Multi-Scenario Optimization Approach to Empty Container Repositioning under Port Disruptions

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[2] Network Optimization Research and Educational Centre (CRIFOR), Department of Land Engineering, University of Cagliari, Italy

This paper addresses the problem of repositioning empty containers in maritime networks under possible port disruptions. Since drastically different futures may occur, any planning methodology in dealing with this problem must to take uncertainty into account. In the proposed approach, disruptions and normal operating conditions are modeled by different scenarios and a multi-scenario optimization model is presented. Numerical experiments show that decisions determined by the multi-scenario model provide a hedge against uncertainty with respect to deterministic formulations and exhibit some forms of robustness, which mitigate the risk of not meeting empty container demand.

Keywords: Empty Container Repositioning, Multi-Scenario Optimization, Port Disruptions, Optimization under Uncertainty.

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A Cost/Risk Balanced Model for the Management of Scarce Resources under Uncertainty Conditions

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In this paper we consider the situation when a scarce renewable resource should be periodically distributed between different users by a Resource Management Authority (RMA). The replenishment of this resource as well as users demand is subject to considerable uncertainty. We develop some cost optimization and risk management models that can assist the RMA in its decision about striking the balance between the level of target delivery to the users and the level of risk that this delivery will not be met. These models are based on utilization and further development in the general methodology of stochastic programming for scenario optimization. By a scenario optimization model we obtain a target barycentric value with respect to selected decision variables. A successive reoptimization of deterministic model allows the reduction of the risk of negative consequences derived from unmet resources demand. Our reference case study is the distribution of scarce water resources. We show results of some numerical experiments in real physical systems.

Keywords: Risk Management, Stochastic Programming, Risk/performance Tradeoff, Scenario Optimization, Water Resources Management.

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Benchmarking of Airport Revenues: Models and Methods

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[1] DISPEA - Politecnico di Torino

[2] DAUIN - Politecnico di Torino

[3] BDS srl

The 2009 annual report of the International Air Transport Association (IATA) declares "Air transport will be a smaller industry for at least the next few years. The challenge is to reshape and resize for profitability". In relation to this need the airports have been pressed, from the national Civil Aviation Authorities and the market, to lower their costs and improve efficiency in invoicing and collecting user charges. Some airports reacted to this situation by improving their capability in organizing public facilities supply, such as parking sites, car rental, duty free, shops, restaurants, bars, and some specific services such as chemist, post office, currency exchange, etc. The main idea is that these non-core services could yield more revenue than the classic air navigation services. One of the main issues to deal with is the benchmarking of these non-core services. In fact, while several applications exist for standard air services, for non-core services the literature is quite limited ([1],[2]). In this paper we present a benchmark study by BDS, an Italian consultancy company specialized in the Airport Services market. This benchmark is the first one focused on Italian airports and it is performed by means of two well known methods: Data Envelope Analysis and ELECTRE Tri. The difficulties in data acquisition, problem structuring and preference modelling are described, along with the results of the two methods and their potential exploitation.

Keywords: Benchmarking, DEA, ELECTRE Tri.

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WeD1 - Flow Models for Maritime Terminals

Session organized by Raffaele Cerulli and Paolo Dell'Olmo

Wednesday, 15.45-17.15
Room B3

Dry Port Location in a Multimodal Network

Anna Sciomachen, Daniela Ambrosino

University of Genova

In this work, we deal with the evaluation of possible locations for freight modal platform with the aim of reducing the impact of containers transport coming from maritime terminal on urban mobility. A noticeable attention has been recently paid to intermodal freight transport research and its development issues. Maritime terminals located in urban and suburban areas characterized by lack of space and heavy commercial traffic can apply a "dry port" policy. The dry port concept is based on a maritime terminal directly connected by rail or inland multimodal terminals, where containers can be collected, stored and handled as they were in a maritime terminal, waiting for their successive destination. In this context, dry ports aims at reducing the heavy traffic. When the dry port is located halfway between the port and the inland, provides also port services, plays the role of concentrating the import / export flow to / from maritime terminals, we are involved in a mid-range dry port. For determining the location of mid-range dry port in multimodal network, we present a heuristic method that combines aspects coming from both classical simple plant location problems and shortest path ones on multimodal graphs. In the first phase of the proposed heuristics, we identify those nodes that could be dry ports on the connected intermodal network. In this phase we select the possible dry ports by analysing their position in the network and their communication capabilities with the other nodes of the network by using a multimodal connectivity criterion. In the second phase, we apply a heuristic algorithm for finding optimal multimodal origin (o) - destination (d) routes in network. We focus our analysis on the logistic network in the Italian north-western regions, taking into a proper account the needs of the seaport network of the Liguria county and the most congested nodes in the transportation network of the city of Genoa. Related results are presented.

Keywords: Multimodal Transportation Network, Location Problem, Dry Port.

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Multi-Tier Service Network Design Models Applied to Dry Port Based Freight Distribution Processes

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Current trends in maritime logistics optimization often consider the presence of inland intermodal terminals, usually referred to as dry ports, directly connected by road or rail to the seaports and operating as centers for the transshipment of sea cargo to inland destinations. In addition to their role in cargo transshipment, dry ports are advanced logistic platforms where consolidation of goods, management services, information processing activities, short-term storage and value-added manufacturing services for the containerized goods take place, before the shipment toward the next destinations. Our research program proposes the study of innovative methods and tools for the planning and efficient management of freight distribution systems based on the presence of inland dry ports in combination with seaport container terminals, intermodal ports and other intermediate distribution centers. In this talk we consider service network design approaches for the optimization of the tactical and operational planning of the freight distribution processes on the multi-tier logistics networks arising from the introduction of the dry ports within the maritime transportation systems. Several features of the considered problems will be explicitly taken into account in the proposed models, including

the characteristics of the fleets associated with the different levels of the distribution network, the transshipment and consolidation processes, the times required for the handling of goods in the logistics platforms, the satisfaction of specific constraints related to the receipt and delivery of goods and containers within coordinated time windows and the presence of different classes of products with different types of associated services.

Keywords: Service Network Design, Dry Ports, Maritime Logistics, Freight Distribution, Intermodality.

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The Framework of a Discrete Simulation Model for an Integrated System Port Terminal Container - Dry Port

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The Prin 2007 research team of the DIEG implemented, in Arena environment, a discrete simulation model reproducing the functioning of a port terminal container. The model, calibrated on the Naples CoNaTeCo. Terminal Container situation showed a good capability in reproducing real scenarios. Afterwards, a first release of a simulation model of an inland logistic platform calibrated on the Nola Interporto Campano situation has been realized. Starting from these two models, the current research team, including, in addition to the authors, Raffaella Cicala and Carmela Piccolo, is working on their integration in order to verify possible improvements of the overall performance through the synergy of the terminal container and the inland platform. In fact the CoNaTeCo Terminal is characterized by a limited capacity due to its reduced dimensions of berths and yards. While an optimal berth allocation can be used to increase the capability of berthing vessels, the enlargement of the yard is strongly constrained by the limited space availability. This aspect represents, in a perspective of increasing trade flows, a strong bottleneck. As the Nolas platform is very wide, it could effectively used, as a dry port, to stock containers arriving from the Naples harbor. This scenario is also coherent with agreements signed by the Naples Harbor Authority and the Interporto Campano management. The physical connection between Nola and Naples is represented, at present, by an existing, not very exploited, railway that, if properly upgraded, could allow the transfer of a significant number of containers from Naples to Nola. In this way Nola could become a dry port improving the performances of Naples port terminal container and, at the same time, strongly reducing the traffic congestion. In this work the general framework of the integrated model (port terminal dry port - railway) is described and some first results provided by the simulation model are illustrated and discussed.

Keywords: Terminal Container, Dry Port, Discrete Simulation, Integrated Logistic System.

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Queue Penalization Effect in a Location-Allocation Problem

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Consider a distribution of citizens in an urban area in which a given number of services must be located. Citizens are partitioned in service regions such that each facility serves the costumer demand in one of the service regions. For a fixed location of all the services, every citizen chooses the service minimizing the total cost, i.e. the capacity acquisition cost plus the distribution cost (depending on the travel distance). In our model there is a fixed cost of each service depending on its location and an additional cost due to time spent in the queue of a service, depending on the amount of people waiting at the service, but also on the characteristics of the service (for example, its dimension). The objective is to find the optimal location of the services in the ur-ban area and the related costumers partition. We present a two-stage optimization model to solve this location-allocation problem. The social planner minimizes the social costs, i.e. the fixed costs plus the waiting time costs, taking into account that the citizens are partitioned in the region according to minimizing the capacity costs plus the distribution costs in the service regions.

Existence results of solutions to the location-allocation problem and computational aspects will be discussed.

Keywords: Location-Allocation Problem, Leader-Follower Model, Continuous Modeling.

WeD2 - Packing and Assignment Problems

Session organized by Michele Monaci

Wednesday, 15.45-17.15
Room C1

The Generalized Bin Packing Problem: Models and Bounds

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[3] Politecnico di Torino, Turin, Italy and CIRRELT, Montreal, Canada

In this paper we introduce the Generalized Bin Packing Problem (GBPP), a new Packing problem where, given a set of items characterized by volume and profit and a set of bins with given volumes and costs, one aims to select the subsets of profitable items and appropriate bins to optimize an objective function combining the cost of using the bins and the profit yielded by loading the selected items. The GBPP thus generalizes many other Packing problems, including Bin Packing and Variable Sized Bin Packing, as well as Knapsack, Multiple Homogeneous and Heterogeneous Knapsack. The contribution of this paper is twofold. First, two different formulations of the problem will be given. Second upper and lower bounds for the problem will be introduced. In more details, the lower bounds are based on the two formulations, while upper bounds are extension of the heuristics for the Variable Sized Bin Packing presented in [1]. The paper introduces new instance sets and analyzes the results of extensive computational experiments, which show that the proposed procedures are quite efficient and the bounds are tight.

Keywords: Generalized Bin Packing, Heuristics, Column Generation.

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Approaches to Real World Two-Dimensional Cutting Problems

Enrico Malaguti, Rosa Medina Durán, Paolo Toth

DEIS - University of Bologna

Given a set of rectangular items and infinitely many rectangular stock boards, the Two-Dimensional Guillotine Cutting Stock Problem (2DCSP) asks to cut all the items through guillotine cuts, by using the minimum number of boards or, equivalently, by minimizing the area of the used boards. We consider a generalization of the problem, which models with comprehensive detail real situations arising in the wooden-board cutting industry. In wooden-board cutting, a set of rectangular items has to be cut from rectangular stock boards, which are usually available in multiple formats. Some items may be rotated, while others have a compulsory orientation, which is determined by the wood grain. The main objective, as in classical cutting stock problems, is stock usage (or equivalently, trim loss) minimization, which is evaluated in terms of the area (or cost) of used boards. A secondary objective is the maximization of the cutting equipment productivity, which can be obtained by cutting several identical boards in parallel. It is usual practice in the industry to optimize as objective function a weighted combination of the used stock area and machine productivity. In this talk we present an algorithm designed so as to obtain good solutions within a computing time which is acceptable for an industrial user, i.e., a time of the order of 10 minutes when processing instances which correspond to an average batch in the cutting industry. The algorithm is based on a Column Generation approach integrated within a diving heuristic so as to obtain integer solutions, and it is concluded by a Local Search and a Population Heuristic refinement. The algorithm was tested on a set of realistic cutting instances and performs very well when compared with some commercial software tools for two-dimensional cutting.

Keywords: Two-Dimensional Cutting Stock, Column Generation, Heuristic.

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Three Ideas for the Quadratic Assignment Problem

Michele Monaci, Matteo Fischetti, Domenico Salvagnin

DEI, Università di Padova

We recently started the ambitious project of solving to proven optimality (at least, some of) the largest "esc" instances of the famous quadratic assignment problem (QAP). These are extremely hard instances that remained unsolved—even allowing for a tremendous computing power—by using all previous techniques from the literature. During this challenging task we tested a number of ideas, and found that three of them were particularly useful and qualified as a breakthrough for our approach. This talk is about describing these ideas and the status of our attempt. So far our method was able to solve, in a matter of seconds or minutes on a single PC, all the easy cases (all esc16* plus esc32e and esc32g). Almost all the previously-unsolved esc instances, namely esc32c, esc32d, esc32h, esc64a and esc128 were solved in less than 3 hours, all together, on a single PC. We also report the solution of the previously-unsolved tai64c, again within very reasonable computing time. To the best of our knowledge, esc128 is the largest QAP instance ever solved by an exact method.

Keywords: Quadratic Assignment Problem, Branch-and-Bound, ILP Models.

WeD3 - Heuristics I

Wednesday, 15.45-17.15
Room B2

A Genetic Algorithm with Passenger Arrival Advanced Information to Solve the Elevator Dispatching Problem

Maite Beamurgia[1], *Rosa Basagoiti*[1], *Ignacio Rodríguez*[2]

[1] Mondragon University

[2] University of Navarra

The elevator dispatching problem deals with the assignment of a group of elevators to the different passengers' requests. This task is complex as it is a dynamically changing process as new requests arises and therefore it must be accomplished in a short period of time. This paper proposes a genetic algorithm that tries to predict future calls using passenger arrival advanced information to solve the elevator dispatching problem. The problem is formulated as a two-level optimization problem. In the upper level, the requests are assigned to the elevators. A genetic algorithm is used to optimize this assignment in terms of average passenger's waiting time. In the lower level, the routing of each elevator is optimized individually using a greedy algorithm that takes into account the passenger arrival advanced information collected of the historical passengers' traffic demand data to help the system to improve the routing with the estimated future calls. When the request calls are assigned to a certain elevator, then the registered calls and the historical passengers' traffic demand data are used to predict the future ones. Both types of calls are taken into account to obtain the best route with the least passengers waiting time. We have used simulated data to compare the performance of the genetic algorithm with and without advanced information. Different traffic patterns have been used with different interfloor traffic. The scenario used for the simulations involves a building with 15 floors and 4 elevators, the capacity of each elevator is considered to be 630 kg, and its maximum velocity is 2.5 m/s, with an acceleration of 0.8 m/s2. The results show that the genetic algorithm with advanced information achieves better performance than the approach without that information.

Keywords: Elevate Dispatching Problem, Genetic Algorithm, Passenger Arrival Advanced Information, Traffic Demand Data.

A Genetic Algorithm Based on k-Diamonds for the Weighted Feedback Vertex Set Problem

Francesco Carrabs, Raffaele Cerulli, Carmine Cerrone

Dipartimento di Matematica - Università di Salerno

Given an undirected and vertex weighted graph $G = (V, E, w)$, the Weighted Feedback Vertex Set problem (WFVS) consists of finding a subset $F \subseteq V$ of vertices of minimum weight such that each cycle in G contains at least one vertex in F. This problem have application in several areas of computer science such as circuit testing, deadlock resolution, placement of converters in optical networks, combinatorial cut design, etc. The WFVS on general graphs is known to be NP-hard and to be solvable in polynomial time on some special classes of graphs (e.g., interval graphs, co-comparability graphs, diamond graphs). In the last years the studies on WFVS are focalized on approximate and fixed parameter tractable algorithms while there are not so much meta-heuristics proposed for this problem. This is probably because it is not so easy to define a neighborhood for the WFVS different from simple exchange set between the fvs F and the forest inducted by $V \backslash F$. In this paper we propose a genetic approach to solve the WFVS. Genetic algorithms are a population-based search technique that use an ever-changing neighborhood structure, based on population evolution and genetic operators, to take into account different points in the search space. In order to improve the quality of solutions produced, our algorithm applies on chromosome a local search based on particular class of graphs, the k-diamonds, on which the WFVS is solvable in linear time. The solution quality and performance of genetic algorithm are compared with the meta-heuristics present in literature.

Keywords: Weighted Feedback Vertex Set, Genetic Algorithms, Diamond Graph.

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A Variable Neighborhood Search for the University Carpooling

Maurizio Bruglieri[1], *Alberto Colorni*[1], *Tatjana Davidovic*[2], *Sanja Roksandic*[2]

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[2] Mathematical Institute - Serbian Academy of Sciences and Arts

Carpooling is a promising policy intervention in traffic decongestion that consists in a shared use of private cars. Typically it is organized by a large company for encouraging its employees to pick up colleagues while driving to/from work. The core of the efficient management of such a service is to find an optimal matching between the users and their preferred routing (according to their origins, destinations and time windows). From the algorithm point of view, the carpooling problem was first proposed and studied in [2]. In this work we consider the special case when the users are university students. This case differs from the carpooling problems considered in the literature mainly for the following characteristics:

-the users (students) can have very different timetables (depending on the classes attended);

-drivers are able to set partial pre-arranged crews;

-users may indicate other users they would prefer to car-pool with (friends) or they don't want to (enemies);

-besides the campus premises, users can select as destination of their car pooling trips the main railway and subway stations (to encourage intermodal transport).

The objectives are to maximize the number of served users, minimize the total route length, maximize the satisfied user preferences (e.g. friendships), respecting the user time windows, possible partial pre-arranged pools and car capacities. The university carpooling problem has been proposed for the first time in [1] where is a tackled with a Montecarlo algorithm. In this work we propose a more sophisticated solution approach based on Variable Neighborhood Search (VNS). VNS [3] is a simple and effective meta-heuristic for solving combinatorial and global optimization problems based on a systematic change of neighborhood within a possibly randomized local search algorithm. The proposed approach is tested on real instances of Milano Politecnico and Università Statale universities arising from the PoliUniPool project [1].

Keywords: Carpooling, User Preferences, Variable Neighborhood Search.

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The Multi-Mode Set Covering Problem

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Several applications in the fields of computational biology, surveillance systems and facility location among others can be formalized as a generalization of the set covering problem. In this talk, we present the multi-mode set covering problem. Given a set of modalities M, a ground set S, $|M|$ families of subsets of S, one for each modality, and a cost function defined on all the subsets of S, the multi-mode covering problem (MMCP) requires finding a least total cost collection of subsets such that each element of the ground set is covered in all the modes, with the additional condition that some constraints (of knapsack type) on the selected sets are satisfied. The MMCP is clearly NP complete and is difficult to solve by commercial solvers. We present a branch-and-bound algorithm based on lagrangian relaxation. To compute feasible solutions of the problem, we implement a Variable Neighbourhood Search metaheuristic. The algorithms are tested on a set of randomly-generated benchmark instances.

Keywords: Set Covering, Lagrangian Relaxation, Branch-and-Bound.

WeD4 - Mixed Integer Nonlinear Programming

Session organized by Maria Grazia Scutellà, Antonio Frangioni and Claudia D'Ambrosio

Wednesday, 15.45-17.15
Room A2

A Storm of Feasibility Pumps for Nonconvex MINLP

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[3] LIX, Ecole Polytechnique, France

One of the foremost difficulties in solving Mixed Integer Nonlinear Programs, either with exact or heuristic methods, is to find a feasible point. We address this issue with a new feasibility pump algorithm tailored for nonconvex Mixed Integer Nonlinear Programs. Feasibility pumps are algorithms that iterate between solving a continuous relaxation and a mixed-integer relaxation of the original problems. Such approaches currently exist in the literature for Mixed-Integer Linear Programs and convex Mixed-Integer Nonlinear Programs: both cases exhibit the distinctive property that the continuous relaxation can be solved in polynomial time. In nonconvex Mixed Integer Nonlinear Programming such a property does not hold, and therefore special care has to be exercised in order to allow feasibility pumps algorithms to rely only on local optima of the continuous relaxation. Based on a new, high level view of feasibility pumps algorithms as a special case of the well-known successive projection method, we show that many possible different variants of the approach can be developed, depending on how several different (orthogonal) implementation choices are taken. A remarkable twist of feasibility pumps algorithms is that, unlike most previous successive projection methods from the literature, projection is "naturally" taken in two different norms in the two different subproblems. To cope with this issue while retaining the local convergence properties of standard successive projection methods we propose the introduction of appropriate norm constraints in the subproblems; these actually seem to significantly improve the practical performances of the approach.

We present extensive computational results on the MINLPLib, showing the effectiveness and efficiency of our algorithm.

Keywords: Feasibility Pump, MINLP, Global Optimization, Nonconvex NLP.

Minimum Euclidean Distance Controlled Adjustment Problems by Perspective Reformulations

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[3] Università di Pisa - Dipartimento di Informatica

Among the main services of National Statistical Agencies (NSAs) there is the dissemination of large amounts of tabular data obtained from microdata by crossing one or more categorical variables. NSAs must guarantee that no confidential individual information can be obtained from the released tabular data. Two main different methods have been proposed for this purpose: the cell suppression technique and the controlled tabular adjustment. The former method deletes the cells containing the confidential data and looks for the minimal number of other cells such that confidential data cannot be derived from the sums of rows and columns. The controlled tabular adjustment (CTA) modifies the confidential data of a certain minimal amount and modifies other data in order to keep unchanged the totals of rows and columns. Binary variables are introduced in order to decide the direction of change for each cell associated to confidential data. The objective function is defined according to a distance metric between the resulting table and the original table. Here we focus on CTA problems with Euclidean distance which can therefore be formulated as Mixed-Integer Quadratic Problems; to the best of our knowledge, this problem has never been tackled before. Indeed, for real-world or realistic data, solving these MIQPs efficiently is difficult: standard MIP heuristics don't work very well, and lower bounds are weak. We improve on lower bounds by using Perspective Reformulations tailored for the specific properties of the feasible set of problem at hand; in particular, we describe projected reformulations, and show that for the fully symmetric case the convex envelope can be obtained with easy and intuitive modifications to the standard formulation,

whereas the asymmetric case is rather more complex. We then computationally compare different models of CTA. This work is partially supported by Project MTM2009-08747 of the Spanish Ministry of Science and Innovation.

Keywords: Mixed-Integer Quadratic Programming, Perspective Reformulations, Statistical Disclosure Control.

Optimistic MILP Modeling of Non-Linear Optimization Problems

Silvano Martello, Claudia D'Ambrosio, Andrea Lodi, Riccardo Rovatti

DEIS, University of Bologna

We present a new piecewise linear approximation of non-linear optimization problems, that can be seen as a generalization of classical triangulations. Intuitively, it is a generalization because it leaves more degrees of freedom to define any point as a convex combination of the samples. As an example, for the classical case of approximating a function of two variables, a convex combination of four points instead of only three is used. As a plane is defined by only three independent points, the approximation obtained by triangulation is uniquely determined, while different approximations are possible in our case. When embedded in a Mixed-Integer Linear Programming (MILP) model, the choice among the different alternatives is guided by the objective function. The new approximation within an MILP requires a significant smaller number of additional binary variables, and allows the use of recent methods for representing such variables with a logarithmic number of constraints. We show theoretical and computational evidence of the quality of the approximation and its impact within MILP models.

Keywords: Non-Linear Optimization, Piecewise Linear Approximation, Mixed-Integer Linear Programming.

WeD5 - Stochastic Programming

Session organized by Marida Bertocchi

Wednesday, 15.45-17.15
Room AM

Risk-Return Trade-Off in Optimization

Marco Campi[1], *Simone Garatti*[2]

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[2] Politecnico di Milano

Setting a suitable trade-off between risk and return is a central issue in any decision making process. In this presentation, I shall overview the different paradigms to deal with uncertainty in decision making processes based on optimization, and will show that randomization offers an opportunity to construct viable solution methodologies to compromise between risk and return. The resulting algorithms are usable across many different application domains including control, prediction, and finance. See [1]-[4] for references.

Keywords: Stochastic Programming, Risk-Return Trade-Off, Chance Constrained, Randomization.

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The Value of Information in Multistage Linear Stochastic Programming: Theoretical Improvements

Marida Bertocchi[1], *Elisabetta Allevi*[2], *Francesca Maggioni*[1]

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[2] University of Brescia

Stochastic programs, especially multistage programs, which involve sequences of decisions over time, are usually hard to solve in realistically sized problems. In the two-stage case, several approaches and measures of levels of available information on a future realization has been adopted in literature, see [1],[2],[3] such as the Value of the Stochastic Solution VSS with relative bounds (SPEV and EPEV) and measures of badness/goodness of deterministic solutions, see [4], such as the loss of using the skeleton solution LUSS and the loss of upgrading the deterministic solution LUDS. In this talk we generalize bounds of Value of Stochastic Solution VSS to the multistage case through the Multistage Sum of Pairs of Expected Value MSPEV and Multistage Expectation of Pairs Expected Value MEPEV by solving a series of sub-problems more computationally tractable than the initial one. This extension has been done by introducing the new concept of auxiliary scenario. We also extend to the multistage case measures of quality of the expected value solution in terms of structure and upgradeability such as MLUSSt and MLUDSt and related with the standard VSSt. Such a measures can help us to understand the behaviour of the deterministic solution with respect to the stochastic and the reason of its badness/goodness. The above measures are also defined in a rolling horizon framework by means of the Rolling Horizon Value of Stochastic Solution RHVVS, the Rolling Horizon Loss Using Skeleton Solution RHLUSS and Rolling Horizon Loss of Upgrading the Deterministic Solution RHLUDS. Chains of inequalities among the different measures are obtained.

Keywords: Multistage, Linear Stochastic Programming, Performance Measures.

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The Value of Information in Multistage Linear Stochastic Programming: a Case Study

Francesca Maggioni[1], *Marida Bertocchi*[1], *Elisabetta Allevi*[2]

[1] DMSIA University of Bergamo

[2] Department of Quantitative Methods, University of Brescia

The talk refers to recently extended measures for valuing the opportunity to use a stochastic approach in the two-stage case to the multistage framework. We generalize bounds of Value of Stochastic Solution VSS defining the multistage sum of pairs expected values MSPEV, the multistage expected value of the reference scenario MEVRS and the multistage expectation of pairs expected value MEPEV. We also extend to the multistage case measures of quality of the expected value solution in terms of structure and upgradeability such as MLUSSt and MLUDSt and related with the standard VSSt. Measures based on a rolling horizon method such as Rolling Horizon Value of Stochastic Solution RHVVS, Rolling Horizon Loss Using Skeleton Solution and Rolling Horizon Loss of Upgrading the Deterministic Solution RHLUDS are also introduced. In this talk we present and discuss, in a real application of a single-sink transportation problem, the computation and results of the above measures in the two-stage and four-stage cases. Approximations of the optimal solution are computed, by solving a series of sub-problems computationally more tractable than the initial one and related to standard approaches.

Keywords: Multistage Stochastic Programming, Expected Value Problem, Value of Stochastic Solution, Pairs Subproblems.

WeE1 - Logistics III

Wednesday, 17.45-19.15
Room B3

A Heuristic Approach for Wiring Configuration Setting in Car Production

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In this work we treat an optimization problem arising in car production. Nowadays customer demand can be very heterogeneous in dependence of the different sets of options to be installed. For each set of options there is a specific electric wiring configuration. The number of options can be up to 50 and this number is not going to decrease in the future, since the market goes towards highly customized products. This would require the usage of several thousand of electric wiring configurations to satisfy all the demands, but only a limited number of them is available at the assembly line. Hence if a wiring configuration needed for a specific demand is not available, it can be replaced by a "richer" compatible one, i.e. by a configuration containing, among others, all the requested wirings ([1], [2]). It is necessary to make a partitioning of the demand set in such a way that each partition is assigned to a specific wiring configuration. This is a particular set partitioning problem ([3], [4]), where the aim is to minimize the number of partitions and, at the same time, to assign each demand of a partition to a unique wiring configuration able to satisfy it at the minimum cost. Given the very large size of real cases of this problem, it cannot be solved exactly in a reasonable computation time. For this reason we approached it by a heuristic which decomposes the main problem in more sub-problems and operates separately on each of them generating iteratively the partitions. The proposed approach has been experienced on several test cases of varying dimension provided by a car firm. The obtained results show that the heuristic is very effective in terms of solution quality and computation time.

Keywords: Wiring, Set Partitioning.

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Scheduling Internal Operations in Distribution Centers Using Mixed Integer Linear Programming and Symmetry Breaking Constraints

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A Distribution Center (DC) is a type of warehouse where the storage of goods is limited or nonexistent [2]. In the DC under consideration, large incoming loads from different suppliers are disaggregated and combined to create consolidated outbound shipments to be sent to customers according to their requests. Inbound trucks are unloaded and the loads are unpacked. Successively, the single items are sorted according to the customer requests, packed and sent to the customers by outbound trucks. The related literature deals with the scheduling of inbound and outbound trucks, in cross docking terminals [1] where the products do not need to be unpacked, sorted and packed but only moved from inbound to outbound docks. Nevertheless, in the literature the terms warehouse, DC and cross-docking are used as synonyms. We consider the problem of scheduling the deconsolidation, sorting and consolidation operations of a generic DC. In the de-consolidation phase, incoming containers are unpacked in pallets and then pallets are unpacked in boxes. Each box

contains items of the same type that are assigned to outbound boxes according to customers requests. In the consolidation phase, the boxes are packed in pallets and successively in containers. The objective is to determine the optimal sequence of operations in order to minimize the total operation time. The problem is modeled by a Mixed Integer Linear Programming formulation that presents a large number of alternative equivalent solutions. To handle with this issue, we use symmetry breaking constraints and objective function perturbations [3]. Moreover, some lower and upper bounds of the operation times are evaluated by heuristic algorithms in order to add constraints to the formulation. Some test results highlight the effectiveness of the proposed formulation.

Keywords: Distribution Systems, Logistics, Scheduling.

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An Extended Model for Logistics Network Design

Maria João Cortinhal, Anabela Costa, Maria João Lopes, Ana Catarina Nunes

ISCTE-IUL and CIO

Nowadays, changeable economic conditions and supply chain dynamics are obliging manufacturing and distribution companies to turn to network design as a solution to remain relevant in the global marketplace. Factors such as wide variety of products, global markets, and more demanding customers, among others, are making companies to deal with more and more complex

supply chain networks. A large strand of research has been devoted to supply chain networks (see, e.g., [1] and references therein). This research extends the work in the field of logistic network design problems by introducing a new mixed integer linear programming model that includes some extra constraints. Additionally to location choices for plants and warehouses with supplier and transportation modes, product range assignment and product flows, this model incorporates modular capacity choices for plants and warehouses, minimum levels of service and non full coverage of customer demands. The non full coverage allows to model situations on which organizations can opt for outsourcing. Nowadays, many public and private organizations are using outsourcing as a way to improve their effectiveness and efficiency [2]. Despite being commonly related with services, outsourcing can be used as an alternative way for the company production, as well. To the best of our knowledge, supply chain network models with non mandatory full coverage demands have never been considered in the literature. Computational experiments on different data sets are presented and the corresponding solutions are discussed.

Keywords: Logistics, Network Design, Mixed Integer Linear Programming.

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A Decision Support Tool for Intermodal Transportation Systems

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The recent developments on information technologies and highly competitive market conditions have forced the governments and private companies to focus their attention to develop effective logistics and transportation systems to

reduce overall costs and enhance flexibility. Selection of transportation modes is the core and pivotal decision point in intermodal transportation. The aim of this study is to present an approach to guide the international transporters in order to minimise logistics costs with minimum time period and maximum satisfaction in distribution route. A multi-commodity transportation model is employed. The proposed decision support system is based on a simulation model to find constantly changing alternative routes and the outputs of the simulation model are used through various optimisation techniques to obtain minimum cost and minimum time period in order to assist the decision maker on a specified distribution network. Optimisation tecniques based on genetic algorithms gave beter results on this research.

Keywords: Decision Support Systems, Intermodal Transportation, Logistics, Heuristics.

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WeE2 - Simulation

Wednesday, 17.45-19.15
Room C1

Simulation and Planning of a Neonatal Screening for Metabolic Diseases

Giorgio Romanin Jacur[1], *Monica Da Frè*[2], *Monica Mazzucato*[2], *Cinzia Minichiello*[2], *Laura Visonà Dalla Pozza*[2]

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Metabolic disease are rare but the whole group shall be considered in its complexity, heterogeneity and relevance, as they may cause severe damages if not cared in time. Since the sixties, several countries developed screening programs, and from the nineties, with the use of tandem mass spectrometry, the possibility to analyze simultaneously a large number of metabolites has allowed the screening of about forty metabolic diseases. A neonatal screening plan, including a first quick test by tandem mass technology to all newborns and a second accurate ambulatory test for patients with positive results, is being planned in Veneto region, North East Italy, where two centres for first test and a centre for second test will be operating soon. A simulation model describing all screening and diagnostic operations, where parameters have been obtained from already performed experiences in the field, has been built and implemented; the scope lays in giving suitable dimension to operating centres, in order to be able to diagnose and care all revealed pathologies within the maximum time before they may become dangerous for the interested patients. The model is pretty general and its application may be extended to changed situation of the same region or to other regions.

Keywords: Metabolic Diseases, Neonatal Screening, Simulation Model, Structure Dimensioning.

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A Markov Chain Method to Bootstrap Multivariate Continuous Processes

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[1] Department of Quantitative Methods, University of Brescia

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In this work we apply the theory of bivariate Markov chains to bootstrap continuous valued processes (in the discrete time). To this purpose we solve a minimization problem to partition the support of a continuous process into a finite number of states. We start from an inflated segmentation of the support and obtain a coarser representation. The resulting partition identifies levels in the support such that the process modifies significantly its dynamics (i.e. its expected value, or its variance, etc.). A distance indicator is used as objective function to favor the clustering of the states having similar transition probabilities. A multiplicity boundary is also introduced to prevent that the bootstrapped series are not diversified enough. The problem of the exploding number of alternative partitions in the solution space (which grows with the initial number of states) is approached through an application of the Tabu Search algorithm. Our method serves also to assess the order k of the process. It turns out that the search of the relevant states contributes to identify also the relevant time lags. The formation of few large groups at some time lags, as opposed to the formation of several small clusters in other time lags, is taken as evidence against the relevance of the former and in favor of the latter. The method is applied to bootstrap bivariate series of prices and traded volumes observed in the German and Spanish electricity markets. The analysis of the results confirms the good consistency properties of the method proposed.

Keywords: Simulation, Energy Policy and Planning, Risk Analysis and Management.

Supply Networks Analysis and Simulation

Rosanna Manzo, Ciro D'Apice, Carmine De Nicola, Luigi Rarità

Dipartimento di Ingegneria Elettronica e Ingegneria Informatica, University of Salerno

Supply networks have been described by different models. Most of them are discrete and based on individual parts considerations; others are continuous dealing with ordinary differential equations (see [3]), or/and partial differential equations. The aim of this talk is to present some numerical results for supply networks modelled by a fluid dynamic approach. A mixed continuum-discrete model is examined ([1, 2]): the dynamics on each arc is defined by a conservation law for the goods density, and an evolution equation for the processing rate. Dynamics at nodes is solved using two different routing algorithms, maximizing the flux on both incoming and outgoing arcs or only on the incoming ones, and considering two additional rules. The first rule tends to make adjustments of the processing rate more than the second one, even when it is not necessary for purpose of flux maximization. A constant input profile with one discontinuity has been chosen for simulations. The obtained results indicate that the production is strongly influenced by the position of discontinuity point of the input profile. A numerical study of the temporal integral of the final product flow (representing the number of produced goods) shows the existence of a time instant at which the discontinuity point of the input profile has to be placed for the maximization of the overall production.

Keywords: Conservation Laws, Supply Networks, Simulation.

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WeE3 - Heuristics II

Wednesday, 17.45-19.15
Room B2

A MIP-Based Heuristic for the Optimization of Contracts and Work-Shifts in Complex Multi-Skill Call Centers

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[2] Università degli Studi di Milano - Dipartimento di Scienze dell'Informazione

The ever-growing diffusion of call centers in service-based economies is posing severe organizational problems. Call centers, in fact, are complex systems, which employ a diversified workforce to satisfy the needs of a very diversified service demand. In such a situation, it is essential to optimize the trade-off between the service level provided to the customers and the cost for the personnel. Moreover, since the literature currently provides only rather simplified models, most of the time the design of these systems is still performed by hand. This leads to a patchwork approach, in which new kinds of contracts are introduced on the fly to respond to "last-minute" requirements, and are quite difficult to remove later, when such requirements fade off. Thus, the management of the whole system tends to become harder as time passes. In this paper we describe a quantitative approach to choose the most suitable contracts to hire the call center operators and the detailed schedule of their shifts along a given time horizon. The purpose is to organize work-shifts, rest periods and lunch-breaks, so that the mix of skills obtained in each time slot approaches as much as possible a desired profile, estimated according to demand forecasts. The approach here proposed is based on a complete mixed integer programming model of the problem, which is decomposed into subsequent heuristic rounding steps, in order to make it solvable by a general purpose linear programming solver.

Keywords: Multi-Skill Call Centers, Workforce Management, Mixed Integer Linear Programming, Rounding Heuristics, Matheuristics.

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A Randomized Neighborhood Search MIP Heuristic

Massimo Paolucci, Davide Anghinolfi

DIST - University of Genova

In this work we present a new simple but effective heuristic approach to MIP problems, called Randomized Neighborhood Search (RANS). The proposed approach shares some concepts with methods recently appeared in literature as Local Branching [1], Relaxation Induced Neighborhood Search (RINS) [2], Evolutionary Algorithm for Polishing [3] and Variable Neighborhood Decomposition Search (VNDS) [4], but, differently, it exploits only a randomization mechanism to guide the solution of MIP problems. In particular, RANS adopts concepts similar to the Iterated Greedy (IG) algorithm proposed in [5] for scheduling problems. RANS starts from a feasible incumbent solution and iterates two steps: first, it determines the solution neighborhood by a random "destruction step"; then it builds a new solution (i.e., it performs a "construction step") by exploring the neighborhood by calling a MIP solver as a black box tool. The proposed algorithm has some self-tuning rules so that it needs as single input parameter the maximum computation time. RANS then is a quite simple algorithm whose purpose is to produce within reduced time bounds high quality solutions especially for large size MIP problems as the ones characterizing real industrial applications. We also include in the proposed algorithm a procedure for generating the first incumbent solution which

exploits the same randomization concepts of RANS and that can be used as an initialization alternative for particularly hard instances. Despite its simplicity, the effectiveness of RANS emerges from an experimental campaign performed on a benchmark set available from literature and from the comparison with the other mentioned methods.

Keywords: MIP Heuristics, Mixed Integer Programming, Combinatorial Optimization.

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A MILP-Based Heuristic for Energy-Aware Network Design with Shortest Path Routing

Edoardo Amaldi, Antonio Capone, Luca Gianoli

DEI, Politecnico di Milano

Internet energy consumption is rapidly becoming an issue due to the exponential traffic growth and the rapid expansion of communication infrastructures worldwide. We address the problem of energy-aware intra-domain traffic engineering in networks where packets are routed along shortest paths from source to destination. We consider the problem of switching off (putting in sleeping mode) network elements (links and nodes) and of adjusting the link weights so as to minimize the energy consumption as well as the total cost of link utilization. We propose a three-phase MILP-based heuristic for tackling this challenging multi-objective problem with priority, which exploits the IGP-WO heuristic [1,4]. Computational results for four real network topologies and different types of traffic matrices show that substantial energy savings can be achieved during low and moderate traffic periods, while guaranteeing the same quality of service and keeping the total cost of link utilization under control.

Keywords: Network Design, MILP Formulation, Heuristic.

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A Window-Based Local Search for a Large-Scale Job Scheduling Problem

Cristiano Nattero, Davide Anghinolfi, Massimo Paolucci

Università degli Studi di Genova

A large scale job scheduling problem, arising in a real manufacturing environment, is solved with a window-based local search heuristic algorithm. Jobs are constituted by a set of operations, which belong to two classes: those that must be outsourced and those that can be executed within the shop floor. A set of feasible machines is specified on the latter ones. Moreover, these operations may require specific tools and materials, the substitution of which needs a given setup time. Finally, operations may also require auxiliary resources, which are available in limited quantity but renewable after use. The problem features precedence constraints among operations in the same job and among different jobs. Given release dates and due dates for each job, the objective is the minimization of the total tardiness. The proposed algorithm uses a single sequence to represent both the sequence of operations on machines and the priority in the use of the resources, whereas the assignment of operations to machines is represented separately. An initial solution is produced using a constructive heuristic procedure, and then it is improved by means of an iterative decomposition approach: at each iteration, a subset of contiguous operations is selected by means of a window and then optimized by a stochastic local search. The window can be slid forward or backward or can even be relocated randomly, and different window movement policies are implemented and tested. This work presents the results obtained by testing different configurations for the characteristics of this approach.

Keywords: Large-Scale Scheduling, Local Search, Metaheuristics.

WeE5 - Stochastic Problems

Wednesday, 17.45-19.15
Room AM

A Stochastic Knapsack Problem with Nonlinear Capacity Constraint

Marcello Sanguineti, Marco Cello, Giorgio Gnecco, Mario Marchese

University of Genoa

There exist various generalizations and stochastic variants of the NP-hard 0/1 knapsack problem [1,2]. The following model is considered here. A knapsack of capacity C is given, together with K classes of objects. The stochastic nature come into play since, in contrast to the classical knapsack, the objects belonging to each class become available randomly. The inter-arrival times are exponentially-distributed with means depending on the class and on the state of the knapsack. Each object has a sojourn time independent from the sojourn times of the other objects and described by a class-dependent distribution. The other difference with respect to the classical model consists is the following generalization. For $k = 1, K$, let n_k be the number of objects of class k that are currently inside the knapsack; then, the portion of knapsack occupied by them is given by a nonlinear function $b_k(n_k)$. When included in the knapsack, an object from class k generates revenue at a positive rate r_k. The objects can be placed into the knapsack as long as the sum of their sizes does not exceed the capacity C. The problem consists in finding a policy that maximizes the average revenue, by accepting or rejecting the arriving objects in dependence of the current state of the knapsack. A-priori knowledge of structural properties of the (unknown) optimal policies is useful to find satisfactorily accurate suboptimal policies. The family of coordinate-convex policies is considered here. In this context, structural properties of the optimal policies are investigated. New insights into a criterion proposed in [3] to improve coordinate-convex policies are discussed and the greedy presented in [5] is further developed. Applications in Call Admission Control (CAC) for telecommunication networks are discussed. In this case, the objects are requests of connections coming from K different classes of users, each with an associated bandwidth requirement and a distribution of its duration.

Keywords: Knapsack Problem, Stochastic Inter-Arrival Times, Nonlinear Capacity Constraint, Coordinate-Convex Policies, Greedy Algorithms.

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A Mata-Heuristic Approach for Stochastic Integer Problems under Joint Probabilistic Constraints with Random Technology Matrix

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This paper deals with integer problems under joint probabilistic constraints with random technology matrix. This class of problems is very difficult to deal with since two different sources of complexity are merged. The first one is related to the presence of probabilistic constraints which assure the satisfaction of the stochastic constraints with a given reliability value, whereas the second one is due to the integer nature of the decision variables. In the case of discrete distributions, the probabilistic problem can be reformulated by using a Big-M approach. The resulting deterministic version has a clear non convex

nature, making the problem highly intractable. This paper presents a mata-heuristic approach designed so to exploit the specific problem structure. The main idea of the solving approach consists of starting from the optimal solution of the continuous relaxation related to the deterministic equivalent problem associated to the reliability level equal to 1, trying to iteratively determine better feasible solutions by investigating some subregions of the non-convex feasible set. Such an exploration is carried out by the solution of simplified integer problems defined in such a way to exploit the stochastic structure of the problem. The proposed heuristic approach has been tested on the probabilistically constrained version of the classical 0-1 multiknapsack problem. The preliminary numerical results have shown that the proposed heuristic is able to quickly determine better quality solutions compared to those provided by the classical Branch and Bound solver implemented in CPLEX.

Keywords: Stochastic Programming, Integer Linear Programming, Mata-Heuristic Algorithm.

Forward-Reverse Logistics Network Design for Spare Parts in Stochastic Environments

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This paper focuses on the optimization of a forward-reverse logistics network design for spare parts, considering uncertainty on both demands and returned spare parts quantities. In particular the problem is formulated in a multi-stage stochastic mixed integer linear programming (SMILP) form. The model is multi-period and the network is multi-echelon, with three echelons in the forward direction (suppliers, manufacturing facilities and distribution centers) and one in the reverse direction (inspection&remanufacturing centers). The model accounts for capacity and inventory constraints and uncertainty on demands as well as on returned spare parts quantities. Uncertainty has been modeled establishing probability distributions. Then, different scenarios, based on those probability functions, have been built to represent uncertainty. The developed stochastic mixed integer linear programming (SMILP) model maximizes the expected total profit over a group of scenarios with their associated probability, subjected to linear and integer constraints. Two possible strategies have been identified in order to face uncertainty: a robust strategy,

that produces the minimum expected total cost, and a stable strategy which determines the minimum variability of the objective function cost components over the different scenarios. Numerical analyses are reported to show the applicability of the proposed model and solution generation approach.

Keywords: Network Design, Spare Parts, Uncertainty.

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Strategic Protection Planning of Median Systems with Recovery Time in the Context of Uncertain Disruptions

Chaya Losada, Atsuo Suzuki

Nanzan University

Previous facility protection models often focus on warranting a highly risk averse decision making criterion based on minimizing the maximum damage [4, 2]. However, protection against worst-case losses may be ineffective if protective investments are spent to prevent the occurrence of disruption scenarios that are as highly disruptive as they are improbable. We introduce a protection problem for capacitated median systems that minimizes both the total investments in protecting the system and the expected operational costs after disruption. A two-stage stochastic program is proposed where protective actions are decided in the first stage before any disruption strikes and where the recourse problem represents the operational behaviour of the system for the protective measures applied in the first stage and a particular disruption scenario. Disruption uncertainty is here viewed in different ways; we define

some random variables to account for, first, the reduction rate in the nominal capacity of the disrupted facilities and, second, the rate increase on the nominal demand requested to the facilities. The recovery time needed by disrupted facilities is considered by letting some additional random variables be defined at every time period as linear functions on the capacity related random variables of the current and former time periods. This allows us to further extend the deterministic problem in [3] to have recovery times subject to uncertainty and a gradual system recovery over time, where the speeds at which facilities are recovered are related to the intensity of the disruptions. A large number of random variables is considered resulting in a large scale stochastic problem. We adopt the so-called Stochastic Decomposition technique [1]. We measure the error in objective estimates and compare results to the Jensen lower bound and statistically estimated upper bounds.

Keywords: Location, System Resilience, Stochastic Programming, Strategic Planning, Stochastic Decomposition.

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ThA1 - Assignment Problems

Thursday, 9.00-10.30
Room B3

An Assignment Problem with Capacity and Ordering Constraints

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The talk concerns the following optimization problem: a set of weighted items must be grouped into stacks, of given height and weight, in such a way that the weight of items decreases from the bottom to the top. The assignment costs depend on the positions assigned to the items within the stacks; the objective function to be minimized is the total assignment cost. We model the problem as a linear program with binary variables and investigate on its special structure, in relation with some other similar, well known, combinatorial problems. We present some preliminary results of a polyhedral analysis of the problem, aimed at strengthening the formulation and designing an exact solution algorithm. On the other hand, we discuss a possible heuristic approach, based on the Lagrangean Relaxation scheme.

Keywords: Assignment Problem, Side Constraints, Polyhedral Analysis, Lagrangean Relaxation.

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A Mixed Integer Programming Approach to the Locomotive Assignment Problem

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The locomotive assignment problem (LAP) is solved assigning a fleet of locomotives to a network of trains optimizing one or more crucial objectives and satisfying a rich set of technical and economic constraints. In the planning version of the LAP, for each train we determine the type and the number of locomotives assigned to that train. Starting from a deterministic train schedule and focusing on the planning version of a real problem faced by CSX Transportation, Ahuja et al. [1] propose to model the LAP as a Mixed Integer Programming problem and to solve it as a multicommodity flow problem with side constraints on a space-time network. Vaidyanathan et al. [4] improve the model of Ahuja [1] and solve the LAP working directly on the assignment of consists (groups of pulling locomotives linked hydraulically and electrically). Adopting a suitable initial set of available consists classes (exogenously determined by CSX), Vaidyanathan et al. [4] solve the planning LAP minimizing the total operative cost. The maintenance and fueling problems are ignored in this phase and make the modeling approach myopic. This work is motivated by the development of a new model able to (partially) integrate the planning and the routing phases, dealing with real-life aspects of the LAP not considered in the previously proposed solution approach. This model explicitly determines the initial set of available consist types and could integrate the expertise of the locomotive manager in the selection of the consist types (selection phase). The selection phase accounts for information about locomotives maintenance (and fueling) not included in the existing models. Consequently we may find high quality solutions that could be excluded by the previous approach. In its simplest form, this model is aimed to integrate an existing LAP model introducing a selection phase that performs like a pre-processing phase. Some numerical implementations of this new solution approach are presented.

Keywords: Heuristic, Locomotive Assignment, Mixed Integer Programming, Multicommodity Flow Problem, Space-Time Network.

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A Fast Heuristic Algorithm for the Train-Unit Assignment Problem

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We study an important NP-hard problem, arising in the planning of a railway passenger system, called Train-Unit Assignment Problem (TUAP) (see e.g. [2]). A train unit consists of a self-contained train with an engine and a set of wagons with passenger seats. TUAP calls for the definition of the "best" train units to be assigned to a given set of timetabled trips, each with a given number of passenger seats requested. We present a fast heuristic based on the solution of a relaxation of the problem, obtained by solving an Integer Linear Programming model that gives the optimal solution in a peak period of the day, and on the solution of a set of Assignment Problems. The heuristic is combined with local search procedures, applied in order to improve the best solution found. The heuristic is tested on real-world instances provided by a passenger train operator running trains in a regional area in Italy. With respect to previous methods (presented in [1]), the proposed heuristic turns out to be faster and to provide solutions of better quality. This makes it particularly suitable for all cases in which the problem either must be solved many times, e.g., when it is integrated with other phases of railway planning, or when it must be solved within short computing time, e.g., within real-time operations.

Keywords: Train-Unit Assignment, Heuristic Algorithm, Assignment Problem, Local Search.

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Robust Platform Assignment in Bus Stations

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The assignment of buses arriving to available gates is a major issue during the daily operations in a bus station. Such a problem is known in literature as Gate Assignment Problem and consists, given the daily bus schedule, in determining the best feasible assignment of the buses to the gates based on certain preference criteria. In order for a solution to be feasible at least two constraints have to be satisfied: each bus must be assigned to one and only one platform and two buses whose time intervals of platform occupation overlap cannot be assigned to the same platform [1]. Problems similar to gate assignment in bus stations arise in the management of airports, train stations, ports, freight villages and so on. There are also strong similarities with the register assignment problem in Digital Signal Processors [2]. In the bus station case, manager may require that the bus-platform assignment plan occupies the minimum number of platforms during the planning horizon. For this problem we propose a novel formulation as a restricted-coloring problem of an interval graph and an integer linear programming model to solve it. Trip delays such as early or late arrivals and late departures are a frequent occurrence in actual day to day bus station operations and it is often not possible to assign such buses to their original platforms. For this reason we considered a mathematical programming model to increase the robustness of the solutions by the minimization of the probability that buses assigned to the same gate

may be "in conflict" [3]. Finally, in order to generate a good solution in a reasonable computation time, we also propose a heuristic algorithm, based on the idea to solve the problem by dividing it into smaller sub-problems, using a receding horizon control, and then reconstructing the complete solution. Computational experiments on a real bus station with 24 platform and more than 200 bus trips have been performed showing the effectiveness of the approach.

Keywords: Bus Station Management, Gate Assignment, Restricted Coloring, Interval Graphs, Heuristic Methods.

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ThA2 - Exact Methods for Combinatorial Optimization Problems

Thursday, 9.00-10.30
Room C1

Column Generation for an Arc-Time-Indexed Formulation of Job Shop

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We propose and present experimental results of a column generation algorithm over an arc-time-indexed formulation for job shop scheduling problems. The formulation can be used to optimize any min-sum objective, for example, total completion time, total tardiness, and also just-in-time functions, including earliness and tardiness costs. The arc-time-indexed formulation we consider was proposed by [1] for job shop, and later by [2], [3] and [4] for single-machine and parallel machine scheduling problems. It is built over a directed graph $G = (V, A)$ where V is a set of vertices representing instants of time for each job on each machine, and A is a set of arcs representing operations of a job (or an idle time). It is a compact version of the well known time-indexed formulation, but the number of variables is still very large. To avoid dealing explicitly with this large number of variables, we solve the problem using column generation, where columns are paths in the directed graph, i.e., a set of operations with specific start/end processing time. A natural possibility is to let each column represent the set of operations of one job. In this case, a column tells when each operation of a specific job begins/ends on each machine. The master takes care of the machine/resource constraints, and the slave of the precedence constraints. The slave problem is a shortest path problem, which can be solved by a pseudo-polynomial dynamic programming algorithm if the input data contains only integer values. An alternative possibility is to let each column represent the operations on a machine. In this case, a column tells when the operations of each job start/end on a specific machine. The

master takes care of the precedence constraints and the slave the resource constraints. Our computational results show that, although harder to solve, the formulation with columns associated with machines yields notably better LP bounds than the one with columns associated with jobs.

Keywords: Column Generation, Job-Shop Scheduling, Combinatorial Optimization.

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On the Partition of an Administrative Region into Homogeneous Districts

Fabio Colombo, Roberto Cordone, Marco Trubian

DSI - University of Milan

We consider the problem of partitioning a given region into connected districts and assigning them to administrative officers. The officer in charge of a district takes care of all the activities in which the municipalities of that district are involved. An activity corresponds to a task which requires the coordination of a subset of municipalities; it implies for the officer in charge a fixed workload for the task, plus a variable workload proportional to the number of municipalities involved. If the subset of municipalities associated to an activity is divided into several districts, the fixed workload is required to each of the corresponding officers, thus leading to a duplication. The problem requires to balance the officer workload and minimize duplications. We model

the problem as that of finding a suitable balanced partition into trees of a node weighted undirected graph. We propose compact and extended formulations, reduction procedures for generating valid inequalities for both formulations, a column generation approach, a cutting plane algorithm for the pricing problem, and local search algorithms for the general and the pricing problems. We provide computational results for random instances and for two real-world instances (Milano and Monza provinces).

Keywords: Column Generation, Graph Partitioning, Cutting Planes.

The Power of Ten

Matteo Fischetti, Michele Monaci

DEI, University of Padova

Suppose you are given a difficult MILP along with a black-box exact solver, and you are allowed to add a single valid cut to your input formulation. How do you define that single cut in a computationally cheap way, so as to reduce the overall computing time of the black-box solver? We analyze different possible options, and present computational results on a set of 38 difficult MIPLIB/CORAL instances showing that one–quite simple–choice succeeds in reducing the black-box (Cplex 12) computing time by a significant amount. Some implications for branching will be discussed.

Keywords: Mixed-Integer Linear Programs, Computational Analysis, Branching.

On the Rank of Disjunctive Cuts

Alberto Del Pia

IFOR - ETH Zurich

Let P be a rational polyhedron, and let P_I be the mixed integer hull of P. We characterize whenever a valid inequality for P_I, or the disjunctive cuts for P corresponding to a lattice-free polyhedron, can be obtained with a finite number of disjunctive cuts corresponding to an arbitrary family of lattice-free polyhedra containing the splits. In the special case where we consider only split cuts, we held a characterization of the lattice-free polyhedra whose corresponding disjunctive cuts have finite split rank.

Keywords: Lattice-Free Polyhedra, Disjunctive Cuts, Split Cuts.

ThA3 - Scheduling II

Session organized by Lucio Bianco

Thursday, 9.00-10.30
Room B2

Scheduling Problems with Unreliable Jobs and Machines

Alessandro Agnetis[1], *Paolo Detti*[1], *Patrick Martineau*[2], *Marco Pranzo*[1]

[1] Università di Siena

[2] Université de Tours

In this talk we present some results concerning scheduling problems in which jobs or machines are subject to failures. When a failure occurs on a machine during the execution of a job, the job and all the remaining work scheduled but not yet executed on that machine are lost. Jobs are characterized by a certain revenue (if successfully carried out) and a certain chance of success. The problem is to allocate and sequence the jobs on m parallel identical machines in order to maximize expected revenue. We will discuss its complexity and analyze the worst-case performance of a simple list scheduling algorithm (LSA) showing that, for $m = 2$, it yields a 0.853-approximate solution. We then focus on the special case in which machines are subject to exponentially distributed failures, and discuss this particular setting, which is of interest in distributed computing. For two relevant performance indices, namely (i) the expected number of completed jobs or (ii) the expected amount of work done, we show that LSA provides the optimal solution for any number of machines.

Keywords: Scheduling, Parallel Machines, Approximation.

A Bilevel Rescheduling Framework for Optimal Inter-Area Train Coordination

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[3] Dipartimento di Ingegneria dell'Informazione, Università di Siena, Italy

Railway dispatchers reschedule trains in real-time in order to limit the propagation of disturbances and to regulate traffic in their respective dispatching areas by minimizing the deviation from the off-line timetable. However, the decisions taken in one area may influence the quality and even the feasibility of train schedules in the other areas. Regional control centers coordinate the dispatchers' work for multiple areas in order to regulate traffic at the global level and to avoid situations of global infeasibility. Differently from the dispatcher problem, the coordination activity of regional control centers is still underinvestigated, even if this activity is a key factor for effective traffic management. This paper studies the problem of coordinating several dispatchers with the objective of driving their behavior towards globally optimal solutions. With our model, a coordinator may impose constraints at the border of each dispatching area. Each dispatcher must then schedule trains in its area by producing a locally feasible solution compliant with the border constraints imposed by the coordinator. The problem faced by the coordinator is therefore a bilevel programming problem in which the variables controlled by the coordinator are the border constraints. We demonstrate that the coordinator problem can be solved to optimality with a branch and bound procedure. The coordination algorithm has been tested on a large real railway network in the Netherlands with busy traffic conditions. Our experimental results show that a proven optimal solution is frequently found for various network divisions within computation times compatible with real-time operations.

Keywords: Train Delay Minimization, Schedule Coordination, Bilevel Programming.

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A Bilevel Programming Model for Scheduling in Grid Computing

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Università di Roma - Tor Vergata

Grids are distributed computational systems, and, in this context, Grid scheduling, that is, the allocation of distributed computational resources to user applications, is one of the most challenging and complex task. Ranganathan and Foster (2002) proposed one of the most known framework for Grid scheduling, where the Grid is modeled by means of three components: an External Scheduler (ES) responsible for determining a particular computing site where a submitted task can be executed; a Local Scheduler (LS), responsible for determining the order in which tasks are executed at that particular site; a Dataset Scheduler (DS). Referring to this framework, we study the following Grid scheduling problem. A set of independent user applications (tasks) is submitted to the ES, and have to be assigned by the ES to a set of Grid computing sites, each one controlled by a LS, for their execution. Each task arrives in the system at a given (release) date and has a due-date, that can be exceeded implying a reduction of the level of service that induces a penalty cost for the Grid proportional to the task tardiness. We assume that there is an upper limit on this cost, implying that it is preferable for the Grid to reject the task (paying a rejection cost) rather than accept it if the related tardiness penalty cost would be greater than that limit. While the ES looks for executing the submitted tasks over the Grid minimizing the total cost for rejecting or delaying tasks, the goal of each LS is maximizing computational resource usage efficiency. The ES problem, together with that of each LS, form a hierarchical optimization problem, where the decision of the ES is constrained by

that of the LSs, and vice-versa. We model this problem by means of bilevel programming. After reformulating the latter as a single level mixed integer program, we propose a heuristic algorithm to cope with large size instances happening in practice. Computational results are presented and discussed.

Keywords: Grid Computing, Resource Management, Bilevel Model.

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ThA4 - Network Flow Problems and Hypergraphs

Thursday, 9.00-10.30
Room A2

A Comparison of the Natural Existing Approaches for Solving Multicommodity-Flow Problems

Tiziano Parriani, Alberto Caprara

DEIS - Università di Bologna

The multicommodity-flow problem arises in a wide variety of important applications. Many communication, logistics, manufacturing, and transportation problems can be formulated as large multicommodity-flow problems. In our work we apply and compare the natural existing approaches for solving multicommodity-flow problems. The purpose of the study is to certify the advantages and drawbacks, in terms of computing time, of the following linear programming formulations: (i) the one in which each variable is associated with an arc; (ii) the one in which each variable is associated with a path (to be solved via column generation) (ii) the one in which each variable is associated with the entire flow exiting from a source (again to be solved via column generation). Tests are mainly performed over the so called PDS (Patient-Distribution System) instances, which are commonly used as a de facto standard for testing the performance of multi commodity codes. In the past other comparisons were studied but it seems that the algorithmic and hardware advances during the last years changed the situation.

Keywords: Graph Theory, Multicommodity-Flow, Column Generation.

Efficient Deterministic Algorithms for Finding Optimal Cycle Bases in Undirected Graphs

Claudio Iuliano, Edoardo Amaldi

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The concept of graph is a powerful mathematical model and its cyclic structure plays a major role in many fields. Given a simple undirected graph G, a cycle is a subgraph in which every node has an even number of incident edges. Since all cycles of a graph form a vector space over GF(2), cycle bases provide a compact representation of the cyclic structure of G. In a variety of applications (e.g., the analysis of electrical circuits, periodic event scheduling, computational biology and organic chemistry, network design) we are given a graph G with a nonnegative weight assigned to each edge and we are interested in finding a minimum cycle basis, i.e., a cycle basis of minimum total weight, where the weight of a basis (cycle) is defined as the sum of the weight of its cycles (edges). We present the best polynomial-time algorithm from the worst-case point of view and we develop efficient algorithms which outperform the existing ones in practice [1,2]. We also study two variants of the problem with topological constraints that are of interest in some applications. In the first problem variant, a nonnegative length is assigned to each edge and we look for a minimum cycle basis such that the length of each cycle does not exceed a given constant. We prove that this problem is NP-hard in general but polynomially solvable when all edges have equal length. For this case we propose an algorithm with the same worst-case complexity as the one for the unconstrained problem [3]. In the second problem variant, an integer bound is assigned to each edge and we wish to find a cycle basis with limited edge overlap, i.e., such that each edge belongs to a number of cycles of the basis not greater than its prescribed edge bound. We prove that it is NP-complete to decide whether such a cycle basis exists and we propose a heuristic aiming at minimizing the edge bound violation [4]. Computational results on a wide set of instances show that our algorithms perform well even on large graphs.

Keywords: Combinatorial Optimization, Undirected Graph, Cycle Basis, Algorithm, Complexity.

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On the Resource Constrained Shortest Path Problem with Sequence Constraints Arising in Crew Scheduling

Stefano Gualandi[1], *Federico Malucelli*[2], *Francesco Bernazzani*[3], *Samuela Carosi*[3]

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[2] Politecnico di Milano

[3] MAIOR

Given a weighted directed acyclic graph $G = (N, A)$, a pair of source-target nodes s and t, a vector of resource consumptions on each arc, the classical Resource Constrained Shortest Path (RCSP) problem consists in finding the shortest path from s to t so that the resources at the node t satisfies given lower and upper bound constraints. This problem arises as subproblem in several transportation problems when solved via a column generation algorithm. Some pseudo-polynomial labeling-based algorithms have been proposed [1], however those algorithms when applied to practical crew scheduling instances suffer when the number of resources and the size of the graph increase. In the context of a column generation algorithm for a bus driver scheduling problem, we consider a variant of RCSP with an additional "sequence constraint" that models a new restriction imposed by European regulations. The sequence

constraint requires that, given a duty, a certain number of breaks are present. More precisely, given a duty of time length d, a time windows w, and two types of break A and B, the sequence constraint requires that for every possible time window of length w contained in the duty there are at least one break of type A and one of type B. We propose a new algorithm for solving the RCSP with the sequence constraints that fully exploits preprocessing techniques in order to reduce as much as possible the input graph. Our algorithm combines different techniques proposed in recent work for the RCSP problem and for the sequence constraint [2,3,4,5]. The algorithm we propose is evaluated using a large set of challenging real instances generated while solving via column generation the bus driver scheduling problem for COTRAL, an Italian public company. The computational results are remarkable: many instances are solved directly in the first phase of our algorithm, that is during the preprocessing phase.

Keywords: Constraint Shortest Path, Column Generation, Crew Scheduling.

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Von Neumann-Morgenstern Clutters

Stefano Vannucci

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A clutter on a set X is a simple hypergraph (X, E) with pairwise non-comparable hyperedges, hence in particular any set of Von Neumann-Morgenstern (VNM) -stable sets of an irreflexive simple digraph is a clutter. Conversely, a clutter (X, E) is representable by VNM-stable sets or VNM if there exists an irreflexive simple digraph (X, D) such that E is a set of VNM-stable sets of (X, D). The class of VNM clutters on a set X is characterized.

Keywords: VNM-Stable Sets, Kernels, Clutters, Sperner Systems, Games.

ThA5 - Heuristics III

Thursday, 9.00-10.30
Room AM

Departures Scheduling for a Multi-Runway Airport

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Many airports have multiple runways, used in different configurations and for different purposes. In this case, the main issue is to find the optimal assignment of each runway to the departing flights, according to some constraints. Hence, the goal is to maximize the use of the runways, avoiding time holes that could compromise the airport performance. We propose the formulation of a multi-runway dispatcher implementing an algorithm based on the integer linear programming. We consider as assignment criteria, the particular configuration, the rate and the category of each runway and the weight class of each aircraft. First, we set the initial placement of aircraft on each runway taking into account the criteria and time slots based on the classical Wake Vortex Separations. Starting by this placement, we developed an heuristic swapping procedure which consists of creating a delay's queue for each runway, using the Departure Management System, and moving iteratively aircraft between the runways in order to decrease the total delay. When each queue is empty, an instance of the multi-runway algorithm run to find an assignment minimizing the total delay. Simulations on typical flight strips from Milano Malpensa airport are shown.

Keywords: Multi-Runway Dispatcher, Departure Management System, Runway Configuration.

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Synchronizing Bus Timetabling

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Timetabling is a sub problem of bus network strategic planning, in which the departure time of each bus is indicated. We address the bus timetabling problem of Monterrey, Mexico, where exists a large bus network where passenger transfers must be favored, almost evenly spaced departures are sought, and bus bunching of different lines must be avoided. We formulate this timetabling problem with the objective of maximizing the number of synchronizations, i.e., to maximize the arrivals of different bus lines to allow passenger transfers or to avoid bus bunching along the network. We consider these synchronizations within a time window to make a flexible formulation. This flexibility is a critical aspect for the bus network, since travel times vary because of reasons such as driver speed, traffic congestion, and accidents. Although this problem is NP-Hard, we analyze the structural properties of the feasible solution space of our model. This analysis leads to a preprocessing stage that eliminates numerous decision variables and constraints, and also it is used to design a multi-start Iterated Local Search algorithm. Empirical experimentation shows that our proposed algorithm obtains high quality solutions for real size instances in a reasonable time. Finally, we propose an integrated formulation of this timetabling problem with the single-depot single-type vehicle scheduling.

Keywords: Bus Timetabling, Synchronization, Passenger Transfer, Bus Bunching, Feasible Solution Space.

An Algorithm Based on Local Search to Solve the Multiparametric 0-1-Integer Linear Programming Problem

Alejandro Crema

Universidad Central de Venezuela

The multiparametric 0-1-Integer linear Programming (0-1-IP) problem relative to the objective function is a family of 0-1-IP problems related by having identical constraint matrix and right-hand-side vector. We present an algorithm to perform multiparametric analysis in the case of an objective function with interval data. We say that a multiparametric analysis was completed if we have found a set of feasible solutions (W) such that: for any member of the family there exists a near optimal solution that belongs to W. The procedure starts with W defined by an optimal solution of a single member of the family. Our algorithm works by solving a finite sequence of non-parametric mixed integer linear programming problems that are designed to perform the multiparametric analysis in the neighborhoods of W. With the non-parametric problems we are looking for the maximal difference between the optimal value for a member of the family that is not in W and an upper bound function based on the solutions that define W. The solution with the maximal difference is added to W. When the local search was completed, according to some predefined tolerance, we have found a new W and then we introduce a local branching cut to generate a new neighborhood and so on. We suppose that we have enough time to obtain W. Once the true cost vector becomes known we have quickly a near optimal solution either to be used or to start a re-optimization. Computational experience will be presented.

Keywords: Multiparametric Integer Programming, Local Search, Local Branching.

A Column Generation Heuristic for Machine-Part Cell Formation

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The international competition and its consequent needs for quick answers to the market demands have lead companies to consider several approaches to control and design the manufacturing systems. The group technology decomposes manufacturing systems into manageable sub-systems, or groups, by aggregating similar parts into families of parts and machines into cells that aim to be independent and completely manufacturing a family of parts. The Machine-Part Cell Formation (MPCF) is the problem of creating manufacture cells aiming best production flow of manageable sub-systems. MPCF is an important and difficult problem largely studied in industrial manufacturing literature. Many optimization techniques have being proposed to create manufacturing cells. Heuristic and metaheuristic methods generally work over machine-part binary matrices, with machines and parts corresponding to its dimensions, and non-zero values indicating which machines are used to produce each part. The objective of these algorithms is to produce matrices blocks of non-zeros. This work presents a new model for the problem as set partitioning with a cardinality constraint. A column generation approach to p-median problems is adapted to produce feasible assignments of parts into families, based on Hamming or Jaccard distances for binary strings. A further heuristic step assigns machines to families of parts to form manufacturing cells. Computational experiments confirm the feasibility of the column generation heuristic to achieve and even improve the clustering efficacy of the best known solutions for test instances from literature.

Keywords: Column Generation, Manufacturing Cells, Heuristic.

FrA1 - Network Optimization

Session organized by Francesca Guerriero

Friday, 9.00-10.30
Room B3

An Iterative Refinement Algorithm for the Minimum Branch Vertices Problem

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To solve the NP-complete minimum branch vertices problem (MBV), we propose a new iterative refinement heuristic. Experimental results will be presented suggesting that this approach is capable of finding solutions that are better than the best known in the literature. In fact, the heuristic looks very promising for the solution of problems related with constrained spanning trees.

Keywords: Constrained Spanning Trees, Branch Vertices, Iterative Refinement.

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Routing Algorithms in Future Internet

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This paper focuses on self-adaptation routing algorithms. In contrast to traditional routing algorithms that are based on static optimization this approach tries to adapt the network to changing network condition. With increasing dynamics, network-wide routing tables and network status information in a centralized views becoming imprecise. Then distributed and self-organizing approaches remain as the only effective solutions in highly dynamic communication scenarios [2]. Presented algorithms are applied in the management of the telecommunication networks but it can be applied also to transportation and logistics networks. Self-adaptation is one a key feature in the Future Internet [1]. The network itself should take proactive or reactive actions in order to adapt to changing networking conditions due to the variation of demands or unexpected anomalies. In the self-adaptation routing algorithms we can distinguish three stages: detection of abrupt changes in traffic flows, localization algorithm and routing adaptation. In this paper we will focus only on routing adaptation algorithms. The algorithms presented in this paper are based on multiple metrics (criteria) for path evaluation. We apply reference point approach [3] for new path finding. On-line traffic information is used for specification of reference points.

Keywords: Routing Algorithms, Networks, Distributed Algorithms.

References

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Solution Approaches for the Multi-Objective Spanning Tree Problem

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The multi-objective spanning tree problem (MOSTP, for short) is considered. This problem arises in both telecommunications and transportation fields. In addition, the growing in both customers demand and social environment, impose that more than one criterion have to be optimized. The scientific literature provides several works that focus on a specialized instance of the considered problem, that is the bi-objective version (shortly, BOSTP) in which only two criteria are taken into account. To the best of our knowledge, no works address the MOSTP. Since the tactical and operative importance of this problem, we have defined solution methods in order to determine the entire set of Pareto-optimal spanning trees in the general case, that is with $k > 1$ criteria. The proposed strategies are also able to solve the minimum spanning tree problem (STP).

Keywords: Multiple Objective Programming, Spanning Tree Problem, Pareto Front.

FrA2 - Routing I

Friday, 9.00-10.30
Room C1

Analysis and Branch-and-Cut Algorithm for the Time-Dependent Travelling Salesman Problem

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Given a graph whose arc traversal times vary over time, the Time-Dependent Travelling Salesman Problem (TDTSP) consists in finding a Hamiltonian tour of least total duration covering the vertices of the graph. The contribution of this paper is twofold. First, we describe a lower and upper bounding procedure that requires the solution of a simpler (yet NP-hard) Asymmetric Travelling Salesman Problem (ATSP). In addition, we prove that this ATSP solution is optimal for the TDTSP if all the arcs share a common congestion pattern. Second, we formulate the TDTSP as an integer linear programming model for which valid inequalities are devised. These inequalities are then embedded into a branch-and-cut algorithm that is able to solve instances with up to 40 vertices.

Keywords: Travelling Salesman Problem, Time Dependence, Lower and Upper Bounds, Branch-and-Cut.

A Variant of TSP with Profits for Servicing Printers and Copiers

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[1] IRIDIA - Université Libre de Bruxelles

[2] Università Ca' Foscari Venezia

In this work, we deal with a case study proposed by a firm located in the Veneto region, that rents and maintains printers, scanners, faxes and copiers. The firm has about 8000 customers, and it has at its disposal 20 service men for ensuring the full efficiency of its equipment at the customers. These service men visit each customer that fills a service request. The aim of the firm is servicing as many customers as possible every day, thus minimizing the number of inoperative pieces of equipment. Customers may indicate the times of their availability, or they may fix an appointment. The firm identifies some customers as extremely important, and thus imposes to its service men to visit them as soon as they fill a service request. The cost that the firm bears for ensuring the service is about 40 Euro per working hour, plus 0.28 Euro per Km traveled. The firm identifies a list of possible types of problems that may require a service. The historical records of the service time necessary for solving these types of problems on different pieces of equipment is the basis for estimating the actual service time. Considering all the parameters and constraints just described, the firms currently relies on the expertise of the department chief for assigning every day some requests to each service man. Then, the service man decides autonomously in which order to visit customers. We tackle this problem as a variant of the traveling salesman problem with profits [1], that is, of the traveling salesman problem in which it is not necessary to visit all the customers. We introduce several constraints for taking into account multiple time windows, appointments, priority of some customers, and all other elements indicated as relevant by the firm. We propose an integer programming model for representing the problem, and we propose various methods for dealing with the partial unpredictability of the service time. We compare the solutions obtained with the ones implemented by the firm.

Keywords: Traveling Salesman Problem with Profits, Multiple Time Windows, Case Study.

References

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A Study on the Bi-Objectives Distance-Constrained Vehicle Routing Problem Relaxation

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[3] Dipartimento di Ingegneria, Università di Ferrara

We consider bi-objectives formulation of the uncapacitated Distance-Constrained Vehicle Routing Problem with identical vehicles and a limit on the maximum route length. The objective functions to be minimized are total distance and number of vehicles. We discuss pros and cons of alternative lagrangian relaxations and the role of surrogate constraints. We conclude by illustrating some computational results for small to moderate size instances.

Keywords: Distance-Constrained Vehicle Routing Problem, DVRP, Multi Objectives, Lagrangian Relaxation.

References

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Planning Vehicle Routes with Uncertain Attended Deliveries

Paolo Brandimarte, Arianna Alfieri, Giulio Zotteri

DISPEA - Politecnico di Torino

We describe a decision support system for short-term planning of customer deliveries in industries such as furniture and white goods, where deliveries involve a significant service component (e.g., assembly of a kitchen) and must be attended. Customers may order standard items, which are kept in inventory, or items that are made to order. When all of the items of a customer order are available, delivery may be arranged, with the twofold aim of staying within an agreed time window and minimizing transportation cost. This is not a classical VRP, as customers must be contacted by phone in order to arrange delivery, which makes the problem uncertain: the customer might be unwilling to accept an appointment for the proposed date and another one must be agreed. The problem we consider is the dynamic sequencing of customer phone calls, without knowing if answers will allow for efficient routes. For instance, imagine that we have two customers, close to each other, but far from the deposit and from other customers. The first customer we call might reject the delivery for the following day; then, including the second customer in the route we are currently building is not advisable. Even worse, if the second customer rejects after the first one has accepted, we cannot undo the route. Deliveries that are not arranged now must be arranged in the following days, and more are added every day. Classical VRP methods are ineffective as they do not account for the basic features of the problem, which is quite critical for deliveries in zones with a low density of customers; in such a case, on the one hand we have an incentive to wait and see if more deliveries in that zone can be arranged; on the other hand, we cannot postpone delivery too much. Computational efficiency is fundamental, since phone calls must be sequenced in real time. We propose and test variants of constructive heuristics through a simulation based on a realistic case study involving a 500+M€ retailer.

Keywords: Logistics, Vehicle Routing Problem, Decisions under Uncertainty.

FrA3 - Financial Optimization

Session organized by Giorgio Consigli

Friday, 9.00-10.30
Room B2

Personal Asset-Liability Management with Insurance Portfolios

Davide Musitelli[1], *Massimo di Tria*[1], *Giorgio Consigli*[2]

[1] Allianz Investment Management

[2] University of Bergamo

Financial innovation has induced in recent years a remarkable diversification of contract payoffs across financial and insurance secondary markets. An aggressive policy by financial intermediaries and institutional investors in search of sustainable operating profits is behind the observed market evolution. A growing proportion of hybrid asset classes, carrying financial and insurance features, can be found as a result in households' investment portfolios. This article explores the effects of such trend on households' allocation strategies from the perspective of individual optimal asset-liability management. A multistage stochastic programming problem with investment opportunities including mutual and pension funds as well as unit-linked contracts and annuities is formulated and solved. The introduction of intermediate investment and consumption objectives with inflation-adjusted living costs leads to the definition of a realistic household long-term financial planning problem whose key elements are summarised with reference to a real-world case problem.

Keywords: Multistage Stochastic Programming, Long Term Individual Financial Planning, Asset-Liability Management, Life Insurance.

Dynamic Derivative Strategies with Risk Overlays

Francesco Sandrini, Dermot Ryan

Pioneer Investments

Fiduciary managers are increasingly facing the challenge to deliver a level of return which can meet investors' requirements, as measured by a cost of funding (e.g. Libor), a market benchmark (e.g. S&P 500) or the present value of a future liability stream (as in the case of a pension fund), whilst actively controlling for portfolio drawdown over a shorter investment horizon. This tendency has been steadily increasing over last few years as a combined result of changes in regulations, and of spikes in risk aversion as a consequence of a quite sharp financial crisis. We advocate Risk Overlays are a powerful, efficient and transparent way to combine goal driven investing and risk mitigation over different time horizons. We introduce an innovative risk overlay algorithm and we show how even the usage of simple dynamic derivatives strategies can play an important role to augment portfolio efficiency. We employ Montecarlo simulation techniques, we assess portfolio efficiency both from a back-testing and forward looking perspective. We finally introduce a dynamic optimization framework for planning and managing portfolios in a framework fully coherent with investors expectations.

Keywords: Risk Control, Dynamic Hedging, Monte Carlo Simulation, Performance Measures.

SP-Based Decision Making for Financial Applications

Vittorio Moriggia, Giorgio Consigli, Gaetano Iaquinta

University of Bergamo

Dynamic optimization techniques, thanks to computational advances and financial awareness, are increasingly replacing canonical static optimization approaches both in the financial and insurance markets. Following a set of real-world projects dedicated specifically to individual and institutional asset-liability management applications, we present the key elements supporting the

definition of a decision support tool employing a dynamic stochastic programming framework. The tool interfaces four modules dedicated to DB management, statistical modelling, optimization and I/O analysis. The core program runs in Matlab, which is interfaced with GAMS, the algebraic modelling language handling the model formulation and solution and Microsoft Excel for I/O purposes. The presentation will focus on the implementation steps and numerical performance of the decision tool from the mathematical description of the financial application to the SP formulation and solution. The importance of output analysis for practical purposes will be emphasized.

Keywords: Dynamic Stochastic Programming, Asset-Liability Management, Computer-Based Decision Making.

Property & Casualty Dynamic Portfolio Management

Giorgio Consigli[1], *Vittorio Moriggia*[1], *Gaetano Iaquinta*[1], *Angelo Uristani*[1], *Massimo di Tria*[2]

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Recent trends in the insurance sector have highlighted expansion of large insurance firms into asset management. In addition to their historical liability risk exposure associated with statutory activity, the growth of investment management divisions has caused increasing exposure to financial market fluctuations. This has led to stricter risk management requirements as reported in the Solvency II 2010 impact studies by the European Commission. The phenomenon has far reaching implications for the definition of optimal asset-liability management (ALM) strategies at the aggregate level and for capital required by insurance companies. In this article we present an ALM model tested in a real-world case study, combining in a dynamic framework an optimal strategic asset allocation problem formulation subject to property and casualty (P&C) business constraints for a large insurer. The problem is formulated as a multistage stochastic program (MSP) and the definition of the underlying uncertainty model, including financial as well as insurance risk factors, anticipates the model's application under stressed liability scenarios. The benefits of a dynamic formulation and the opportunities arising from of an integrated approach to investment and P&C insurance management are highlighted in this chapter.

Keywords: Property and Casualty Insurance, Asset-Liability Management, Multistage Stochastic Programming, Insurance Liabilities.

FrA4 - Data Mining

Friday, 9.00-10.30
Room A2

A Data Mining Approach to the Pharmacogenomics of Anticoagulation

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[2] DISCo, University of Milano-Bicocca

Oral anticoagulation, administered to reduce the risk of thrombotic events mostly in atrial fibrillation patients, carries a substantial risk of adverse hemorrhagic effects. To balance the 2 risks the index INR, base on a simple blood test, is to be kept in a prescribed range: this is challenging due to high inter individual and temporal variation of the dose/response relationship. Genetic profiling of the patients offers the possibility of a tailored, even individualized, therapeutic protocol. This work, performed within the project NEDD (Network Enabled Drug Design) sponsored by Regione Lombardia, has focused on several issues: exploratory data analysis of a data set of about 4000 patients, their classification through machine learning techniques according to their genetic and clinical features and the regression analysis of the optimal dosing problem.

Keywords: Data Mining, Anticoagulation Therapy, Pharmacogenomics.

A Column Generation Algorithm for the Inverse Frequent Itemset Mining Problem

Luigi Moccia[1], *Antonella Guzzo*[2], *Domenico Saccà*[2], *Edoardo Serra*[2]

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[2] DEIS - Università della Calabria

Transaction databases are databases where each tuple, called transaction, is defined as a subset of an underlying fixed set of items I. A mining task over transaction databases yields the set of the frequent itemsets, i.e., all the subsets of I (called itemsets) which are contained in a significant fraction (user-specified as a minimum support threshold) of the given database size. The Frequent Itemset Mining Problem (FIMP) attracted relevant research efforts in recent years, and several solution methods have been discussed in the literature. The inverse problem, called Inverse FIMP (IFIMP), has been recently introduced to define generators for benchmarks of mining algorithms [2]. Moreover, the IFIMP can be useful in privacy preserving contexts [3, 4], where the goal is to publish some data while avoiding disclosure of sensitive or private knowledge. In this presentation, we first show how the IFIMP can be modeled as an integer linear program with an exponential number of variables. We then discuss the practical relevance of the linear approximation of this formulation, which can be solved by column generation [1]. Unfortunately, the pricing problem is such that there is no ϵ-approximate polynomial algorithm for it, unless P = NP. We present an integer linear program formulation for the pricing problem, which we prove being stronger than a previously defined formulation. A fast constructive heuristic for the pricing problem is also introduced. Computational experiments are reported and show the efficacy of the proposed column generation algorithm.

Keywords: Inverse Requent Itemset Mining Problem, Column Generation, Transaction Databases, Data Mining.

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Data Mining Categorical Time Series Using a Hybrid Clustering Method

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The identification of different dynamics in time series data has become an everyday need in scientific fields such as marketing, bioinformatics, finance, or social sciences. Contrary to cross-sectional or static data, this type of observations (also known as stream data, temporal data, longitudinal data or repeated measures) are more challenging as one has to incorporate data dependency in the clustering process [2]. In this research we focus on clustering categorical time series. The method proposed here combines model-based and heuristic clustering. In the first step, the categorical time series are transformed by an extension of the hidden Markov model into a probabilistic space, where a symmetric Kullback-Leiber distance can operate. Then, in the second step, using hierarchical clustering on the matrix of distances, the sequences can be clustered. This paper illustrates the enormous potential of this type of hybrid approach using the well-known Microsoft dataset with website users search patterns [1].

Keywords: Data Mining, Time Series Data, Hidden Markov Models, Clustering, Categorical Data.

References

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A Data Mining Analysis of the Impact of Air Pollution on Cardio-Respiratory Emergency Admissions in Milano

Ilaria Giordani[1], *Francesco Archetti*[2], *Luca Cattelani*[2], *Enza Messina*[2], *Paolo Testa*[2]

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[2] University of Milano Bicocca

In this paper we present a data mining approach to assess the impact of air pollution levels on emergency cardio-respiratory hospital admissions. This work, performed within the European project LENVIS (Localized Enviromental and health information services for all) has led to the development of a DSS based on 2 main computational modules: data preprocessing, including exploratory data analysis, and forecasting which is the specific focus of this paper. Hidden Markov Models(HMM) are shown to be a suitable model to capture the relation between the two time series of hospital admissions and pollution levels. Coupling them with diffusion models, at different time scales, allows an efficient forecasting of the admission levels.

Keywords: Hidden Markov Models, Air Pollution Levels, Health Data.

FrA5 - Graph Theory and Optimization

Session organized by Federico Della Croce

Friday, 9.00-10.30
Room AM

Minimum Zone Evaluation by Mathematical Programming

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[1] DISPEA - Politecnico di Torino

[2] DI - Università degli Studi di Torino

[3] DAUIN - Politecnico di Torino

Coordinate Measuring Machines (CMM) have become quite popular in the industry in view of their ability to control a variety of product characteristics. Given the coordinates of a set of points probed with a CMM, it is necessary to associate them the nominal surface that undertakes the manufactured one. The two most popular association criteria, proposed by international standards, are Least Squares and Minimum Zone. The first one is a statistical method that estimates, minimizing the sum of square of residuals, the feature best fitting the set of points. The tolerance error is estimated by using the distance of sampled points from the reconstructed surface and usually it leads to an overestimation of tolerance error. On the other hand Minimum Zone is a deterministic method that find the two nominal surfaces, of the form of the considered tolerances, containing the set of sampled points. Although using mathematical (specifically, linear) programming for such problems was already envisaged in [1], recent literature contains a wide range of surprisingly sophisticated heuristic approaches (Genetic Algorithms [3], and Particle Swarm Optimization [2] to cite a few). We revise the most common minimum-zone problems covering almost the whole set of tolerances employed in technical specification, and we show that, under mild assumptions, linear programming effectively handles such problems, providing good results by means of standard LP software packages.

Keywords: Minimum Zone, Mathematical Programming, Tolerance Assessment.

References

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On the Max k-Vertex Cover Problem

Federico Della Croce[1], *Vangelis Th. Paschos*[2]

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In the max k-vertex cover problem a graph $G(V, E)$ with $|V| = n$ vertices $1, ..., n$ and $|E|$ edges (i, j) is given together with an integer value $k < n$. The goal is to find a subset K of V with cardinality k, that is $|K| = k$, such that the total number of edges covered by K is maximized. The problem is well known to be NP-hard and has been shown to be fixed-parameter intractable. MAX k-Vertex cover is known to be polynomially approximable within approximation ratio 3/4, while it cannot be solved by a polynomial time approximation scheme unless P=NP. First, a combinatorial algorithm able to compute the optimal solution in $O^*(2^t)$ is proposed where t is the size of the minimum vertex cover on the same graph. Such algorithm leads also to a running time $O^*(2^{bn})$ (with $b = 1 - 1/D$) where D is the maximum degree of the graph. Then, an exact branch and reduce algorithm based on the measure and conquer paradigm is proposed requiring running time $O^*(2^{cn})$ with $c = 1 - 2/(D + 1)$. Such algorithm is then tailored to graphs with maximum degree 3 inducing a running time $O^*(1.3339^n)$. We finally study approximation of max k-vertex cover by moderately exponential algorithms.

Keywords: Max k-Vertex Problem, Exact Exponential Algorithms, Moderate Exponential Complexity Approximation.

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Detecting Critical Nodes in Graphs: MILP Models and Valid Inequalities

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We consider the problem of minimizing a connectivity measure in an undirected graph by removing a limited number of nodes (called "critical" nodes). The connectivity measure is defined as the number of node pairs linked by some path in the residual graph. The problem has been tackled by several authors in recent years, for applications related to network immunization [1], transportation networks [2], telecommunications [3]. A promising heuristic approach is sketched in [4]. We compare two different mixed-integer linear programs for such problem, one of which is characterized by a number of constraints that is exponential in the number of nodes. Also, we propose different classes of valid inequalities and discuss their effectiveness through computational experiments.

Keywords: Complexity, Critical Node Problem, Mixed-Integer Linear Programming.

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Detecting Critical Nodes in Graphs: Complexity Results

Andrea Grosso[1], *Bernardetta Addis*[1], *Marco Di Summa*[2]

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We give complexity results for the problem of minimizing a connectivity measure in an undirected graph by deleting a subset of nodes (called "critical" nodes) subject to a budget constraint. We prove that the problem is NP-hard on several simple classes of graphs, and give polynomial algorithms for graphs with special structure. The considered connectivity measure is the number of node pairs linked by some path in the residual graph, but some of our results are easily extended to different objective functions.

Keywords: Complexity, Critical Node Problem, Dynamic Programming.

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FrB1 - Logistics IV

Friday, 11.00-12.30
Room B3

Scheduling with Multiple Tasks per Job – the Case of Quality Control Laboratories in the Pharmaceutical Industry

Alex Ruiz-Torres[1], *Jose Ablanedo-Rosas*[2], *Daniel Otero*[3]

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This paper addresses a complex scheduling problem encountered in a major pharmaceutical industry setting. Specifically, the problem deals with assigning tasks to technicians as part of the quality control phase in order to minimize the total flow time, and the number of jobs not meeting a required time window. The problem considers test batching, overlapping tests, and resource assignments constrained by test specific capability requirements. Furthermore, batching tasks of similar types is possible, but batch sizes are particular to each product-test type combination. This is a significant difference from previous literature in batching parallel machines. The particular problem described in the paper is highly relevant to the pharmaceutical industry and has not been previously addressed in the literature. Various approaches to solve this particular problem are described and compared via statistical analyses. Finally, the authors present a software prototype with implemented solution algorithms.

Keywords: Scheduling, Production Planning, Quality Planning, Quality Control, Real World Applications.

Mailroom Production Planning

Sandro Bosio

IFOR, ETH Zurich

A Multi-Feeder Mailroom is a machine for high-speed insertion of advertising inserts into folders. It consists of a single production line on which several insert feeders operate independently. The input to a Mailroom Production Planning problem is given by a set of advertising inserts and by a collection of insert bundles, which are subsets of inserts to be fitted together (e.g. into a folder or a newspaper). Each bundle has a demand (number of copies) and a corresponding production time. In order to produce a bundle all of its inserts have to be loaded on the feeders. There are less feeders than inserts, and different bundles use different inserts. Therefore, the inserts loaded on the feeders will change during the production. Loading an insert on a feeder requires a set-up time, during which the feeder cannot be used. If a loading cannot be performed during the idle time of the corresponding feeder then a machine stop has to be triggered, which delays the production and incurs operational costs. The Mailroom Production Planning problem consists in deciding the order of production for the bundles and, for each bundle, the allocation of its inserts to the feeders. The main goal is to minimize the number of machine stops, which is equivalent to minimize the production make-span. Other (conflicting) objectives that can be considered are the minimization of the number of insert loadings (ideally, one per insert), and the minimization of the number of feeders on which each insert is loaded (ideally, one per insert). We describe the complexity of the problem under different scenarios, and propose possible solution approaches. Some application-oriented extensions of this problem, including production deadlines, load balancing, and inhomogeneous feeders, are also discussed.

Keywords: Production Planning, Scheduling.

An Exact Algorithm for the Capacitated Total Quantity Discount Problem

Daniele Manerba, *Renata Mansini*

University of Brescia - Department of Information Engineering

We analyze the procurement problem of a company that needs to purchase a number of products from a set of suppliers to satisfy demand. The suppliers offer total quantity discounts and the company aims at selecting a set of suppliers so to satisfy products demand at minimum purchasing cost. The problem known as Total Quantity Discount Problem (TQDP) is strongly NP-hard ([1]). In particular, we address the capacitated variant of the problem (Capacitated TQDP), where the quantity available for a product from a supplier is limited. A branch-and-cut approach (implemented using CPLEX 12.2 through Concert Technology 2.3) is provided to solve this problem. Different families of valid inequalities and their separation problems are studied and implemented. A hybrid algorithm, called HELP (Heuristic Enhancement from LP), is used to provide an initial feasible solution to the exact approach. This heuristic, globally structured like a Variable Neighborhood Search with Decomposition, exploits information provided by the continuous relaxation problem to construct neighborhoods optimally searched through the solution of mixed integer subproblems. Since this variant of TQDP has never been studied before in the literature, a collection of hard-to-solve benchmark instances has been generated. A streamlined version of the proposed exact method can optimally solve in a reasonable amount of time instances with up to 100 suppliers and 500 products, and largely outperforms an existing approach available for the TQDP and CPLEX 12.2, that frequently runs out of memory before completing the search.

Keywords: Branch-and-Cut, Hybrid Heuristic, Supplier Selection, Total Quantity Discount.

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The Distance Constrained Vehicle Purchaser Problem

Renata Mansini[1], *Nicola Bianchessi*[2], *M. Grazia Speranza*[2]

[1] University of Brescia, Dept. Information Engineering

[2] University of Brescia, Department of Quantitative Methods

In the Distance Constrained Vehicle Purchaser Problem (DVPP) a fleet of vehicles is available to visit markets offering different products. The DVPP consists in selecting a subset of markets so to satisfy products demand at the minimum traveling and purchasing cost, while ensuring that the distance travelled by each vehicle does not exceed a predefined upper bound. The problem generalizes the classical Traveling Purchaser Problem (TPP) [2] and adds new realistic features to the decision problem. To the best of our knowledge, this problem has never been addressed in the literature, whereas a recent contribution has appeared on a multiple vehicle variant with capacity constraints (see [3]). In this work we address the problem solution by means of a branch-and-price algorithm. The DVPP is modeled using a set-packing formulation where columns represent feasible routes for the vehicles. At each node of the branch-and-bound tree, the linear relaxation of the set packing formulation, augmented by the branching constraints, is solved through column generation. In particular, each column generation step is carried out solving the pricing problem with dynamic programming. A set of benchmark instances has been derived from those proposed in [2] for the TPP. Computational results show the effectiveness of the proposed approach.

Keywords: Vehicle Purchaser Problem, Time Constraint, Branch and Price.

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FrB2 - Routing II

Friday, 11.00-12.30
Room C1

Refuse Collection in Large Urban Areas: Models and Algorithms

Ana Catarina Nunes[1], *Maria Cândida Mourão*[2], *Maria João Cortinhal*[1]

[1] ISCTE-IUL and CIO

[2] ISEG-UTL and CIO

Refuse collection in large urban areas may by modeled by a Sectoring-Arc Routing Problem (SARP). The SARP groups two families of problems: sectoring (or districting) problems and capacitated arc routing problems (CARP). Therefore, it combines two levels of decisions: i) medium/long term decisions tactical/strategic level on which sectors are defined; and ii) short term decisions operational level where trips for each sector are built. In the literature, the refuse collection in urban areas is usually modeled by the CARP. However, despite being more difficult to solve than the CARP, the SARP has some advantages: it avoids sub optimization, and some features such as sectors balance, contiguity, and compactness may be better handled. The relevance of these marks is justified by the need of obtaining balanced vehicle crew services with a number of intersections as small as possible. The SARP is defined over a mixed graph with links (arcs and edges) representing the street segments, and some of these links require collection. For each link, a traversal duration is known. Furthermore, for each demand link, collecting quantity and time are also given. The SARP aims to build a given number of similar sectors (sub-graphs) and a set of collecting trips in each sector. The objective is to minimize the total duration of the trips. All of the demand links of a sector are collected by exactly one vehicle. Vehicles are identical and have limited capacity. Each vehicle is assigned to only one sector and performs one or more trips with total duration no more than a limited working time. Linear mixed integer programming formulations and algorithms are presented for the SARP. Computational results are reported for a set of benchmark problems.

Keywords: Routing, Heuristics, Sectoring.

Impact of Generalized Travel Costs on Satellite Location in Two-Echelon VRP

Simona Mancini[1], *Teodor Gabriel Crainic*[2], *Guido Perboli*[1], *Roberto Tadei*[1]

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[2] UQAM, Montreal, Canada

In this talk we address the Two-Echelon Vehicle Routing Problem (2E-VRP), a variant of VRP where the delivery from one or more depots to customers is performed in two phases; first, freight is delivered to intermediate depots, called satellites, where, it is loaded on smaller vehicles, and, in a second phase, it is delivered to customers. The goal is to minimize the global routing costs of the overall two-echelon network. This approach is strictly connected to City-Logistics, [1] and particularly to two-tier distribution systems [2]. In previous works, the attention was mainly focused on the minimization of the total traveled distances [3], [4]. A deep analysis of the layout impact on distribution costs is given in [5]. The analysis focuses on the impact of several parameters, directly correlated to the instance layout, like number of customers, number of satellites, customers distributions and satellites location. Computational results also show that the Two-Echelon approach is strongly preferable respect to the Single-Echelon one. The work we present aims to address more realistic situations in urban freight delivery where the travel costs are not only given by distances, but also by other components, like fixed costs for using the arcs, operational costs, and environmental costs. More in detail, our scope is twofold. First, we introduce a generalized travel cost able to combine the different issues (operational, environmental, congestion based). Second we analyze how the different components of the generalized cost affect the satellite location in the 2E-VRP and whether and under which conditions the Two-Echelon approach will dominate the Single-Echelon one.

Keywords: Routing, Distribution, Two-Echelon.

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A Hybrid Algorithm for Single-Depot Integrated Vehicle Routing Problem

Jiaqi Chen, Yuan Qu

Management School, Jinan University

This paper designed a simulated annealing algorithm (SA) for the single depot integrated vehicle routing problem and introduced the principium of the algorithm. The SA is based on the delivery route expressed with natural numbers. Considering the difference between delivery distance and time windows limits, the penalty function and the properties of the limits are proposed into the simulated annealing algorithm for the depot insertion control. For the search space extension, three kinds of neighborhood are proposed and incorporated into the state generating function. In addition, the algorithm uses tabu rules to control the sampling process. We conducted a comparative analysis between discrepant scales and different algorithms. The results of computational experiments showed that the proposed algorithm is effective in solving the single depot integrated vehicle routing problem with delivery distance and time windows limits.

Keywords: Vehicle Routing Problem, tabu Rules, simulated Annealing Algorithm.

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FrB3 - Finance and Risk Analysis

Friday, 11.00-12.30
Room B2

Robust Delegated Portfolio Management

Mustafa C. Pinar

Bilkent University Ankara Turkey

Assuming a one-period economy with an investor acting as the principal and a portfolio manager with a constant absolute risk aversion, facing a set of risky (whose return is normally distributed) assets with first and second moment information where the first moment information is subject to ambiguity, we consider the problem of setting optimally the fee to the portfolio manager who makes an ambiguity-robust portfolio choice for the investor. The ambiguity in the mean return of risky assets is modeled using an ellipsoidal uncertainty model. A closed-form solution for the robustness premium is obtained. We repeat the analysis for a Socially Responsible investor requiring investment in a green subset of the asset universe in addition to being ambiguity averse.

Keywords: Delegated Portfolio Management, Ambiguity, Robust Optimization.

Robust Network Analysis of European Stock Markets

José G. Dias, *Sofia B. Ramos*

ISCTE - Instituto Universitário de Lisboa, UNIDE, Lisboa, Portugal

This paper investigates the application of networks analysis in the understanding of the dynamic interrelations between stock markets. In order to measure these interactions, network analysis tends to use correlations. One disadvantage of using correlation measures on raw data is their lack of robustness to extreme data values. This paper introduces a new robust approach that filters the data by a hidden Markov model prior to computing the measures of association. Results are illustrated with European stock markets using different measures of association and dynamic visualization techniques, in particular rolling measures of association and minimum spanning trees (MST).

Keywords: Network Analysis, Stock Indexes, Hidden Markov Models.

Heuristic Algorithm for a Scenario-Based Capital Budgeting Model

Anabela Costa[1], *José Paixão*[2]

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[2] Faculty of Science at the University of Lisbon and CIO, Portugal

Real options techniques such as contingent claims analysis can be used for project evaluation when the project develops stochastically over time and the decision to invest into this project can be postponed. With this kind of evaluation method, one determines the project value but, also, one discerns when to exercise the option to invest. Following that perspective, in [1] is presented a scenario based model that captures risk uncertainty and managerial flexibility, maximizing the time-varying of a portfolio of investment options. However, the corresponding linear integer program turns out to be quite intractable even for a small number of projects and time periods. We propose an alternative scenario based model involving a much less number of variables. The optimal

solution of this model is used for guiding a greedy-type heuristic procedure for building up a feasible solution for the original scenario based model. Our computational experience ensures a reasonable quality for approximate solutions with huge reductions on the times required for solving large size instances.

Keywords: Real Options, Capital Budgeting, Scenario-Based Optimization, 0-1 Integer Programming, Heuristic.

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Fooled by Robustness: the Role of Local and Global Robustness in Risk Analysis

Moshe Sniedovich

The University of Melbourne

While there is an agreement among experts that robustness can, perhaps even should, play a central role in risk analysis, the details are much less clear-cut. To see how diverse the approaches to robustness can be and actually are, including the contradictory results that they can generate, it is sufficient to read and compare the extensive literature on say, robust optimization, and the much less extensive literature on applications of robustness models in such areas as say, ecology and environmental management. This discussion focuses on the different roles that local and global robustness can play in risk analysis in general and in decision-making in the face of severe uncertainty in particular. To set the scene, five different types of robustness are discussed and illustrated: two are local and three are global in nature. They represent approaches to robustness in such diverse fields as applied mathematics, engineering, economics, control theory, operations research, global optimization, ecology, bio and homeland security, finance, and so on. One of the major conclusions emerging from this analysis is that apparently the "fooled by randomness" phenomenon, so eloquently described in Taleb's two best-selling books, also applies to "robustness". That is, in the case of severe uncertainty, it is apparently not too

difficult to be fooled by robustness. This is illustrated by a comprehensive examination of numerous applications of models of local robustness of the "radius of stability" type, as a tool for the modeling, analysis and management of severe uncertainty. It is shown that in such applications conclusions about local robustness in the neighborhood of a poor (point) estimate are mistaken for conclusions about global robustness over the given uncertainty space. It is argued that an important step towards the prevention of misapplications of the concept "robustness" would be to identify and clearly explain the many faces of this intuitive concept.

Keywords: Robustness, Local, Global, Uncertainty, Risk Analysis.

FrB4 - Dynamic Optimization and Simulation

Friday, 11.00-12.30
Room A2

Optimal Dynamic Management of Energy Systems: Implementations and Empirical Analysis

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Dipartimento di Statistica, Sapienza Università di Roma

Management of multiple systems to generate energy is important both with regard to the costs to incur, the effects on the environment and the flexibility of the system to cater for oscillations in the demand and supply of energy. These aspects must be considered in a dynamic context, through time and past events must be assessed to formulate optimal policies for predictions and the management of the energy plants. Methods must be accurate so that precise management of plants to produce energy will be achieved. The aim of this paper is to present the Data Driven algorithm, present the empirical analysis of an implementation and show the generality, the advantages and optimality of the planning procedure adopted.

Keywords: Energy Systems, Polygenerated, Dynamic Systems Optimal Control, Empirical Implementations.

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Determining Advertising Exposures for a Seasonal Good in a Heterogeneous Market

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[2] University of Padua, Dept. of Pure and Applied Mathematics

The optimal control problem of determining advertising efforts and production quantity for a seasonal good in a heterogeneous market is found to be equivalent to a nonlinear programming problem. We characterize optimal advertising exposures under different conditions: the ideal situation in which the advertising process can reach selectively each segment, the more realistic one in which a single medium reaches several segments with different effectiveness, and the situation in which several wide-spectrum media are available, under the assumption of additive advertising effects on goodwill evolution.

Keywords: Marketing, Advertising, Optimal Control, Nonlinear Programming.

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Dynamic Simulation of a Flexible Transport System

Marco Baldassarre[1], *Pasquale Carotenuto*[2], *Giuseppe Raponi*[1], *Giovanni Storchi*[3]

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[2] Consiglio Nazionale delle Ricerche - Istituto per le Applicazioni del Calcolo "M. Picone"

[3] Università degli Studi di Roma Sapienza - Dipartimento Scienze Statistiche

The concept of innovation in transport systems requires the satisfaction of two main objectives: flexibility and costs minimization. The demand responsive transport systems (DRTS) seem to be the solution for the trade-off between flexibility and efficiency. They require the planning of travel paths (routing) and customers pick-up and drop-off times (scheduling) according to received requests and respecting the limited capacity of the fleet and time constraints (hard time windows) for each network's node. Even considering invariable conditions of the network a DRTS may operate according to a static or to a dynamic mode. In the static setting, all customers' requests are known beforehand and the DRTS returns routing and scheduling solutions by solving a Dial-a-Ride Problem (DaRP) instance which derives from the Pick-up and Delivery Problem with Time Windows (PDPTW). In the dynamic mode, customers' requests arrive when the service is already running and, consequently, the solution may change over time. In this work, we use an algorithm able to solve a dynamic multi-vehicle DaRP by managing incoming transport demand as fast as possible. The heuristics is a greedy method that tries to assign the requests to one of the fleet's vehicles finding each time the local optimum. The usage of vehicles only when strictly necessary, provides to costs minimization. The work is enriched by a series of tests with different values of the fleet's vehicles and their capacity, of time windows and of incoming requests' number. The solutions provided by the heuristics are simulated in a discrete events environment in which it's possible to reproduce the movement of the buses, the passengers' arrival to the stops, and in the next step the delays due to the traffic congestion and possible anomalies in the behaviour of the passengers. Finally, at the end of the simulation, a set of performance indicators evaluate the solution planned by the heuristics.

Keywords: Discrete Event Simulation, Dial-a-Ride Problem, Heuristics, Demand Responsive Transport Systems.

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