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Plenary Lectures

Derivative-Free Constrained Global Optimization, with Applications

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In many practical optimization problems the values of the objective and of the constraint functions are not given by analytical formulas: they are obtained by the direct measurements of some physical or economic quantities or by the output of some surrogate model or by the output of some simulation program. In particular, the last two cases are known as black-box optimization problems.

It is clear that in these cases the optimization algorithms cannot resort to the use of the derivatives of the problem functions, as usual in continuous optimization. Therefore we are lead to develop Derivative Free (DF) optimization algorithms.

In these cases it is also presumable that the phenomenon of interest lacks of any convexity properties, therefore we are interested in global, rather than local, optimization algorithms.

Most DF global optimization algorithms have been developed for unconstrained optimization problems. However, we faced a number of real applications characterized by the presence of constraints. These applications compelled us to develop *Derivative Free Constrained Global Optimization* algorithms.

In this lecture, we first describe some of the applications mentioned before. Then we describe the approaches adopted in the optimization procedures, making reference to two different cases:

- in the first case, even if the derivatives of the problem functions are not available, we can assume that the phenomenon of interest enjoys some underlying continuity structure ensuring that the derivatives indeed exist;
- in the second case, not only the derivatives of the problem functions are not available, but also we do not rely on any assumption about their existence.

Challenging optimization problems in E-commerce logistics

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Keywords: Stochastic Programming, Logistics, Transportation

E-commerce has been continuously growing in the last years to become a major retail market. In Europe, the percentage of turnover on e-sales in 2014 rose 17 % of the total turnover of enterprises with 10 or more employees, and this percentage increases with the size of the company. 43% of large enterprises made e-sales corresponding to 24 % of total turnover in this size class. At the same time, new challenges arise in the e-commerce supply chain management due to demand variations and to higher requirements in delivery services. This leads to address new optimization problems which are by nature stochastic and/or dynamic.

In this presentation, we first describe their main characteristics and the challenges they raise. Next, we illustrate these issues on two problems we tackled recently. For each problem, we center the talk on its description, on a proposed formulation and on representative computational results. The picking and shipping problem is an integrated logistics problem in which tactical decisions related to manpower resources at a warehouse, and to transportation capacities are jointly addressed with operational decisions regarding the preparation of packages. Due to the uncertainty in order arrivals, we propose a stochastic optimization model over a rolling horizon and related solution methods. The shift scheduling and load assignment problem is an integrated optimization problem occurring in companies offering attended home delivery services. It consists in generating, for each courier, a daily master plan as well as a detailed schedule to efficiently satisfy a random demand over time. We propose a two-phase method combining the solutions of a two-stage stochastic programming problem and of an assignment problem. Last, we conclude by presenting some research opportunities in E-commerce logistics.

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Healthcare Logistics

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Healthcare logistics addresses the efficient planning, realization and control of patient-, material- and information-flow within the healthcare sector. Therefore, the use of Operations Research methods plays a crucial role in healthcare logistics. However, the unique feature in this field of application is to not only put emphasis upon the economic efficiency but also to take into account the quality of care and patient satisfaction. Accordingly, the medical competence is never interfered in.

Especially in hospitals, scheduling problems and inhouse logistics are of great importance. With the help of medical and technical devices patients are examined, treated and cured if possible. Hospital logistics are all technical and organizational measures that are needed to transfer patients from an initial state ("ill") into a final state (in the best case "healthy") while also regarding the corresponding goods and information. Usually, hospital processes are grown historically ("We have always done it this way."). Consequently, processes have not been analyzed critically until reforms of the health system have put increasing pressure on hospitals. Nowadays, hospitals are looking for possibilities to improve their processes. Therefore, the success of logistics concepts in hospitals lies in resource conservation for non-value-adding activities (not directly relevant for the healing process, e.g., administrative work) and high resource utilization for value-adding activities (e.g., surgery) while the personnel shall not be over-utilized (i.e., no overtime). Moreover, the interaction of appropriate logistics concepts with modern OR models allow a patient centered treatment, by respecting the needs of a patient and allowing a smoother process. Moreover, the digitalization of the health care sector offers new opportunities to OR.

Clinical pathways should determine an optimal sequence and schedule for the patient's treatment with the objective of minimizing delays and maximizing the quality of care while taking into account resource capacities. To reach this goal, logistics aspects on different hierarchical levels as hospital layout planning (strategic), appointment planning (tactical) and patient transportation (operational) have to be integrated into the clinical pathway.

In this talk, we give an overview on how OR methods can be used in order to support process optimization in healthcare organizations. We focus on healthcare logistics applications arising in different healthcare sectors and dealing with different time scales. Examples include: Hospital layout planning, Appointment planning, Patient transportation, Ambulance location and Home health care.

Both, OR models and numerical results – also from real world projects - will be presented. In addition, we will give some advice on how teaching in OR for Health Care could be done.

Parallel Sessions

Energetic shortest path problem

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Keywords: Shortest Path, optimal routing, electric vehicles

Electric vehicles (EV) powered by batteries will have a growing impact on the road traffic in the near future.

The characteristics of these electric vehicles - limited driving capacity, long charge times, and the ability to recover energy in particular driving conditions (downhill path) pose the problem of identifying new routing algorithms that simply determine the shortest path, but the path best suited to the needs of electric vehicles (see [1]). In some circumstances we have to take in account that rather than to consume energy the vehicles can be refilled along the trip. Similar situations can be occurred when we consider vehicles bi-fuel, i.e. vehicles that use two different type of fuel (see [2]). In this paper we propose different type of shortest path algorithms that look to the problem of optimal route for energy saving.

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Recent advances of Bin Packing Problems in the field of Transportation and Logistics

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Keywords: Bin Packing Problems, Transportation, Logistics

Bin packing problems make up an important topic of optimization problems. Their pioneering studies began in the seventies with a number of important works [1,2]. Fundamentally, their aim is to accommodate a set of items into a set of bins in order to optimize a given objective function while satisfying a number of constraints. Moreover, capacity constraints ensure that bin capacities are not exceeded. Nowadays, we are witnessing a particular trend concerning bin packing problems. While, at the beginning of the research, bin packing problems were mainly conceived as loading problems at an operational level, the evolution of problem formulations allows us to use bin packing problems in the field of Transportation and Logistics, both at an operational and tactical level, taking also into account economical and management aspects [3]. This evolution of the problem settings pushed researchers to address more sophisticated problems such as the Generalized Bin Packing Problem (GBPP) and the Generalized Bin Packing Problem with bin-dependent item profits (GBPPI) [4].

In this paper, we present the last advances of the GBPPI in the field of Transportation and Logistics. In particular, we present new methodologies and bounds, which allow us to better estimate gaps for large-size instances.

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A mathematical programming approach for train calendar generation

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Keywords: Text Generation, Set Covering, Train Calendar

This paper describes a new method for generating automatically a text in a representation concise and clear to the customers having as input a calendar represented by a boolean vector. We focus on problems arising for calendars in the transportation area and in particular on railway services. Indeed, railway undertakings are trying to improve their communication with commuters, employees and travelers, especially for the frequent occurrences of path modifications implying scattered calendars and descriptions not intelligible appearing in various outputs such as websites, mobile devices, timetable boards, train transport diagrams and books. Our aim is to verify if, with a mathematical programming approach, it is possible to optimize the quality of outcomes in terms of intelligibility. We propose two mathematical programming formulations for this challenging task. The first one consists in a specific set covering model with embedded generation of sets out of the ground set. The second one combines a set covering model with a parallel vector generation algorithm. We used a mip solver to solve the two models, while we designed a specific parallel algorithm for the vector generation problem in the second approach. The approaches have been tested on several real railways timetables getting always optimal solutions which are better than those obtained with current practices. Computational times in the experiments show that both approaches can be competitive and applicable in a practical context.

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Scheduling of working hours of nurses in hospital: The case of the University Hospital in Cagliari

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Keywords: rostering nurse, scheduling, optimisation, healthcare

In this talk we focus on the problem of scheduling working hours of nurses and medical social workers in hospital over long periods. In more detail, we consider a surgery department and a time horizon of one month. We propose a mathematical model that characterizes the set of admissible scheduling that satisfy a series of constraints related to contractual rules, specific local requirements, and different positions of workers (e.g., parenthood, part-time, full-time, beneficiaries of parental leaves, and so on). The way constraints are defined enables us to easily introduce preferences and specific requirements of workers. Different performance indices could be chosen and an optimal solution with respect to them could be computed solving an integer linear programming problem with binary variables. The obtained scheduling are compared with those computed by the hospital planner who currently computes them manually. It can be shown that in certain cases, the degrees of freedom are so few that the resulting scheduling coincide as it often happens in other real word applications. In other cases, the proposed method finds out solutions that were not considered by the planner who operates manually. It is also worth pointing out that, in all the considered scenarios, an optimal solution could be computed in few minutes. We remark that the proposed tool is not only useful to derive an optimal scheduling, but could also be successfully used as a support to find out redundancies or weakness in the staff.

As a future work we plan to extend the above results in several directions. First, we plan to consider more general scenarios, simultaneously dealing with sets of departments in the same hospital. Second, we plan to extend it so as to compute summer and winter holidays based on previous years and specific/personal requirements of the staff, which are automatically used as an in-

put to the proposed scheduler. Finally, we would like to define a user friendly interface that makes the resulting tool appealing for hospital operators.

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Models for the design of a primary care network

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Keywords: healthcare, primary care, models

A primary care system delivers care for most of their everyday health needs. For each citizen, it represents the first contact point with the National Health System. An efficient and effective primary care system can have a positive impact on the overall population health. To this purpose, many countries started a re-organization process and, by consequence, many researchers started to study the problems arising from those re-organization processes [1][2][3].

Primary care in Italy is delivered by General Practitioners (GP) in their own studio, opened from 20 to 30 hours per weeks, and sometimes helped by a secretary and/or by a trainee. Each GP serves about 1200 patients on average, and no more than 1500 patients. Capitation fees remunerates GPs. Same model for paediatricians but they can only serve no more than 800 patients aged from 0 to 14. In Italy, a new organizational model is introduced by a 2014 national law: the new model consists in gathering a number of GPs and paediatrician - assisted by further medical staff - on a single facility (AFT) in order to provide a 24/7 service.

In this paper we discuss an optimization model to design the new 24/7 primary care system in the city of Turin, Italy. Turin is a city in the north west of Italy with about 900000 inhabitants served by 843 GPs and 113 (2014 datas). Several constraints are taken into account when considering different age groups. For instance, we would like to evenly distribute elderly citizens among AFTs. An extended version of the model should deal with GP and paediatrician preferences. Both models are fed by open data available at http://www.dati.piemonte.it/ through the strategic EU MED project HOMER. The use of open data aims at raising awareness and testing economic, social and political benefits of making public data open and reusable.

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Rare diseases health care network: model and simulation

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Keywords: rare diseases, health care network, simulation

Italian ministerial decree number 279 of May 18th, 2001, provides the establishment of a national network devoted to rare diseases, by means of which preventing action is to be developed, care is to be activated, interventions directed to diagnosis and therapy are to be improved, information and education are to be promoted.

Rare disease network is made up by all structures and regional system services which contribute, in an integrated way and each one related to its specific competences and functions, to develop and implement all actions provided by the up decree.

In detail, main nodes of Rare Diseases Network are accredited providers, preferably hospital ones, suitably identified by Regions among those which possess documented experience in diagnosis and cure of specific Rare Diseases or Rare Diseases groups, and are equipped with adapt support structures and complementary services.

Network providers are connected, in a diversified way on the basis of different regional health organizations, to hospital and territorial services closer to sick people residence places. These connections, even if experimented as strategic for the effective charge of people with rare diseases, currently suffer from a fulfilment diversity and still result lacking in many territorial areas.

The scope of the paper is then the carrying out of a simulation model, made out by language Rockwell Arena, which permits to reproduce the Rare Diseases network actual system and to dynamically analyze its behaviour, to test management criteria, to evaluate critical situations in running queues and in efforts to which each node is called, to suggest and validate planning choices, to compare alternative solutions in short times and with very small expenses.

Moreover data processing supplies a by-product consisting in a database which records all paths covered by every patient among centres both from a medical and simply from a geographical point of view; such paths may be influenced both by external parameters (managed as system variables) like for instance the appeal of a professional operating in a centre, or by inner parameters like the specific planning which assigns a larger or a smaller basin to a node. Such a way we can not only observe how patients population is distributed on

the basis of statistical laws, but also how patients population behaves on the basis of strategic decisions.

In the model every newborn is inserted into the system according to a statistics which arrives at different distributions for every week of the year, with characteristics like for instance the birth zone. If the newborn is sick, then all necessary treatments are listed with necessary resources, duration, beginning, etc. All treatments remain in a queue until they are effected: queues (time and lengths) are revealed related to every centre resources and to centre choice policy.

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Temporary Depot Location-Routing in Humanitarian Relief Logistics

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Keywords: Humanitarian Logistics, Location-Routing, Floods Disaster

While questions regarding the position of general or commercial logistics management have long been a topic of interest, much of the existing literature on humanitarian logistics management is quite fresh and limited. It has started to evolve a lot in the last years because of the recent increasing number of heavy disaster since 2000s [1]. A broad overview of the relevant present research literature has covered a variety of optimization problems in order to best describe the complex mechanism of the relief supply chain and humanitarian logistics [2]. Research in the field of humanitarian logistics is divided based on most existing studies into three major categories: (i) facility location, (ii) network design and relief distribution, (iii) mass evacuation. The category of facility location covers the mathematical models made for resource allocation, pre disaster facility location, post disaster facility location, location-allocation, and maximal covering models. The category of network design and relief distribution covers the relief distribution planning, vehicle routing, assessment routing, causality transportation, international relief distribution, and location-routing models. The category of mass evacuation covers traffic control planning and mass evacuation models in pre and post disaster scenarios [3].

Much existing research proposed the study on permanent facility location while the study on temporary depot routing-location with multi carrier has never been found to treat with floods natural disasters in this area [4]. The function of this temporary depot is mainly for transferring relief supplies from one carrier type to another carrier type rather than storage as in the permanent facility or warehouse. Since the particular floods case study occurs in a slow-onset disaster (non-flash floods), a huge amount of demand remaining in the flooded area. Thus, the need of temporary depot is crucial which candidate locations for locating this facility is the boundary of floods in order to receive supplies from DCs and transfer those supplies to the people in the flooded area. The research also considers multimodal transportation which are trucks and boats in order to more closely to realistic behaviour of floods disaster in Thailand. The most challenging point for this study is that a unique and special of flood character is about the dynamic capabilities. Floods may not hit as so urgently as earthquake or other natural disasters but present the unstable size and impact over time instead. Therefore, the use of multi-period approach to describe the problem is

presented to determine the optimal location of temporary depot as a real-time decision following this changing size of floods.

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Optimization of obsolete part reusing: a case-study

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Keywords: Push-Pull production, Part reusing, Integer programming

Companies operating in fashion markets usually adopt production models that are mostly demand-pull oriented. Indeed the pull model is intrinsically more attuned to meeting the customer needs and allows to be better positioned to react to changes in customer tastes and expectations. Although operating in response to customer demand aims to reduce the costs of material waste and inventory management, the high turnover of trends, typical of the fashion markets, rapidly makes stocked parts obsolete or even useless, with significant losses for the production companies. Obsolete components can be reallocated for the production of items that will be sold at a lower price on parallel markets – such as *outlet* and second markets – at the cost of purchase the missing components that are required to complete the bill-of-material of out of fashion products.

In this work, we propose an integer linear program that finds the best trade-off between the purchasing cost of missing parts and the profits of parallel markets selling. The formulation takes into account constraints on the overall number of produced items, budget for new component orders and minimum lot scheduling thresholds. The mathematical model has been tested under different configurations and with real data provided by a prominent fashion company.

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Resolving Real World 3D Packing Problems

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Keywords: multi-dimensional bin-packing, ruin-and-recreate, real-world application

Multi-dimensional bin-packing problems are challenging optimization problems with many applications from cargo loading to cutting and project scheduling.

In this work we present two real-world 3D packing problems for truck and aircraft loading, respectively, characterized by several complex operational constraints: Bins can have different shapes; Items might be (un)loaded at different stages and it must be possible to perform the loading operations without moving other items; It is required to safisfy weight and balance constraints; Some items have to be secured with ropes, which waste some cargo space; There are rules for stacking items and ensuring their stability.

We developed a ruin-and-recreate approach, which makes use of constructive procedures based on the concept of extreme point introduced in [1]. We tested it on real-world instances, showing its effectiveness in producing good quality solutions in short computing times.

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Construction Consolidation Centers: a Stochastic Facility Location Approach

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Keywords: Stochastic facility location, two-echelon, consolidation centers

This work builds on the Horizon 2020 SUCCESS Project, that deals with reducing the environmental and social impacts and the costs of the construction sites in urban areas. Among all, one of the most interesting ways of doing so is the introduction of Construction Consolidation Centers (CCCs) to consolidate materials headed to construction sites and decrease the number of huge trucks entering urban areas. Our aim is to study the introduction of CCCs and to optimize their location and the vehicles and materials related to them and to the construction supply chain and reverse logistics.

Due to the many and uncertain demands of construction materials that can occur years after installing a CCC, to locate a CCC we took into account the uncertainty into a Stochastic Facility Location model. We thus solve Stochastic Programming Models with the use of L-shaped algorithms. Many real features had to be considered to represent the real problems, such as multiple materials, multiple vehicles, multiple periods, time windows, traffic dependent costs, etc.

Our models and algorithms will be tested by using real-world data collected in the four pilot sites of the SUCCESS Project, located in Luxembourg, Paris, Valencia, and Verona.

Sportello Matematico: a project for Innovation through Mathematical Technologies

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Keywords: Knowledge transfer, Industrial optimization, Mathematical Technologies, Operations Research

We present the main results achieved in a few years by Sportello Matematico, a networking project funded by the italian Ministry of Education, University and Research to foster Technology Transfer of Mathematical Sciences towards the Industry and italian SME's. The project is developed by a team of researchers and technologists at the National Research Council of Italy, and is based on the active involvement and participation of many italian public and private research centers with outstanding competencies on Mathematical Modeling, Operations Research, Optimization and Simulation, Probability and Statistics. The network of scientific partners of Sportello Matematico involves currently more than 40 public and private research centers: these are invited to participate to the technical meetings organized by the Technology Translators of the Sportello Matematico team, where companies expose their innovation challenges. Afterwards, research centers will have the chance submit their cooperation proposals to companies, focusing on innovation and impact on production efficiency.
Several fruitful cooperations between companies and research partners were promoted: some of these are currently in progress, while others successfully completed with mutual satisfaction and benefits in terms of real-world impact, scientific production, knowledge transfer, joint patents.
In the field of education, Sportello Matematico is pursuing an innovative breakthrough: the activation of specific post-graduate training programs for the professional figure of Technology Translators in Mathematical Technologies. Graduates enrolled in such internships are provided with the opportunity to empower their education, matching their technical core-competencies with soft skills and practical experiences in the field of Technology Transfer, and actively promoting cooperations between companies and research centers.
The action of Sportello Matematico at an international level also favoured the

birth of the EU-MATHS-IN foundation, currently involving about 15 National Networks of research centers in Europe, including Sportello Matematico as the italian partner. The goal of this foundation is fostering the role of Mathematics for Innovation at a European level and promoting the presence of Mathematical Technologies, such as Modeling, Simulation, and Optimization, among the Key Enabling, Future and Emerging Technologies within the European Research programs classification.
During the talk, some cases from the Sportello Matematico's portfolio of successful matches between research centers and italian SME's will be provided. Moreover, strategies for the further development of the project will be outlined, and the increasing network involvement of researchers from University Departments, Research Institutes and Academic Spin-Offs will be fully clarified.

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Modelling and solving the direct ship-to-ship container transshipment problem

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Keywords: Container Transshipment, Tabu Search

At a maritime container terminal, containers discharged from a vessel are usually stored in the yard, and then loaded on different vessels. The storage phase allows to decouple in time the ingoing and outgoing container flows. Therefore, if the sojourn time of the containers (dwell-time) in the yard is sufficiently long, the discharging and loading operations are independent, so that they can be planned and scheduled separately and efficiently. On the other hand high dwell-times represent a drawback for the terminal management as well as for the shipping operators. Actually the former would increase the terminal throughput by reducing the dwell-times, and the shipping operators would reduce the port fees. This amounts to say that short dwell-times is a common target for the two main operators of the transhipment market. In view of that, the terminal planners are considering the feasibility of a new operational modality, called live connection. In this modality a discharged container is immediately transshipped to the outgoing vessel, completely skipping the yard storage phase.

Here we are concerned with the case of two vessels, simultaneously berthed at not necessarily adjacent berths, given that sufficient terminal resources (machines and operators) have been previously allocated. We assume that some of the containers discharged from each of them must be directly loaded into the other, while the rest of the cargo follows the conventional transshipment flow (quay-yard-quay). Clearly in the direct transhipment modality the unloading and loading operations are no longer independent and the related scheduling processes are concurrent: the same container represents two dependent tasks, to be executed by different machines (quay cranes) operating on different vessels, linked by a strict precedence relationship. Our aim is to schedule all the vessel operations and decide the stowage positions for the containers directly transshipped, so as to minimize their waiting time and the overall service time of the vessels. For this problem we review a Linear Integer model proposed in [1], propose some advances in the solution procedure based on the Tabu Search paradigm and discuss the numerical experience.

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Modeling and solving the multi-port container stowage planning in circular routes

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Keywords: Containership stowage planning, Mixed integer linear programming (MIP) model, Matheuristics

In this work we deal with the Multi-Port-MBPP (MP-MBPP), that is the problem of determining the stowage plan for each port included in the circular route of a containership. This planning problem concerns the shipping line operator, who establishes the whole route of the ship and aims at satisfying the transport demand with origin and destination in the ports of such route. In more details, the problem consists in determining how to stow in each port a given set of containers into bay locations, either on the deck or in the hold, in order to satisfy some structural and operational constraints related to the containers, the ship and the maritime terminals. Containers are split into different groups according to their size, type, class of weight and origin-destination ports. The considered different type of containers are standard cargo, reefers and open top, with a size of 20' and 40', and subdivided into three classes of weights (light, medium and heavy containers).

All the transport demand must be served. The minimization of ship berthing time is the main and common aim of both shipping line and terminal operators. Therefore, re-handles must be minimized when defining stowage plans. In addition, the planning should also focus on the unbalance among the number of loading and unloading operations performed by the cranes working in parallel at each port on the ship.. Finally, another important factor influencing the time necessary for complete unloading and loading operations is the number of movements of hatches, that must be opened to stow containers in the hold (or to unload them from the hold) and then closed at the end of the operations.

In the this work, we propose a new MIP formulation for the MP-MBPP derived from the one in Ambrosino et al. (2015): in particular, the model includes a new objective component for the minimization of the movements of

hatches, as well as new and more accurate stability conditions which replace the ones in Ambrosino et al. (2015).

Papers in literature dealing with MP-MBPP generally propose decomposition approaches (among others Pacino et al. 2011). We present a new MIP model for the MP-MBPP able to manage realistic scenario and find stowage plans for containerships up to 18000 TEUs. Moreover, we also propose matheuristic approaches based on the exact MIP model that can be used for finding good stowage plans in a short amount of time, presenting and discussing some preliminary results.

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Two-level heuristics for the all-colors shortest path problem

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Given an undirected edge-weighted graph with a label (color) assigned to each vertex, the all-colors shortest path problem seeks a minimum-weight, non-necessarily simple path reaching at least a vertex for each different color. The problem is known to be NP-Hard by reduction from the Hamiltonian Path problem, and finds application in several scenarios, such as distribution network planning. We present heuristic and metaheuristic approaches to solve the problem. Our main underlying idea is to consider a high-level abstract solution containing exactly one vertex for each color. This solution is then refined by looking for the shortest paths between consecutive colors in the high-level solution, leading to the final solution for the problem. Comparisons with previously proposed approaches show the competitiveness of our algorithms.

Managing the ship movements in the Port of Venice[1]

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Keywords: Scheduling problem, Network design, Combinatorial optimization, Port of Venice

The new mobile gates at the inlets of the Venice lagoon and the new environmental laws issued in response of the Costa Concordia wreckage in 2012 have forced the Port Authority of Venice to rethink the harbor activities.

In this paper, we tackle the Port Scheduling Problem that the Port Authority faces in scheduling both ships' and tugs' movements within its canal harbor in this new context. We introduce the problem, explain which data it needs, and provide the description of a heuristic algorithm for its solution. Finally, we present some practical applications.

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Dynamic capabilities in new product development and its effects on firm performance

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Keywords: Multi-Criteria Decision Aids, Strategic Planning and Management, Supply Chain Management

Achieving a sustainable competitive advantage through supply chains (SC) leads to a firm being able to generate an economic surplus into the future (Teece, 2007). Prior studies have highlighted that developing organizational capabilities are a means by which this sustainable competitive advantage can be realised (Grant, 1996). In particular, dynamic capabilities, which are considered as higher order organizational capabilities, are necessary for the firms to enhance its performance in a business environment where both market demand and technology are continuously changing. Firm performance in the context of new product development (NPD) depends on the continuous creation of new products and processes and the implementation of new organizational forms and business models which both require dynamic capabilities supported by senior management involvement (Pavlou and EI Sawy, 2011).

In dynamically competitive environment, the understanding of relationship between dynamic capabilities (DC) and the superior performance of firms through new product development (NPD) performance enable firm's managers to make a sound, robust and quick decision. While differential performances of firms in the high technology industry such as automotive or aerospace industry are so important for achieving sustainable competitive advantage, the study searches for the explanation of this phenomenon in the view of dynamic capabilities. Through a comparative multi cases study of fairly large R&D intensive manufacturing firms, the analysis focuses on identifying and evaluating the effects of organisational and managerial processes on the development of three capacities of sensing, seizing and reconfiguration that form dynamic capabilities through product development activities. While dynamic capability facilitates an effective and efficient product development, the integrated findings of the analysis is to show the performance assessment of dynamic capability using multi

criteria decision analysis (MCDA) that determines the success and failure of manufacturing buyer's firms in the recent volatile environment. The results contribute to the literature by verifying the conceptual framework of foundations and micro-foundations of dynamic capabilities, illustrating the transformation of its multiple roles, and introducing an extended framework for managerial actions. Most importantly, this research confirms that the superior performance of a company in the automotive or aerospace industry is best explained by the theory of dynamic capabilities. In short, the research provides an insight for managers to define relevant product development strategies to adapt to rapid changes in today's modern business environment.

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Evaluating The Criteria for Choosing The Best Pharmaceutical Warehouse as Supplier in Pharmaceutical Supply Chain by Using Fuzzy Type-2 Analytic Hierarchy Process

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Pharmacies are the last tier in a pharmaceutical supply chain before the pharmaceuticals reach to patients. Pharmaceutical warehouses are suppliers of pharmacies. Pharmaceutical warehouses appear in a very critical point in pharmaceutical supply chains. They buy pharmaceuticals from producers, store them and then distribute them to pharmacies and hospitals. There are many pharmaceutical warehouses and pharmacies should decide from which warehouse they buy the pharmaceuticals. It is a very important and strategic decision for pharmacies. There are many conflicting criteria while determining on the best warehouse especially in pharmaceutical sector, because pharmaceuticals have a direct impact on human health. Pharmaceuticals are perishable products, so some specific criteria should be also considered. In this study we evaluate the supplier selection criteria for pharmacies in a pharmaceutical supply chain. To rank the criteria, fuzzy type-2 Analytic Hierarchy Process is used. Fuzzy sets are one of the best ways to deal with the uncertain situations and type-2 fuzzy sets enable the decision makers more flexibility for evaluation, so type-2 fuzzy sets and Analytic Hierarchy Process are integrated. First, the criteria are determined by experts and studies from literature and then the weights of the criteria are obtained by using type-2 fuzzy Analytic Hierarchy Process. Finally, the most important criteria for supplier selection are determined.

Multi-criteria decision aid processes from hundreds of indicators to structured models and applications

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A multi-criteria decision aid process is developed in interaction with decision makers (DM) and stakeholders but it may also be oriented to facilitate the Intelligence phase of a decision process, by means of a preliminary study that includes modelling and application of multi-criteria (MC) methods, in order to clarify the situation and to propose a consistent approach for the later phases of the decision process. These last situations are very frequent when the decision situation is complex and not well structured, and there is time to develop a "simulative" approach to the problem, to analyze the results and use them to formulate a new treatment for the problem situation.

In these situations an MC model has to be structured and developed without a formal decision system (not yet activated), and therefore the most frequent modeling approach is the use of data that are available in databases, as criteria and not as dummy variables of the problem, in relation with the literature (also when there are contradictions between experts' visions). The number of these criteria is often very high, because the data-indicators are not expensive and their multiplicity is consistent with the general belief that only a large amount of data produces information. In general the logical structure of a model is not considered essential because DM and stakeholders are not involved and the "visualization" and validation of the model with them is not possible.

The decision aid processes can be improved, in these situations, by means of some precautions and a clear and whole attention to all the activities of the modeling-validation process. The definition of the model structure and parameters is difficult because it is implemented far from the actual decision process. However the visualization of both a structured model and the results of an MC method application, and the identification of weakness and strength points facilitate and improve the modeling phase.

These elements will be presented in relation to the problem of a territory agency who has to allocate resources in relation to the different performances of some territorial units. Their behavior (also in terms of intangible assets) can be easily evaluated by means of an MC model that includes technological, economic,

environmental, political and social facets. A first case study, related to the disaster resilience of the municipalities near the Italian Ombrone river had been dealt with proposing new modeling and visualization logics. The results have been used to explain the role of this methodological approach and to propose a collaboration, which is currently underway, in relation with a problem of the Piedmont Region.

Flight Retiming in an Integrated Airline Scheduling Problem

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In this work, we integrate three stages of the airline scheduling problem, namely fleet assignment, aircraft routing, and crew pairing, and combine the integrated problem with flight retiming (i.e., we allow a given discrete set of alternative departure times for each flight).

Flight retiming has been proposed in Aloulou et al., 2013 [1], Burke et al., 2010 [2], Lan et al., 2006 [5] and Maher et al., 2014 [6] to obtain robust schedules to the aircraft routing problem or to the integrated aircraft routing-crew pairing problem in Dunbar et al., 2014 [4].

Our goal is to determine solutions that are robust against delays, but also efficient in terms of cost minimization. To achieve this goal we adapt a solution approach proposed in Cacchiani and Salazar-González, 2016 [3], so as to improve the robustness and efficiency of the derived solutions.

We formulate the problem as an Integer Linear Programming (ILP) model, with path variables that define the crew pairing and arc-flow variables that represent the aircraft routing. Column generation of the path variables is applied to solve its Linear Programming relaxation. A heuristic solution for the problem is computed by solving a restricted ILP model that contains all the arc-flow variables and only the path variables generated during the column generation process.

Computational experiments on a set of real-world instances, provided by a regional airline company flying in Canary Islands, show that flight retiming is very effective in reducing the short and the long connections, thus leading to a more robust and efficient schedule.

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Air traffic distribution through the modulation of en-route charges

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Keywords: air traffic management, congestion and peak load pricing, air transport

Peak-load pricing (PLP) is widely used in scheduled transport and is, in general, transparent and predictable to users (since peak times and prices are known in advance). This paper extends the use of PLP to the context of the European Air Traffic Management system, as EU regulation No 391/2013 allows the modulation of en route charges to avoid network congestion in a specific area or on a specific route at specific times. In particular, we propose a centralised approach to PLP (CPLP) where a Central Planner (CP) is responsible for setting en-route charges on the network and Airspace Users (AUs) assess the routing of each flight.

Set en route charges should guarantee that air navigation service providers (ANSPs) are able to recover their operating costs and that AUs are able to perform flights, overall avoiding imbalances between the demand and available airspace capacity. En route charges are set by the CP to achieve an overall objective, which is to reduce the amount of delay on the network. However, since in the current system en route charges are set by the ANSPs, and the AUs can only react to them by choosing alternative and cheaper routes, we model the relationship between the CP and the AUs as a Stackelberg game where a leader (CP) makes his decision first with complete knowledge on how the follower(s) (AUs) would react to it. The Stackelberg equilibrium is obtained by means of an optimisation problem formulated as a bilevel linear programming model, where the CP sets, for each ANSP, one peak and one off-peak en route charge and the AUs make their routing choice.

The bilevel optimisation problem is solved though an exact (MILP) approach on real data instances on a regional scale. European-wide instances are solved through a meta-heuristics based on genetic algorithms.

Metaheuristics for efficient aircraft scheduling and re-routing at busy terminal control areas

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Keywords: Job Shop Scheduling, Variable Neighbourhood Search, Tabu Search

Intelligent decision support systems for the real-time management of landing and take-off operations can be very effective in helping traffic controllers to limit airport congestion at busy terminal control areas [1, 2, 3, 7]. The key optimization problem to be solved to this aim can be formulated as a mixed integer linear program. However, since this problem is strongly NP-hard, heuristic algorithms are typically adopted in practice to compute good quality solutions in a short computation time [6]. This paper presents a number of algorithmic improvements implemented in the AGLIBRARY solver [4, 5, 8] in order to improve the possibility of finding good quality solutions quickly. The proposed framework starts from a good initial solution for the scheduling problem with fixed routes, obtained via a truncated branch-and-bound algorithm. A metaheuristic is then applied to improve the solution by re-routing some aircraft. The new metaheuristics are based on variable neighbourhood search, tabu search and hybrid schemes. The neighbourhoods differ from each other in terms of the aircraft that are re-routed in each move. Computational experiments are performed on an Italian terminal control area under various types of disturbances, including multiple aircraft delays and a temporarily disrupted runway. The metaheuristics achieve solutions of remarkable quality, within a small computation time, compared with a commercial solver and previous versions of AGLIBRARY.

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A statistical analysis of flight routes in the European Airspace

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Keywords: Flight routes, Air traffic flow management, statistical analysis

The choice of flight routes has many determinants, e.g., length, time, en-route charges, fuel consumption, etc. etc. However, the criteria adopted by airlines when selecting different routes between origin and destination are not always fully known, and, yet, those criteria play a fundamental role in Air Traffic Flow Management (ATFM). Indeed, as shown in [1], different airlines may choose different routes between the same origin-destination pair. In addition to the considerations described above, which are more specific of the airspace users' preferences and priorities, quite often the actual operated route may differ from the planned one for a variety of reasons, e.g., weather conditions and congestion among others.

In this talk, we present a data-driven approach to formulate hypotheses on route choice determinants. In particular, we conduct a statistical analysis based on the routes actually selected and operated in the European Airspace. This analysis is part of a preliminary study to understand the airspace users' preferences and priorities in the ECAC area to be used for the development of mathematical models for trajectory based operations.

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Simulated Annealing for Discrete Lot-Sizing and Scheduling

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Lot-sizing and scheduling (LSS) is a production planning problem that is very relevant in production economics. Several versions of the problem have been proposed in the literature, depending on the specific application domain. In this work, we consider the discrete, single machine, single level, multi-item version of the general LSS problem, denoted by the acronym MI-DLS-CC-SC. This version of the problem is also called Pigment Sequencing (PS) by Pochet and Wolsey [1] (§14.4), and it has been recently included in the problem library CSPlib [2] (prob058).

For the PS problem, we propose a metaheuristic approach based on Simulated Annealing, along with a statistically-principled tuning procedure. Due to the scarcity of public instances and the unavailability of really challenging ones, we also developed a parametrized instance generator. Using our generator, we created instances with different features, in terms of items, periods, and production level.

In order to assess the quality of our solver, we compare it with the state-of-the-art search methods, which are, to the best of our knowledge, the three MILP models designed and implemented in Mosel by Pochet and Wolsey [1]. To this aim, starting from their original source code, we reimplemented the three models in CPLEX (v. 12.5), and ran them on the same environment of our solver.

The outcome is that CPLEX, using the most effective of the three models of Pochet and Wolsey (model 3), in 1 hour is able to find the optimal solution on about 44.4% of the instances, a nearly optimal one on other 37.7% (i.e., a gap inferior to 3% respect to the lower bound), and it is far from the lower bound in the remaining ones. Our solver finds a nearly optimal solution for all instances in a reasonable time (about 75s). More specifically, our average solutions are at most 1.33% worse than the best/optimal solution, and at most 2.89% worse than the lower bound. On the CSPlib benchmarks, both model 3 in CPLEX and our method always reach the optimal solution with average computational times of 0.33 and 4.5 seconds, respectively.

All instances and best solutions are available for verification and future comparisons at the website opthub.uniud.it, along with the online solution validator.

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Improved time-indexed MILP formulation for the Resource-Constrained Project Scheduling Problem

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Keywords: Resource-constrained project scheduling, Mixed integer linear programming, exact algorithms, computational evaluation

In the Resource-Constrained Project Scheduling Problem (RCPSP), we are given a number of tasks to schedule across a planning horizon. Each task has a duration, resource requirements, and a list of precedence constraints. The objective is to find the starting time for all the tasks in such a way that the resource availabilities and the precedence relations are satisfied, and the project makespan is minimized. The problem has been extensively studied in the literature and several Mixed Integer Linear Programming (MILP) models have been proposed, as well as some performant exact approaches and metaheuristics (see Artigues et. al [1] for a complete survey).

In this work, we are interested in the so called "time-indexed" MILP formulation, which considers, for a given task, one variable for each possible starting time. Some recent papers (see Koné et. al [2]) showed that solving pseudo-polynomial MILP models of this kind with an up to date MILP solver produces satisfactory results.

We continue this line of research by proposing several improvements, including preprocessing techniques to reduce the number of variables and lifting techniques to strengthen the resource constraints. We show through extensive computational experiments on benchmark instances that the improvements we provide are very effective and make the time-indexed MILP formulation a competitive solution tool for the RCPSP.

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The Shuffled Teams Round Robin Tournament Problem

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Keywords: Mixed Integer Programming, Sports Timetabling, Round Robin Tournament

Sports optimization attracts the attention of researchers and practitioners in many branches as operations research, such as scheduling, graph theory and combinatorial optimization. We refer among others to Kendall et al. 2010 for a comprehensive survey on state-of-the-art applications and methods for solving optimization problems in sports scheduling.

Standard sport scheduling problems typically involve $2n$ teams that have to play against each other once (resp. twice) in single (resp. double) round robin tournaments. This basic problem has a large number of variants considering traveled distance, breaks, mirroring, carry-over effect to cite a few. Here we introduce a novel sport scheduling problem: the Shuffled Teams Round Robin Tournament (STRRT) Problem. STRRT is related to teams composed by two players (as in tennis doubles matches). The problem consists in creating a tournament of $4n$ players where teams (composed by pairs of players) are not fixed apriori but have to be generated while creating rounds and matches. The *Canonical* STRRT (CSTRRT) problem can be defined as follows: each participant has to play with all other players as playmates and against all other players as opponents during a complete league in a round robin tournament. The CSTRRT is said to be balanced iff each player plays the same number of times j (typically $j = 1$) with all playmates and the same number of times k (typically $k = 2j$) against all opponents.

This problem can be generally encountered when designing recreational competitions for sports like tennis and badminton or for card games like bridge and, more in general, when the schedules are based on non-predetermined couples of players.

In this work, we show that already with 8 players and $j = 1$ the standard 1-*factorization* of a graph does not lead to a feasible solution of the CSTRRT problem. We present several MIP models of the problem for deriving canonical schedules with 8, 12 and 16 players where, in the 16-player case, special patterns can be exploited to generate a feasible solution. Below, a CSTRRT schedule is shown for 8 players where each participant plays exactly once with all other

players and exactly twice against all other players.

	Match 1		**Match 2**	
	First Team	*Second Team*	*First Team*	*Second Team*
Round 1	1 2	3 4	5 6	7 8
Round 2	1 3	6 8	2 4	5 7
Round 3	1 4	6 7	2 3	5 8
Round 4	1 5	4 8	2 6	3 7
Round 5	1 6	2 5	3 8	4 7
Round 6	1 7	3 5	2 8	4 6
Round 7	1 8	2 7	3 6	4 5

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Open Pit Mine Planning

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Keywords: Open Pit Mine, Deterministic Approach, Integer Programming

Open pit mine can be presented as a set of three dimensional blocks via discretisation. The planning problem schedule the sequence of blocks that are extracted, when it is required, over the life time of the mine such that net present value is maximised. The blocks have precedence relationship in order to represent feasibility of the extraction and safety requirement. These represent a large part of the problem but are relatively easy to handle. The problem is complicated by the presence of resource constraints limiting the amount that can be mined in any period. Open Pit Mine Planning Problem (OPMPP) can be formulated as a very large scale MIP problem and in real life the OPMPP is very difficult to solve exactly. In this paper we present a matheuristic algorithm based on Lagrangian relaxation ideas, designed for distributed computing. We discuss implementation issues and provide numerical results on standard benchmark instances.

An Integrated Algorithm for Vehicle and Crew Scheduling Problems for Local Public Transport Companies

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Keywords: Vehicle Scheduling, Crew Scheduling, Simulated Annealing, Local Search.

This study deals with an integrated approach to solve two shift scheduling problems for local public bus companies: the first one aims at finding the best scheduling of vehicles with a given set of rides, while the second one aims at finding the best assignment of drivers to the returned vehicle scheduling solution of the first problem. The first subproblem to be faced is the *Multiple Depot Vehicle Scheduling Problem* that is known to be NP-hard. We propose a heuristic algorithm to find suitable solutions for real life instances. The designed algorithm aims at improving iteratively an initial solution by applying local search operators and escaping from local optimum solutions by resorting to a shaking strategy based on simulated annealing. The best vehicle scheduling is then used as input data for the Crew Scheduling Problem, in which drivers must be assigned to the trips. This problem is also NP–hard. A two phases algorithm is presented. In the first phase, a sequential procedure is designed to find a feasible solution of the Crew Scheduling Problem. In the next phase, the solution obtained so far is modified by changing the allocation of trips to the vehicles in order to improve the overall solution taking into account both vehicles' scheduling cost and drivers' assignment cost within a combined objective function. Both problems have been modelled taking into account as more real-world constraints as possible. Several operative constraints coming from the European Union restrictions on how the driver shifts must be composed are integrated in the overall problem making it different from the ones presented in the literature. The computational study performed on benchmark instances arising from real cases show the effectiveness of the proposed method.

An enhanced exact solution approach for the Constrained Shortest Path Tour Problem

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Keywords: Shortest path problems, Network flow problems, Combinatorial optimization, Branch & Bound, GRASP

Given a directed graph with non-negative arc lengths, the aim of the constrained shortest path tour problem (CSPTP) is to find a single-origin single-destination shortest path, which needs to cross a sequence of node subsets that are given in a fixed order. The subsets are disjoint and may be of different size. In addition to the restrictions imposed in the shortest path tour problem ([1], [3], and [4]), in the CSPTP it is required that the path does not include repeated arcs.

In [2], we have studied the theoretical properties of the problem, proving that it belongs to the complexity class NP-complete. To exactly solve it, we have designed a Branch & Bound method. Given the problem hardness, a Greedy Randomized Adaptive Search Procedure has been also developed to find near-optimal solutions for medium to large scale instances.

In this talk, we will describe an enhanced Branch & Bound algorithm and we will discuss about extensive computational experiments that have been carried out in order to empirically evaluate the performance of the proposed approach.

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Reoptimizing shortest paths: from state of the art to new recent perspectives

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Keywords: Shortest Paths, Reoptimization, Auction Algorithm

Reoptimizing shortest paths consists in solving a sequence of shortest path problems, where the k^{th} problem differs only slightly from the $(k-1)^{th}$ one, because the origin node has been changed, some arcs have been removed from the graph, or the cost of a subset of arcs has been modified. The different cases can be classified in two classes, *query change* when the origin has been changed, *arc cost change* the others.

Each problem could be simply solved from scratch, by using either a *label-correcting* or a *label-setting* strategy. Nevertheless, a clever way to approach it is to design ad hoc algorithms that efficiently use information resulting from previous computations. The most efficient ad hoc algorithms were proposed in [5], [6], and [7] for the query change while in [2], [4], and [8] for the arc cost change.

In this talk, we will formally define the different shortest path reoptimization problems arising in several different scenarios and/or conditions and we will briefly survey the most efficient state-of-the-art algorithms to approach them. It will be also described a new query change technique, inspired by the dual mathematical formulation of the problems and based on the auction strategy [1]. Let T_r be an optimal solution for the shortest path tree problem, a new origin s is selected. Starting from a partial optimal solution T_s, the algorithm performs a sequence of extensions, applying a strongly polynomial auction algorithm [3], in order to extend T_s to a new node $j \in T_r$; the subtree T_j is pruned from T_r and attached to T_s. The algorithm ends when an extension to r is performed.

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Named Entity Recognition: Resource Constrained Maximum Path

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Keywords: Named Entity Recognition, Conditional Random Fields, Resource Constrained Maximum Path Problem

Information Extraction (IE) is a process focused on automatic extraction of structured information from unstructured text sources. One open research field of IE relates to Named Entity Recognition (NER), aimed at identifying and associating atomic elements in a given text to a predefined category such as names of persons, organizations, locations and so on. This 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 can modelled through a stochastic process involving both hidden variables (semantic labels) and observed variables (textual cues).

In this work we investigate one of the most promising model for NER based on Conditional Random Fields (CRFs) [1], which is a discriminative undirected graphical model able to encode known relationships among tokens (observations) and labels (hidden states). CRFs are enhanced to include in the decision process a set of logic rules that can be either extracted from data or defined by domain experts [2]. The inference problem is defined as a Resource Constrained Maximum Path Problem (RCMPP) [3] associating a resource with each logic rule. Proper resource Extension Functions (REFs) and upper bound on the resource consumptions are defined in order to model the logic rules as knapsack-like constraints. A well-tailored dynamic programming procedure is defined to address the RCMPP.

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A new GRASP metaheuristic for biclustering of gene expression data

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The term biclustering stands for simultaneous clustering of both genes and conditions. This task has generated considerable interest over the past few decades, particularly related to the analysis of high-dimensional gene expression data in information retrieval, knowledge discovery, and data mining [1]. Since the problem has been shown to be NP-complete, we have recently designed and implemented a GRASP metaheuristic [2,3,4]. The greedy criterion used in the construction phase uses the Euclidean distance to build spanning trees of the graph representing the input data matrix. Once obtained a complete solution, the local search procedure tries to both enlarge the current solution and to improve its H-score exchanging rows and columns. The proposed approach has been tested on 5 synthetic datasets [5]: 1) constant biclusters; 2) constant, upregulated biclusters; 3) shift-scale biclusters; 4) shift biclusters, and 5) scale biclusters.

Compared with state-of-the-art competitors, its behaviour is excellent on shift datasets and is very good on all other datasets except for scaled ones. In order to improve its behaviour on scaled data as well and to reduce running times, we have designed and preliminarily tested a variant of the existing GRASP, whose local search phase returns an approximate local optimal solution. The resulting algorithm promises to be a more efficient, general, and robust method for the biclustering of all kinds of possible biological data.

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A Compact Formulation for the Orderly Colored Longest Path Problem

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Keywords: labeled graph, longest path

The Orderly Colored Longest Path (OCLP) problem consists of finding, into an edge colored graph, the longest path that follows a predefined order of colors. The application of the OCLP is related, among other, to the interpretation of Nuclear Magnetic Resonance experiments for RNA molecules [1]. IP formulations have been proposed in [2] that solve efficiently problems of small and medium size. In this talk we propose a new compact formulation with size significantly smaller than the ones already proposed. Moreover, the formulation is tightened using some classical valid inequalities deployed in a Branch&Cut framework. Preliminary tests are promising and indicate smaller solution time for the proposed approach.

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A two-phase algorithm for singly linearly constrained quadratic programs subject to lower and upper bounds

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Keywords: constrained quadratic programming, gradient methods, projection methods

We propose an algorithmic framework for the solution of convex Quadratic Programming (QP) problems with bounds and a single linear equality constraint:

$$\begin{array}{ll} \min & \frac{1}{2}\mathbf{x}^T H\,\mathbf{x} - \mathbf{p}^T\mathbf{x} \\ \text{s.t.} & \mathbf{l} \leq \mathbf{x} \leq \mathbf{u}, \\ & \mathbf{q}^T\mathbf{x} = b. \end{array} \tag{1}$$

Inspired by the GPCG algorithm [1] for bound-constrained QP problems, our algorithm alternates between two phases until convergence: an *identification phase*, which performs Barzilai-Borwein or Cauchy Gradient Projection steps until either a candidate active set is identified or no reasonable progress is made, and a *minimization phase*, which reduces the objective function in the working set defined by the identification phase, by applying either the SDC or the SDA method recently proposed for unconstrained QP [2,3]. The aim of this work is twofold. First, we want to investigate if the effectiveness of SDA and SDC, as well as their regularizing properties [4], can be extended to constrained minimization. Second, we focus on the formulation of the reduced problem in the minimization phase, presenting an effective way to deal with the linear constraint.

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On the unconstrained minimization of nonsmooth DC functions via DC piecewise-affine approximations

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Keywords: DC programming, Nonsmooth optimization

We focus on the unconstrained minimization of a nonsmooth nonconvex function, $f : \mathbb{R}^n \mapsto \mathbb{R}$, for which a difference-of-convex (DC) decomposition is available, i.e., there exists a pair of convex functions $f_1,\ f_2 : \mathbb{R}^n \to \mathbb{R}$ such that $f(x) = f_1(x) - f_2(x)$.

We introduce a proximal bundle method for the numerical minimization of $f_1 - f_2$, based on some classic ideas coming from cutting-plane approaches for the convex case. In particular, we iteratively build two separate piecewise-affine approximations of f_1 and f_2, grouping the corresponding information in two separate bundles $\mathcal{B}_1$ and $\mathcal{B}_2$, where $\mathcal{B}_1$ only contains information related to points close to the current iterate, while $\mathcal{B}_2$ refers to a global model of f_2. We combine the two convex piecewise-affine approximations of f_1 and f_2, and generate a DC piecewise-affine model, which can also be seen as the pointwise maximum of several concave piecewise-affine functions. Such a nonconvex model, following the latter remark, is tackled by means of two auxiliary quadratic programs, whose aims are, respectively, to generate a descent search-direction (or to certify stationarity), and to improve the approximation properties of the nonconvex model.

We discuss of the main convergence issues of the method, and provide some preliminary computational results on a set of academic test problems.

Preconditioning techniques for nonlinear conjugate gradient methods based on quasi Newton updates

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Keywords: Large Scale Unconstrained Optimization, Preconditioned Conjugate Gradient, Quasi Newton-Updates

In this work we deal with novel preconditioning techniques to be used within the Nonlinear Conjugate Gradient (NCG) method, in large scale unconstrained optimization. We build our preconditioners drawing our inspiration from quasi–Newton updates. Indeed, they are based on new low–rank quasi–Newton symmetric updating formulae, resulting as by–product of the NCG method at some previous steps. Our aim is to possibly approximate in some sense the inverse of the Hessian matrix, while still preserving information provided by the satisfaction of secant equation or its modifications.
These preconditioners are also inspired by some recent proposals in the context of Newton-Krylov methods [2], along with some effective preconditioning techniques from the literature of preconditioners for symmetric linear systems, namely the Limited Memory Preconditioners [3].
In particular, the construction of our preconditioners is matrix-free and is iteratively defined by means of rank-1 updates. Starting from the relation between BFGS and the Conjugate Gradient method, in the strongly convex quadratic case, we attempt to infer information both from the NCG and the secant equation, in order to guarantee some theoretical properties along with numerical efficiency. This induces us to possibly consider the use of smart and provably effective modified BFGS and L-BFGS schemes.
The results of an extensive numerical experience are reported highlighting the effectiveness of the proposed approach.

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A linesearch derivative-free method with adaptive precision function evaluations and application to bilevel minimization problems

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Keywords: derivative-free methods, bilevel optimization methods, nonlinear optimization

Some important classes of engineering problems can be modelled by optimization problems where the values of objective functions and the constraints can be obtained only by means of very complex numerical evaluations. This class of optimization problems can not be efficiently tackled by the optimization methods which need the exact values of the objective functions and the constraints at every iteration.

In this work we propose a new linesearch derivative-free algorithm for nonsmooth optimization problems with adaptive precision function evaluations. Under suitable assuptions we prove that an accumulation point of the sequence produced by the algorithm is a Clarke-stationary point of the considered problem.

The proposed method is applied for solving a particular class of bilevel minimization problems. Every problem belonging to this class consists of an upper level problem which depends on the optimal solution of an lower level problem. The use of the proposed derivative-free algorithm allows to obtain stationary points of the bilevel problem by using "approximated solutions" of the lower level problem.

Finally we report the results of a preliminary numerical experience showing a possible practical interest of the proposed approach.

On a probabilistic selective routing problem

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Keywords: Stochastic vehicle routing, orienteering problem, probabilistic TSP

We study a probabilistic selective routing problem defined as follows. Consider a directed graph where a cost is associated with each arc and a prize is associated with each node; each node will be available for visit only with a certain probability. A server starts from a fixed origin, visits a subset of nodes, and ends at a fixed destination. In a first stage, a node subset is selected and a corresponding a priori path is determined such that the server can visit all nodes in the subset and reach the destination without exceeding a time limit. In a second stage, after the list of available nodes is revealed, the server follows the a priori path by skipping the absent nodes. The task is determining a first-stage solution that maximizes the expected profit of the second-stage path, i.e., the difference between the expected total prize and the expected total cost. We call this problem the Probabilistic Orienteering Problem (POP).

We discuss the novelty of the model and its practical motivations. We show its formulation as a linear integer stochastic problem. We develop a branch-and-cut approach for the POP and several simple matheuristic methods, corresponding to different strategies to reduce the search space of the exact method. Extensive computational tests on instances with up to 100 nodes show the effectiveness of the exact method and the efficiency of the matheuristics in finding high quality solutions in a few minutes. Moreover, we provide an extended analysis on a subset of instances to show the value of explicitly modelling the stochastic information in the problem formulation. Finally, we discuss possible usages of the POP in tackling more complex models and dynamic situations.

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Speed Optimization for conflict free routing problem

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Keywords: conflict free routing, speed optimization, energy consumption

Conflict free routing problem arises in vehicle-based internal transport systems, where automated guided vehicles (AGVs) are commonly used to move loads between pickup and delivery points in facilities such as automated warehouses, flexible manufacturing systems and port terminals. In such a context, the travel network consists of a physical or virtual path layout made up of tracks. Each track has a unit capacity, i.e., it can be traversed by a single vehicle at a time. When two or more vehicles try to enter a track at the same time, a contention arises and at least one of them will be delayed or re-routed. Transportation tasks are expressed in terms of workstation for each pickup or delivery point and the pickup and delivery times are decided from a given manufacturing schedule. The aim is to find for each vehicle a conflict-free routing and to determine the corresponding travel speeds, in order to minimize the total energy consumption.

In this article, we propose a Branch-And-Bound algorithm for the problem, based on the relaxation obtained by removing track capacity constraints. In particular, the resulting relaxed problem is non linear and separable, and its optimal solution can be determined by solving in quadratic time a SOP for each vehicle. We devise a feasibility-check procedure aiming to determine if the optimal solution of the relaxation problem corresponds to a conflict-free routing. Finally, the branching procedure applies space-based and time-based branching constraints, so that to cut off conflicts detected by the feasibility-check

procedure. We demonstrate the efficiency and applicability of the proposed approach by solving instances of increasing complexity.

Minimizing the logistic ratio in the inventory routing problem

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Keywords: Inventory routing problem, logistic ratio, non-linear fractional programming

The inventory routing problem combines two well-known problems, namely, vehicle routing and inventory management. We consider a single product and a single depot where the vehicles start and end their routes. The depot is located at the product supplier for which the quantity to be produced in each period of a planning horizon is known. The product is consumed by a set of customers and the quantity consumed in each period is known for each customer. Each customer has an inventory capacity that must be respected. At the supplier and at each customer, there might be an initial inventory.

The inventory routing problem consists of determining in which period(s) each customer must be visited, the quantity delivered at each visit, and the delivery routes to perform in each period. Typically, the objective of the IRP consists of minimizing the sum of the routing costs and the holding costs. However, with this objective, there is no incentive to leave inventory at the customers where the unit holding cost is higher than at the supplier. In this paper, we consider a different objective that is also used in practice, namely, to minimize the so-called logistics ratio which is given by the total routing costs divided by the total delivered quantity. In this case, no holding costs are considered. The resulting problem is denoted inventory-routing problem with logistics ratio. We propose an exact algorithm to solve the problem and show computational results which provide some insights in the problem characteristics.

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Lean Thinking and Mathematical Optimization: Two Worlds Apart? A Case Study in Scheduling Chemotherapeutic Treatments

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Keywords: lean thinking, scheduling, healthcare operations management

This talk discusses the relationship between *lean thinking* (LT) and *mathematical optimization* (MO). Many practitioners view both LT and MO as part of the background of management engineers, but their role is very different, since LT often relies on qualitative approaches and tools, for which MO is not needed. Here we want to discuss and clarify the distinct roles that the two approaches may play and how their combined action may largely benefit the system. To this aim, we refer to a specific case study, concerning process reengineering in the chemotherapeutic center of the Azienda Ospedaliera Senese, a large Italian hospital. This center provides daily chemotherapeutic treatment to a large number of patients. In the current situation, patients are given appointment for a certain day and randomly gather to the center throughout the day. Drugs are manually prepared in advance by the nurses, with a certain chance of mistakes or mishandlings (very risky for both patients and nurses). On the whole, patients experience long waits, nurses are forced to stay overtime and at the same time processing resources are often underutilized. The idea of automating the preparation process has triggered an overall reengineering effort, approached by both LT and MO. In this talk we first describe how LT has reshaped the process, and thereafter we present the contribution of MO modeling. Thereafter, we describe in detail the problem of scheduling daily patients. It turns out that the problem can be viewed as a parallel machine scheduling problem with additional resources, namely the specialized personnel (nurses) in charge of carrying out patient setup operations. After some discussions, an ILP formulations was finally devised that correctly includes all real-life constraints. Such formulation was run on real data using Cplex 12.2 and the solution found (in few minutes) was deemed realistic by medical personnel. We discuss the benefits accruing from the implementation of this solution.

Dynamic patient admission scheduling and bed assignment problem

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Keywords: healthcare, integer linear programming model, matheuristic

The bed assignment problem here addressed consists in assigning elective patients to beds. Features such as uncertainty in length of stay and possible delayed admissions, as well as constraints on bed availability in departments, patients' clinical characteristics, competing requests for beds, gender segregation, are taken into account. The high complexity of this dynamic problem and needs of tools to support bed managers in making fast decisions motivate researchers to design suitable approaches. We formulate an integer linear programming model to support hospital managers in the bed assignment decision-making process. We propose a matheuristic solution framework based on a re-optimisation approach for solving this assignment problem. The approach is tested on benchmark instances and preliminary results are presented.

Multiple Classifiers approaches for improving Clinical Decision Support Systems

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Keywords: Machine Learning, Multiple Classifiers, Clinical Decision Support Systems

Machine Learning (ML) approaches in medical domains are increasing rapidly due to the rather effective impact to classification and prediction problems, rising in supporting clinicians in their decision-making. In this study, we propose approaches for developing medical knowledge (KM) modules for Clinical Decision Support Systems based on ML algorithms. The basic idea is to design each KM as a Multi Classifier System that combines the advantages of different individual classifiers to obtain better results. The proposed approach uses misclassified instances as guideline and it is based on two phases. In the first one, a set of different base classifiers are trained on a single dataset and each classifier could misclassify a certain sub-set of train instances. In the second phase, a distance measure is used to find the closest instance to the given test sample. If a classifier makes an incorrect prediction for the closest instance, then the likelihood that it will misclassify also the test sample is high. Therefore, at classification time it will not used. Our approach make this decision for each test sample separately. Conflicts (several classifiers predicted correctly the label for the closest instance) are solved using the accuracy of the base classifiers. On this basis, we developed two multi classifiers. They differ in the method of search the closest instance. To show the behaviour of the proposed approach we used four dataset from the UCI Repository [http://archive.ics.uci.edu/ml] regarding very important medical decision-making problems: Wisconsin Breast Cancer Dataset (WBC), Wisconsin Diagnosis Breast Cancer Dataset (WDBC), Wisconsin Prognostic Breast Cancer Dataset (WPBC) and Cleveland Heart Disease Database (CHD). We implemented our approach in Java using the API (Application Programming Interface) for WEKA (Waikato Environment for Knowledge Analysis) data mining tool. All experiments are based on 10- fold cross validation. Experimental results on both classifiers show that the achieved accuracy is high and

outperforms other techniques proposed in the literature.

Evaluating online approaches for the Real Time Management of operating rooms

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Keywords: healthcare, operating room, online optimization

At the operational decision level, the problem arising in the Operating Room (OR) management is also called "surgery process scheduling", which usually consists in (i) selecting elective patients from an usually long waiting list and assigning them to a specific OR session over a planning horizon, (ii) determining the sequence of surgical procedures and the allocation of resources for each OR session, and (iii) dealing with the arrival of non-elective patients requiring a surgery within a given time threshold.

The Real Time Management (RTM) of operating rooms is the decision problem arising during the fulfilment of the surgery process scheduling of elective and non-elective patients, that is the problem of supervising the execution of such a schedule and, in case of delays, to take the more rational decision regarding the surgery cancellation or the overtime assignment [1][3]. The RTM, which is characterized by the uncertainty of its main parameters [4], could deal with different conflicting objectives [2].

Dealing with only elective patients, the online approach consists in two procedures, that is the resequencing and the overtime allocation. The resequencing ensures the surgery of those patients close to their Maximum Time Before Treatment (MTBT) trying to maximize the OR utilization. Several criteria are checked to decide whether to allocate the overtime available or to keep it for future requests. To consider also a non-elective patient flow, the online decision consists in when and in which ORs to insert the surgery of the non-elective patients. To this purpose, we develop the Non-Elective Worst-Fit (NEW-Fit) algorithm, which is a greedy construction of an alternative schedule of the patients in which we try to insert the waiting non-elective. On the basis of this alternative schedule, the online algorithm NEW-Fit establishes the next patient to be operated on during a certain OR session, that is to continue with the ex-ante schedule or to insert a non-elective patient in such a session.

The online solution is characterized by the lack of knowledge about what might happen in the remaining of the planning horizon. On the contrary, at the end of the planning horizon, we have a complete information about what is happened. Thus it is possible to evaluate what would be the optimal decisions

to be taken. We provide a ILP model to compute the optimal offline solution to compare online and offline solutions.

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A Dynamic programming approach to solve multi-objective optimization problem under fuzzy rule constraints

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Keywords: Dynamic Programming, Fuzzy rule, Linguistic variable

A multi-objective optimization problem under fuzzy rule constraints is a problem where functional relationship between decision variable and objective function is not completely known. It is assumed that information source which is giving the knowledge about the objective function consists of a block of fuzzy if-then rules, where the antecedent part of the rules contains some linguistic values of the decision variables and the consequence part is either a linear combination of crisp values of the decision variables or consists of a linguistic value of the objective function. In this paper, our focus is to solve this type of problem when the decision variables are large in numbers (say n). First we decompose n variable problem in to $n - stage$ single variable problem for each objective then using dynamic programming and appropriate fuzzy reasoning scheme, obtain the solution for this problem. The obtained solution is very promising and signify the potential of proposed approach. The optimization model and the computational procedure has been illustrated by a numerical example.

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A Bridge between Bilevel Programs and Nash Games

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Keywords: Bilevel programming, Generalized Nash Equilibrium Problem (GNEP), Hierarchical optimization problem, Stackelberg game.

We study connections between optimistic bilevel programming problems and Generalized Nash Equilibrium Problems (GNEP)s. We remark that, when addressing bilevel problems, we consider the general case in which the lower level program is not assumed to have a unique solution. Inspired by the optimal value approach, we propose a new GNEP model that is closely related to the bilevel program. We provide a complete analysis of the relationship between the "vertical" bilevel problem and the corresponding "horizontal" (one-level) GNEP model. We define classes of problems for which solutions of the bilevel program can be computed by finding equilibria of the GNEP. We develop a simple algorithm, which turns out to be globally convergent, for the solution of classes of our GNEP; we study how it is then possible to recover a solution of the bilevel problem from the computed equilibrium. Numerical experience shows the effectiveness of our approach.

A Modular Genetic Algorithm Specialized on Linear Constraints

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Keywords: Multi-Objective, Heuristics, Linear Programming

Solving multi-objective linear programming and combinatorial optimization problems with search heuristics is a common practice widely discussed in literature with hundreds of different implementations. Genetic algorithms (GAs) are considered one of the most efficient strategies owing to their modularity and ability to being easily adapted to specific problems. They are particularly well-suited for complex non-linear problems or problems which generate a set of Pareto optimal alternatives in the presence of multiple objectives. In this work we present the Multi-Objective Genetic Algorithm for Structured Inputs, or MOGASI. This algorithm combines modules and operators of standard GAs with specialized routines aimed at achieving enhanced performance on instances with specific types of constraints, in particular linear. MOGASI uses specialized data handling strategies to classify variables and constraints in sub-problems with different data structures. It has a classic pre-processing phase which restricts the feasible domain. Furthermore, MOGASI reduces the problem dimension by exploiting linear equality constraints: a subset of variables is expressed in terms of the remaining ones so that the equality can be replaced with a linear combination of the remaining variables. Usually GAs work with a set of configurations called population and they try to evolve it towards the optimal solutions. MOGASI works with two separate but communicating populations instead. The first one takes advantage of the linear constraint properties: it introduces specialized operators which maintain design feasibility with respect to the computed linear convex space from one generation to the next. The second population on the other hand considers all linear and non-linear constraint domains. The algorithm also has a mechanism which replaces, whenever possible, unfeasible individuals. MOGASI has been tested against a set of benchmarks well-known in literature. Results show its efficiency on different multi-objective optimization problems compared to other state-of-the-art genetic algorithms.

A Nonmonotone GRASP

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Keywords: Combinatorial Optimization, GRASP, Metaheuristics, Local Search, Nonmonotone Line Search, Maximum Cut Problem, Weighted Maximum Satisfiability Problem, Quadratic Assignment Problem

A Greedy Randomized Adaptive Search Procedure (GRASP) is an iterative multistart metaheuristic for difficult combinatorial optimization problems. Each GRASP iteration consists of two phases: a construction phase, in which a feasible solution is produced, and a local search phase, in which a local optimum in the neighborhood of the constructed solution is sought. Repeated applications of the construction procedure yields different starting solutions for the local search and the best overall solution is kept as the result.

The GRASP local search applies iterative improvement until a locally optimal solution is found. During this phase, starting from the current solution an improving neighbor solution is accepted and considered as the new current solution.

In this talk, we propose a variant of the GRASP framework that uses a new "nonmonotone" strategy to explore the neighborhood of the current solution. We formally state the convergence of the nonmonotone local search to a locally optimal solution and illustrate the effectiveness of the resulting Nonmonotone GRASP on three classical hard combinatorial optimization problems: the Maximum Cut Problem, the Weighted Maximum Satisfiability Problem, and the Quadratic Assignment Problem.

Neurorehabilitation treatment scheduling in a healthcare setting

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Keywords: Periodic arc routing problem, Mixed graph, Integer programming, Branch-and-cut

Although for many areas of healthcare there were developed automated scheduling programs (e.g. nursing rosters, doctor's surgeries, other health service's management), rehabilitation has been somehow left behind. In particular, neurological rehabilitation is a complex issue in care's pathway for severe brain damage patients. Indeed, such patients have to follow an individual therapeutic program, including session of different treatments, such as physiotherapy, speech therapy, cognitive rehabilitation, nursing, sense stimulation, etc. Session' durations are different for treatment type, as well as for clinical condition of the patient.

The aim of this work is to show how automated scheduling can provide a far more effective and efficient alternative to manual scheduling by hand. The application is designed for the IRCCS Centro Neurolesi "Bonino-Pulejo" at Messina, which is one of the biggest and innovative center for neurorehabilitation in south Italy.

The scheduling problem considered here is formulated as a combinatorial optimization problem. The objective function maximizes those patient-professional matchings allowing the care continuity on the patients. Constraints are formulated taking into account resources involved, such as the number of sessions per treatment, the duration of each session, the staff's rosters (different by the category of employed), the availability of the devices for robotic rehabilitation, the professional ability to use these robotic devices. Finally, the model also consider the minimal regulatory requirements provided by the Sicilian Department of Health (i.e. minimum daily overall duration of the care program for admission code).

Finding the complete set of efficient solutions for the bi-objective integer minimum cost flow problem: state of the art and a new two-phases approach

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Keywords: Resource-constrained project scheduling, Mixed integer linear programming, exact algorithms, computational evaluation

In the poster will be illustrated an important class of multiobjective combinatorial optimization problems: the bi-objective integer minimum cost flow problem. It is well known that the single objective case can be solved efficiently through the network simplex algorithm (see [1]). In the bi-objective case, due to the presence of non-supported efficient solutions, the situation is entirely different. The problem is NP-hard and the number of efficient solutions can be exponential in the size of the problem (see [2]). The existing exact algorithms to solve this problem can be distinguished in two main classes: the ε-constraint methods and the two-phases approaches (see for example [3] e [4]). In the ε-constraint methods the problem is reduced to a single objective, chosen among the all criteria of the original problem, turning into knapsack-type constraints the remaining criteria. Appropriately specifying the right-hand-side values it is possible to find all the efficient solutions. This implies the destruction of the problem structure, that is often harder to solve than the single objective version of the original problem and makes this technique inefficient, especially for large size problems. In the two-phases approaches the search of the efficient solutions is partitioned in two steps: in the first phase the extreme efficient solutions are found, in the second phase the other supported and non-supported efficient solutions are identified. For the bi-objective integer minimum cost flow problem, with integer capacities, costs and demands, in the first phase can be used any approach to solve the bi-objective continuous network flow problem, because of the unimodularity of the matrix associated with the flow conservation constraints, to generate a complete set of extreme efficient solutions (see [5], [6], [7] e [8]). In the second phase, starting from the extreme efficient solutions, an exploration of the outcome set permits to generate the other efficient solutions. In the works [5] and [7] the first attempts of this type are presented. Indeed in both papers, only a subset of the Pareto front is identified, as it is explained in [9]. More recently, in [4] a two-phases algorithm able to generate a complete set of efficient solutions (supported and non-supported) for the same problem is proposed. In the first phase a parametric network simplex algorithm is used to find the extreme efficient solutions. In the second phase, through an adaptation of the k-best flow algorithm (see [12]), the other efficient solutions are generated.

In the poster will be reviewed the main existing approaches and it will be presented the main components of a new two-phases approach (joint work with M. Ehrgott), that in the first phase uses the dual variant of the Benson's algorithm (see [10] e [11]) to generate the efficient extreme solutions, and in the second one, through new variant of the k-best flow algorithm, finds the remaining efficient solutions.

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Operations Research and Optimization for Transportation and Logistics

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Transportation and Logistics play a fundamental role nowadays. All kinds of freights are daily shipped from origins to destinations across the world and by different modes of transport. Therefore, the optimization of the operations behind transportation plays an important role.

The aim of this poster is to present a research conducted in Transportation and Logistics, which vision is to support the firm at any planning horizon (strategic, tactical, and operational) and in the maintenance of the network.

At a strategic level, the firm needs to design the network for future transportation. Once the infrastructure has been built, the firm needs to manage the freight flows through the network and to assign the freight to intermediate transportation companies. These activities arise at a tactical level. At an operational level, the freight needs to be efficiently packed into containers in order to be shipped to destination. Finally, maintenance is essential to ensure an efficient and safe network.

The goal of the presented problems is to help the firm to achieve the above objectives.

The proposed problems are the Capacitated Transshipment Location Problem with stochastic handling utilities at the facilities ($CTLP_S$), the Generalized Bin Packing Problem (GBPP) and its variants, the Three-Dimensional Knapsack Problem with Balancing Constraints (3BKP), and the Stochastic Tactical Railway Maintenance Problem (STRMP).

The $CTLP_S$ allows to plan the routes at a strategic level through which the freight will be shipped. Moreover, the $CTLP_S$ also manages freight flows. The GBPP and its variants arise at a tactical level to efficiently assign freight to transportation companies in charge of the shipment. The 3BKP can be exploited at an operational level: once the freight has been assigned to containers, it is loaded to maximize the volume used and satisfy balancing constraints, which are fundamental for a stable transportation of freight.

Finally, the STRMP aims to develop an efficient maintenance plan. Previous works are mainly deterministic and over a single plan. The innovation of the STRMP is the creation of an adaptive plan to schedule maintenance operations over a planning horizon and under a stochastic setting.

Operations Research and Optimization for Transportation and Logistics

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The adaptive large neighbourhood search (ALNS) metaheuristic has become a popular template for implementing heuristic solution methods. The metaheuristic allows the use of problem specific knowledge when specifying operators for partially destroying and then repairing a solution to an optimisation problem. Problem independent components of the ALNS dictate how different destroy and repair operators should be used and control the search trajectory. One presumably important component that influences the search trajectory is the move acceptance criterion. In the original ALNS, this criterion was based on simulated annealing, whereas earlier work on large neighbourhood search by Shaw had accepted only improved solutions. Recently, some implementations have used the record-to-record acceptance criterion instead. Currently, however, there are no guidelines available to recommend one acceptance criterion over another. This paper intends to fill this gap by investigating a large number of different move acceptance criteria by subjecting them to extensive computational testing. Through empirical experiments we will attempt to 1) suggest which move acceptance criterion is better suited for an implementation of ALNS, 2) quantify the effect on performance from using different acceptance criteria, 3) attempt to measure in which way the move acceptance criteria influence the search behaviour.

Combining Mixed Integer and Constraint Programming

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The extensive use and success of Mixed Integer Programming (MIP) and Constraint Programming (CP) in many practical applications highlights their significance inside the field of Operational Research. There has been some effort into exploring synergies between these two Mathematical Programming paradigms, and this is the overall theme of the research presented here. We study two topics, one of which focuses on the algorithmic influences of CP into MIP, while the other treats a modeling enhancement of MIP that is inspired by the tools provided in CP.

In particular, we outline the importance of bound tightening techniques in the context of MIPs with so-called indicator constraints and their implementation by extensive propagation procedures as in CP. We then report on computational experiments regarding the incorporation of such procedures into a novel exact algorithm for Mixed Integer Linear Programming (MILP) problems applied to Job Shop Scheduling.

Finally, we present an extension of the class of MILPs that allows for linear expressions with "holes" in their domains. This is inspired by the fact that in CP, we can flexibly use non-contiguous domains, whereas in MIP we have to use auxiliary variables to model such phenomena. We show theory and computational results on cutting planes, in particular an extension of split cuts, for such problems. We also demonstrate how to use these structures in branching and that overall, the algorithmic exploitation of holes in MIP can be advantageous.

Real Time Traffic Management in Railway Nodes

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In order to promote the use of train it is necessary to provide faster, more reliable and on-time train services. If some parts of a rail network -such as a railway node, that is an area comprising some stations and junctions- are undercapacitated, this limits the augmentation of the trains schedule offer for congested areas and huge investments for network augmentation/rightsizing are required. Furthermore, when disturbances to the rail traffic arise, many decisions on traffic such as (re)routing, (re)scheduling and precedences are taken in real time by human operators (dispatchers and coordinators) at a local level since it is difficult to predict their effect outside each dispatching area.

In a scenario of growing complexity and scarcity of resources it is necessary to exploit an automated Decision Support System (DSS) for routine activities of real time traffic management, suggesting possible routes and schedules to dispatchers and coordinators which in turn may select and validate the proposed solutions via a Human Machine Interface, thus allowing skilled human operators to focus on exceptions and ensuring that the train ordering decisions result in optimal capacity allocation of the railway network.

A primary objective of a real time Traffic Management Systems - incorporating advanced tools from Mathematical Optimization to solve the Dispatching problem - is to make the trains run on schedule, detecting any possible conflict in the use of a railway resource and finding a new solution which enumerate the possible routings and, for each one, propose a schedule which is feasible (i.e., conflict-free, compliant with safety constraints and train priorities) and optimal (able to minimise costs and a certain measure of the lateness).

A vast amount of research has been developed addressing the real time dispatching problem in a railway line or station. Notably, advanced rescheduling and dispatching techniques have never been implemented in large and congested

railway nodes, also due to the complexity of known exact algorithms which are exponentially growing with the problem size. Recently, new effective techniques for handling traffic on railway lines have been developed and put in operation in Italy, Latvia and Norway. A different methodology has been also developed for tackling large stations, and it is scheduled to be in operation in Italy. The present research, indeed, intends to merge and further develop these successful techniques into an integrated approach capable to manage a large node.

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Un ambiente di supporto alle decisioni per l'ottimizzazione della logistica nella gestione delle risorse umane

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I responsabili della gestione di un'azienda sono chiamati ad un confronto quotidiano con piccoli e grandi problemi di fronte ai quali si richiede di prendere una decisione. Queste decisioni possono, ad esempio, riguardare la definizione di un piano strategico che comporta scelte di investimento rilevanti oppure la definizione di un piano di produzione che utilizzi le risorse umane e informatiche a disposizione in modo efficace ed efficiente. Talvolta, soprattutto per imprese di piccole e medie dimensioni, questo flusso continuo di decisioni viene affrontato dal management aziendale in modo istintivo e non strutturato, sulla base delle sole informazioni già note al decisore che deve operare le scelte. Questo comportamento, improntato a pratiche di gestione piuttosto informali, presenta indubbi vantaggi quali la rapidità delle decisioni, la loro flessibilità e la possibilità di effettuare modifiche e aggiustamenti nel tempo. Esistono tuttavia evidenti limiti che derivano da questo atteggiamento informale nei confronti dei processi di decisione. La descrizione formale del problema consente di acquisire una migliore comprensione del fenomeno aziendale analizzato. Ad esempio costringe il decisore ad individuare con lucidità le decisioni alternative a disposizione, nonchè la gerarchia degli obiettivi che governano le sue scelte. Dal punto di vista dell'impresa, si consegue un evidente vantaggio di trasparenza dei criteri e delle analisi che hanno condotto ad intraprendere determinate scelte. Esistono inoltre numerosi esempi di problemi decisionali caratterizzati dalla numerosità delle alternative disponibili e dalla complessità delle relazioni che legano i diversi fattori coinvolti nel processo decisionale. In situazioni di questo tipo il compito del decisore, rivolto ad individuare la scelta più vantaggiosa per l'azienda, appare piuttosto ardua. Risulta quindi di notevole utilità il ricorso a modelli quantitativi che forniscano ulteriori informazioni di supporto al decisore. Questi modelli

devono essere comunque tradotti in strumenti informatici che possano essere utilizzati agevolmente dal decisore e aggiornati quando è necessario adattarli a nuove esigenze aziendali o quando la natura e la quantità di informazioni disponibili richiedono un adeguamento sostanziale. Uno degli scopi di questa ricercha è proprio quello di curare il passaggio dalla validazione di un modello matematico di ottimizzazione della logistica per la gestione di risorse umane ad uno strumento informatico efficiente che possa costituire un reale strumento di supporto alle decisioni in settori, quale quello della logistica portuale, ospedaliera e piccole e grosse aziende. Questi lavori sono sviluppati dal gruppo di ricerca del Dipartimento di Matematica e Informatica e del Dipartimento di ingegneria Elettrica e Elettronica dell'Università di Cagliari che si avvale dei finanziamenti regionali e europei e della collaborazione con Partner aziendali quali Cagliari International Container Terminal (CICT), società del Gruppo Contship Italia, Policlinico Universitario di Monserrato, azienda CFADDA ecc.. Tali collaborazioni si sono rivelate cruciali sia in fase di costruzione del modello matematico che dello sviluppo del sistema di supporto alle decisioni superando il gap spesso esistente tra ricerca e reali esigenze aziendali.

A multi-trip drayage problem with heavy and light container loads

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Keywords: Drayage, Vehicle Routing, Container logistics

This paper addresses a drayage problem motivated by the case study of a carrier, which provides door-to-door freight transportation services. The carrier manages a fleet of trucks and containers to serve two types of transportation requests: the delivery of container loads from the port to importers and the shipment of container loads from exporters to the port, [1]. Some customers need to ship or receive heavy container loads, which must be moved by trucks carrying only one container. Other customers must ship or receive light container loads, which must be hauled by trucks carrying one or two containers. A truck can perform more than one route, and the number of containers carried by a truck in each route could change. The total working time, comprehensive of travel time and service time at nodes, must not exceed the maximum working time allowed by driver contracts. A limited fleet of homogenous trucks is considered. The goal of the problem is to identify the optimal workplan for the vehicles, which allow minimizing the total travel distance, while respecting working time limitations. We present a mathematical paths based formulation and a preprocessing method to reduce the number of routes that must be passed to the model, basing on dominance rules. Computational results show that the model can be solved to the optimality, by means of commercial solvers, for small and medium size instances. In order to address larger instances, we propose a heuristic mechanism to select most promising routes.

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The Periodic Rural Postman Problem with Irregular Services

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Keywords: Periodic arc routing problem, Mixed graph, Integer programming, Branch-and-cut

The periodic rural postman problem is a variant of the classic rural postman problem [1] in which some links of a graph must be visited a given number of times (frequency) in sub–periods of a specified time horizon. These links are called customers. The problem consists of designing a set of a least-cost routes that satisfy the service requirements of the customers. We refer to the case in which the services are irregular. Specifically, each customer has its own service plan with sub–period sizes and frequencies that can vary. Some practical applications of the periodic rural postman problem with irregular services (PRPP-IS) can be found in road maintenance operations and road network surveillance [2]. We focus on the activities for which the vehicle capacity can be considered unlimited. For the PRPP-IS, we describe a mathematical model and a solution approach based on the branch-and-cut paradigm [3]. In the solution framework, constraints ensuring connectivity and other valid inequalities are identified by using specific separation procedures. Computational results are also presented.

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An Efficient Algorithm for Handling the Vehicle Routing Problem with Multiple Time Windows

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In the Vehicle Routing Problem with Multiple Time Windows (VRPMTW) for each customer a single time window has to be selected to minimize the total duration of the solution. This increases the complexity of the routing problem compared to classical vehicle routing problems where there is only a single time window per customer. By determining the optimal selection of time windows the waiting time in a route can be reduced. We present an exact polynomial time algorithm to efficiently determine the optimal time window selection when a neighborhood operation is applied. The algorithm is embedded in a tabu search metaheuristic to solve the VRPMTW and the results are compared to the best-known solutions of the VRPMTW instances from the literature.

Global Optimization based on small dimensional feature spaces

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Keywords: Global Optimization, Clustering, Features, Disk Packing

At the beginning of global optimization algorithmic research several methods had been developed based on the idea of clustering; those methods prescribed to stop as early as possible a local search procedure when it was likely that it would have led to an already discovered local minimum. Similarly, some efforts have been recently done in applying machine learning to guide local searches, as in the so-called LeGO (Learning for Global Optimization) approach. Both kinds of approaches become inefficient as the dimension of the problem increases.

In this talk we present preliminary results on revisiting those methods based on a mapping from the original variables to a small dimensional feature space.

Experience is provided with application to the circle packing problem, a hard large scale optimization problem which lends itself very naturally to the employment of geometrical, symmetry-invariant features.

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A new inexact forward–backward algorithm with applications in image processing

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Keywords: Forward–backward methods, Variable metric, Nonconvex optimization

A variety of applications arising from signal and image processing can be numerically reformulated as the minimization of a functional $f = f_0 + f_1$, in which the differentiable, possibly nonconvex term f_0 measures the distance between the measured data and the reconstructed object, whereas the convex, possibly non differentiable function f_1 aims at imposing some specific properties on the desired object. Such a class of optimization problems can be addressed by the proximal forward-backward (FB) algorithm [1], which alternates a gradient step on f_0 and a proximal step on f_1. Although the FB algorithm requires a low computational cost per iteration, it may suffer from slow convergence and, in addition, the proximal operator might not be available in closed form.

In this light, we propose a new forward-backward method denominated VMILA (Variable Metric Inexact Linesearch Algorithm) [2,3]. The key ingredients of the proposed approach are the use of an Armijo–like rule to determine the linesearch parameter along a suitable descent direction, in order to ensure the sufficient decrease of the objective function, and the possibility of adopting a metric which may change at each iteration. The parameters involved in the definition of such variable metric, e.g. a scaling matrix D_k and a steplength parameter α_k, are not necessarily related to the Lipschitz constant of ∇f_0, as

seen in other works [1,4], but should be considered as free parameters. Implementable conditions for the approximate computation of the proximal point are also considered.

Theoretical guarantees for VMILA are given both in the convex case, where the strong convergence of the iterates to a minimizer of the objective function f is proved under some additional hypotheses on the type of metric involved [2], and in the nonconvex case, where the same result holds provided that f satisfies certain analytic properties and that ∇f_0 is Lipschitz continuous [3]. Numerical effectiveness of VMILA in comparison with other state-of-the-art methods is shown in several imaging applications.

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Globally convergent decomposition algorithm for risk parity problem in portfolio selection

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Keywords: Portfolio, Risk-Parity, Decomposition

The risk parity approach in portfolio construction aims to create a portfolio where all assets have the same marginal contribution to the total risk. In this work we consider a nonconvex least-square formulation with general box constraints on the weights of the assets in order to take into account specific preferences.

Decomposition methods for a (more general) class of constrained minimization problems are proposed and global convergence results are stated. Computational experiments and comparison with standard solvers show the effectiveness of the proposed algorithms in terms of both computational effort and quality of the obtained solutions.

Topology optimization for stress-constrained lightweight structures

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Keywords: Non-linear programming, Topology optimization, Stress constraints

Topology optimization studies problems whose aim is to determine the optimal topological features of a structure such as the shape, the number, and location of holes in the solid body, and the connectivity of the domain in order to outline structures better than those obtained without such optimization.

Given a set of forces acting upon the solid body, the problem of engineering stress-constrained lightweight structures is modeled as a non-convex and highly non-linear problem consisting in minimizing the volume (or mass) of the structure while satisfying a set of stress constraints.

In this talk, a new solution technique will be described that avoids pathological behaviors such as mesh-dependency and checkerboard patterns, while attaining results of emerging interest given the new opportunities supplied by the recently popular additive manufacturing techniques.

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A Branch-and-Price framework for the Pure Parsimony Haplotyping Problem

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Keywords: Integer programming, Computational biology, Branch-and-price

Following the important achievement of the human genome sequencing, studies have been focusing on the sites of the DNA where all the significant differences among human beings are contained, representing the 1% of the whole information contained in it. These sites are called *Single Nucleotide Polymorphisms (SNP)*. As the DNA consists of chromosomes made of a double chain of nucleotides, each SNP is characterized by two nucleotides, one for each chain.

The knowledge of nucleotides chains that compose the double DNA chain of an individual has great importance in a medical environment, where they are needed to study diseases and populations' behaviours. However, due to the presence of the SNPs, determining experimentally the single nucleotides chains that, paired, form a certain portion of the DNA is expensive and time-consuming, so that mathematical approaches have been proposed to deduce them once we are given the double chains, that are more easily obtained. In particular, the Haplotype Inference by Pure Parsimony problem (HIPP) consists in, given a set of genotypes (strings over a ternary alphabet $\{0, 1, 2\}$), determining the smallest set of haplotypes (binary strings over the set $\{0, 1\}$) so that each genotype can be "generated" by some pair of haplotypes, meaning that they are compatible with the genotype and can fully explain its structure. [1].

The polynomial-size Integer Programming model presented in [2] is highly efficient for small instances but hardly suitable for instances with a large number of genotypes, while the Integer model obtained by decomposition in [3] presents an exponential number of variables and can be solved using a Branch-and-Price approach. An effective procedure to solve the root node is presented in [4] and it mainly consists in looking for an efficient way to solve the Pricing Problem, including a stabilization procedure and a smart enumeration of all possible solutions. As the variables involved contain a lot of information on the solution, we present a branching rule that, at the same time, provides a more balanced branching tree with respect to the standard variable branching and allows the branching information to be encoded in the pricing problem, avoiding any changes to the Reduced Master Problem. The aim of using this formulation

for HIPP is to outperform in efficiency previous models for instances with a large number of genotypes.

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Discrete Consensus for Asynchronous Distributed Task Assignment

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This paper deals with the problem of assigning tasks to a set of nodes communicating in a connected graph topology to satisfy the following requirements: assigning all the tasks to the agents; assigning to each agent no more than M tasks; minimizing the maximum total load of each agent.

A gossip-based algorithm is presented: starting from an unfeasible solution, at each iteration a node solves a Local-Integer Linear Programming problem with its neighbors (i.e., the connected nodes in the communication graph). The convergence of the algorithm is proved and the expected convergence time is evaluated. A simulation campaign shows experimental results on the performance of the proposed approach.

The complexity of some pattern problems in the logical analysis of large genomic data sets

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Keywords: Logical Analysis of Data, Patterns, Computational Complexity

Many biomedical experiments produce large data sets in the form of binary matrices, with features labeling the columns and samples associated to the rows. An important case is when the rows are also labeled into two groups, namely the *positive* (or healthy) and the *negative* (or diseased) samples. The *Logical Analysis of Data* (LAD) is a procedure aimed at identifying relevant features and building boolean formulas (rules) which can be used to classify new samples as positive or negative. These rules are said to explain the data set. Each rule can be represented by a string over {0,1,-}, called a *pattern*. A data set can be explained by alternative sets of patterns, and many computational problems arise related to the choice of a particular set of patterns for a given instance. In this paper we study the computational complexity of these pattern problems and show that they are, in general, very hard. We give an integer programming formulation for the problem of determining if two sets of patterns are equivalent. We also prove computational complexity results which imply that there should be no simple ILP model for finding a minimal set of patterns explaining a given data set. We also show that the number of all patters that explain a given set of data is polynomially bounded in the number of data. This result allows for modeling the problem of finding a minimal set of patterns that explains a given set of data as a polynomial size set covering problem.

A variant of the generalized assignment problem for reliable allocation of sensor measurements in a diagnostic system

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Keywords: Generalized Assignment Problem, Sensor Allocation, Diagnostic System Reliability

Tokamaks are the most promising devices currently under development to achieve the production of energy from controlled nuclear fusion reactions (magnetic plasma confinement). In a nuclear fusion reactor the plasma is monitored using a diagnostic system composed of a variety of spatially distributed probes. These probes allow to retrieve a large set of features which are stored in a data acquisition system. These features are used to improve the plasma physics knowledge (magnetic flux and field) and to regulate the plasma main characteristics. Indeed, opportunely combining these *direct measurements*, it is possible to infer a large amount of *composed measurements (functions)*, such as plasma energy, current, and to estimate location and size of a large number of plasma instabilities. These measurements play a key role in the protection and operation of the reactor itself. Each function can be computed in several ways (*alternatives*), using different combinations of the direct measurements. Given a data acquisition architecture, an alternative can be computed only if all the needed direct measurements are stored in the same acquisition unit. Moreover, a "weight value" is associated to each alternative of each function to evaluate the quality of the alternative.

It is easy to understand that, in order to maximize the dependability and reliability of the data acquisition system, the most profitable alternatives of a given function should be stored distributing them in different acquisition units. In this way, if one unit gets lost, a function can be computed by a different alternative using the information stored in another unit.

This problem, referred to as the Optimal Measurement Probes Allocation problem, can be tackled as a variant of the generalized assignment problem (GAP). The GAP consists in determining the maximum profit assignment of n objects to m bins such that each object is assigned to exactly one bin, satisfying the capacity constraints. With reference to the tokamak diagnostic system, the objects to be allocated are the direct measurements, the bins are the acquisition units and the profit to be maximized is expressed as a function of the alternative weights.

An ILP based solving approach will be presented for the defined problem and its variants. Results on randomly generated and real instances will be presented, showing the effectiveness of the proposed method.

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Models and algorithms for the traveling salesman problem with time-dependent service times

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Keywords: TSP, bounds, integer linear programming

We study the Traveling Salesman Problem with time-dependent Service Times (TSPST) which has been recently introduced in Taş et al., 2016 [1].

TSPST is a variant of the well-known NP-hard Asymmetric TSP (ATSP). As in the classical ATSP, we are given a directed complete graph, and each arc is assigned a cost representing the corresponding travel time. In the TSPST, each customer also requires a service time. In most works, service times are either ignored or considered as constant and consequently summed to the travel times. On the contrary, in the TSPST, the service duration depends on the time at which the service starts at that customer. The TSPST calls for finding a Hamiltonian tour (i.e. a tour visiting each customer exactly once) such that the total duration of the tour (i.e. the sum of the travel times and of the service times) is minimized.

In Taş et al., 2016 [1], "compact" Mixed Integer Programming (MIP) formulations, using a polynomial number of constraints, are proposed. Despite their directness and simplicity, these formulations are often associated with weak linear programming relaxations. We are interested in strengthening the MIP models by studying exponential-size formulations that explicitly incorporate subtour elimination constraints. Extensive computational experiments on benchmark TSPST instances are reported.

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A matheuristic for the Asymmetric Capacitated Vehicle Routing Problem

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Keywords: Vehicle routing problem, matheuristics, compact MILP formulations

We consider the Asymmetric Capacitated Vehicle Routing problem (ACVRP), which is a particular case of the standard Capacitated Vehicle Routing Problem in which the costs on the arcs are not symmetric. We propose an optimization-based approach that combines heuristic concepts with compact mixed-integer linear programming (MILP) formulations. The matheuristic includes three sequential stages: firstly the problem size is heuristically reduced by discarding unpromising arcs, then a starting feasible solution is derived and finally an optimization-based improvement procedure is invoked to iteratively generate near-optimal solutions of sequences of two or three-vehicle ACVRP subproblems. The procedure is solely based on solving compact MILP formulations and it is relatively easy to be coded, however we provide empirical evidence that it often delivers high-quality solutions within an acceptable computation time.

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On the Green Vehicle Routing Problem

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Keywords: Alternative-fuel Fleet Operations, Refuelling Station, Mixed Integer Linear Programming

The road transport impacts significantly on the worsening of the air pollution as highlighted by recent studies. The use of Alternative Fuel Vehicles (AFVs) contributes to the reduction of the harmful emissions but it is currently limited by the short driving range so that an AFV may require many refuels in a trip. In addition, the poor availability of the Alternative Fuel Stations (AFSs) on the networks limits the usage of AFVs also in urban contexts. Therefore, the problem of efficiently routing the AFVs to provide eco-sustainable transport solutions arises. It is not new to the Operations Research community and it was introduced in the literature by [1] as the Green Vehicle Routing Problem (G-VRP). The G-VRP deals with the planning of the routes of a fleet of AFVs, based on a single depot, serving a set of customers, geographically distributed, while minimizing the total travel distance. Each AFV starts/ends from/to the depot, respecting both the limited cargo and fuel tank capacity. For refueling reasons, intermediate stops to the AFSs have been also planned to prevent drivers remaining without the minimum fuel level to either reach an AFS or return to depot. The G-VRP has been addressed from both the modeling and methodological point of view and generally, to allow multiple visits at the AFSs, dummy copies of them are introduced consequently increasing the problem complexity. In this work, a new Mixed Integer Linear Programming formulation for the G-VRP is proposed in which the visits to the AFSs are only implicitly considered, avoiding dummy copies. Moreover, the number of variables is reduced also by pre-computing, for each pair of customers, an efficient set of AFSs, given by only those that may be actually used in an optimal solution. Numerical experiments, carried out on benchmark instances, extending those presented in [3], show that our model, solved through an optimization tool software, outperforms the previous ones proposed in the literature [1,2]. Moreover, it allows certifying optimal solutions also for instances previously not solved to optimality. References

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Matheuristics in logistics systems: an application to a cruise liner network design problem

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Matheuristics are model based heuristics which exploits mathematical programming inside a metaheuristic framework. The aim of this work is to discuss the use of matheuristics in logistics problems and, in particular, in rich VRPs, where several additional constrains make difficult to apply standard optimization techniques. Matheuristics can be used in a variety of metaheuristics frameworks. However, literature show a growing interest in composing model based heuristics inside neighborhood based metaheuristics. In particular, very large neighborhood search require efficient algorithms to explore the defined search space at each iteration. In large neighborhood based metaheuristics the neighborhood is implicitly defined by destroy and repair operators. The main weakness of this approach, is that generally the repair phase is carried out with simple constructive heuristics which produce low quality solution. In matheuristics, the model is used to explore the neighborhood defined by destroy operators. This allow to produce high quality repaired solutions within short computational time. The approach is tested on an application case based on cruise liner network design problem. The problem can be represented as an original variant of the VRP where all the given fleet must be routed and the total fixed and variable traveling costs must be minimized. Variable speeds, multiple and not mandatory visits of nodes, multiple timewindows are treated as additional constraints. The mathematical model is used inside a large neighborhood based metaheuristics where it is effectively used to explore the generated neighborhood. Destroy operators are defined on the basis of computational analysis and peculiarities of the problems. In particular, removing of nodes, and selection of number of visits allowed to ports are exploited as operators. Computational experiments show the effectiveness of the approach.

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On the Collaboration Uncapacitated Arc Routing Problem

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Keywords: Arc routing, Collaboration, Exact method

Nowadays, collaborative transportation is regarded as one of the major trends in transportation research. Whereas a carrier would benefit from having its customers concentrated in the same area, for a number of reasons they may end up being geographically dispersed. It is often the case that customers that are inconveniently located for a carrier are conveniently located for a different carrier. Thus, a collaborating set of carriers can redistribute the customers, opening up, through collaboration, cost saving opportunities otherwise non achievable. Logistic collaboration can be pushed further considering that it allows carriers to increase the average load of the vehicles.

Increasing attention to the environmental impact of emissions in cities represents an additional strong motivation to study collaboration among carriers. Recently, collaboration has been enhanced by advances in information and communication technology that have enabled information sharing among carriers.

We consider a set of carriers cooperating under the guidance of a central station that acts in a non-partisan way. Each carrier has a depot and a set of customers. Each customer is represented with an arc and its service generates a revenue. Each carrier identifies a subset of customers that it wants or needs to serve. These customers may be the most easily served, the most profitable or the most strategic ones. The remaining customers are defined as shared customers, that is customers that may be served by other carriers. A shared customer may end up being served by the carrier that decided to share it, when combined with customers shared by other carriers. Part of the revenue of a shared customer goes to the carrier that decided to share the customer and part goes to the carrier that actually serves it. We assume that each carrier has one vehicle and that the vehicles are uncapacitated. We call the proposed problem Collaboration Uncapacitated Arc Routing Problem (CUARP). We study two variants. In the first one the goal is the maximization of the total profit. The second variant includes a lower bound on the individual profit of each carrier. We formulate mixed integer programming models. We also look at the CUARP

from a game theory perspective. We solve the formulations with a branch-and-cut algorithm and quantify the impact of collaboration. We solved all but 14 instances, out of the 953 we generated, within few seconds. On each instance we compare the optimal solution obtained in the case where no collaboration is allowed with the case where collaboration is allowed, and show that the profit of the coalition increases up to twice or even three times the profit achieved without collaboration.

Decision-making problems in eco-innovation transport and logistics applications

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The present work focuses on the so called "eco-innovation" topic applied to transport and logistics. In particular, the impact of new and innovative eco-innovative practices is presented in relation to some real applications implemented by the Codognotto Group company.

Eco-innovation practices in transport and logistics are all measures of relevant actors (logistic service providers, logistic service clients, freight forwarders, authorities, associations, ...) which develop new ideas, behaviour, products and processes, and then apply or introduce them to contribute to a reduction of environmental burdens or to ecologically specified sustainability targets.

Codognotto Group is one of the most dynamic realities in the European transport industry, attracting attention not only for its important growth but also for a continuous will to innovate a constantly develop. In Codognotto Group innovation means being open to prospective and possibilities requested by clients, offered by the market or testable through partnerships and collaborations. Its interest in innovation and experimentation can be seen even in the management of the vehicles of its fleet and by recent investments in equipment to monitor tyres state, to guarantee constant traceability of vehicles, to monitor the performances of the drivers in terms of fuel consumption, and the first LNG vehicles are already operating and the company intention is to increase these efforts and reach a progressive conversion of the fleet to alternative fuels.

The main aim of the presented work is to investigate the impact of these eco-innovative practices in the decision-making process of a large and innovative transportation company. The scope of the decision to invest and apply new technologies and practices concerning the reduction of environmental impact has a twofold meaning for a transportation company: on one side it has to produce positive effects in market and revenues terms but on the other side the overall transport and logistics efficiency has to be carefully considered and evaluated. For this second aspect, optimization and simulation techniques have to be adopted and tested. Since the problem to be analysed is very complex, with several aspects to be considered and optimized at the same time, for large transportation company is very interesting to evaluate the effects of such optimizations. The evaluation should be performed in qualitative way, in terms of

added valued perceived for the final users and logistics clients, as well as in quantitative way, in terms of enhanced values measured by selected key performance indicators.

Therefore, this work presents some of the main challenges in the transport sector occurring when implementing new technologies and practices devoted to the enhancement of the sustainability of the logistics chain. Indeed, these challenges represent worthy opportunities for the academic sector to help improving companies' efficiency and decision-making processes.

Decision Support Systems for Logistics Management

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Keywords: Decision Support Systems, Discrete Event Simulation, Optimization, Metaheuristic algorithms, Logistics

Nowadays business are changing faster so logistic operators need the capability and flexibility to incorporate, as fast as possible, technological advances in order to face a constantly growing competition by lowering cost and increasing productivity. To face this challenge, Decision Makers (DMs), such as coordinators and managers, should be able to take decisions quickly and as effectively as possible. Although personal qualifications remain valuable, the increasing complexity of modern business environment imposes the use of advanced Information and Communications Technologies (ICT). The possibility to bringing together the personal experience and the huge amount of available data is offered by Decision Support Systems (DSSs).

Several papers are available in the literature which specify what a DSS is and how it can be used. A DSS can be defined as an interactive computer based system, which helps decision makers to utilize data and models to solve unstructured models. In a general way, [1] considers a DSS as an umbrella term to describe any computerized system that supports decision making in an organization.

DSSs are widely used in a lot of different environments such as, for instance, healthcare applications, where they are used for medical diagnosis, or for health calculators on topics such as stress, nutrition, and fitness.

More specifically, another important application field for DSS is the logistics system involving ports, dry ports and inland terminals that are widely studied

during the recent years. In a DSS is presented, which enables strategic, tactical, and operational decision making in supply chains. Moreover, Roso et al. [2] point out that the dry ports are not only terminals linked to another one but also terminals where some typical services of the seaports are moved, in order to provide more available space and to require less service time at the port area. In the related literature there are several papers analyzing intermodal terminals [3,4] and in particular container terminals.

This research deals with designing and developing a Decision Support System (DSS) that will be able to manage the flow of goods and the business transactions for logistic systems. In particular we present a simulation based decision support system for multimodal logistic management.

Generally the high level architecture of the DSS includes the three main components: the data component, the model component and the interface component [1].

The data component collects two kinds of data: the historical data and the real time data. The historical data are collected from external databases: the transporters, the highway managers, the shipping agents, the inland terminal managers and the port authorities. The real time data come from devices and sensors that monitor the environmental, the vehicles and the traffic. Moreover, information can come from smart phones and tablets of drivers.

The model component mainly includes the model of the system behavior and it may be described by mathematical models or description languages such as UML [5]. This component describes the operations in various levels and the type of functions used according to the operation that they have to support.

The decision component is in charge to suggest and support the DM during the decision process. It can merge information coming from the data component and the model component in order to propose solutions to the DM through the interface model.

The interface component is responsible for the communication and interaction of the system with the decision makers and the real system. Moreover, the interface component provides the service outputs of the DSS and regardless of the quality and quantity of the available data, the interface of the system must ensure that the decision maker will be able to take advance of the system capabilities.

This research presents the architecture and the main objectives of a model based DSS that offers different services integrating logistics management and decision support for multimodal transportation systems [6]. In particular, the presented DSS includes five different services to improve the logistics efficiency through cooperative information sources and to reduce fuel consumption and CO2 emission for sustainable mobility of goods. In particular we describe in detail the DSS Cargo Transport Optimization service (CTO) proposed for the case study of the Trieste port logistics network (Italy) within the EU 7th FP project CO-GISTICS. Moreover [7], the advantages of the proposed DSS application are assessed by a simulation study that allows us to achieve two objectives: i) determining the values of the thresholds necessary to implement the CTO; ii)

evaluating the benefits of the service application by comparing the performance measures in a set of scenarios.

Future research will specify in details the other DSS services also including in the decision making the real time information about the weather conditions and the emergency issues.

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Evaluation framework in cooperative intelligent transportation systems (C-ITS) for freight transport: the case of the Trieste intermodal transportation network

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Keywords: Freight transportation, C-ITS, EU projects, performance evaluation, intermodal transportation networks

In modern economies, the transportation sector represents a key process for people and goods movements imposing economic, social and environmental issues on European society. In this context, freight transportation plays an increasing role with road transportation covering three quarters of the 2,200 billion tonne-kilometres (tkm) in 2013. Cooperative Intelligent Transport Systems (C-ITS) are promising enablers of more sustainable freight transportation systems, attracting even more European Commission founding targeting research and innovation aspects. In recent years, several projects concerning C-ITS applications in freight transportation started, posing the challenge of a harmonised and valuable evaluation of the systems performances. The current work overviews the impact assessment methodologies and presents the ongoing 7^{th} Framework Program project "COoperative loGISTICS for sustainable mobility of goods (CO-GISTICS)" evaluation framework. Moreover, a case study reports the Key Performance Indicators (KPIs) used to evaluate the performances of C-ITS adoption in the Trieste intermodal transportation network

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A Solution for the Multi-Day Container Drayage Problem

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We present a general Multi-Day Container Drayage Problem (MDCDP) that consists in assigning trucks to container transportation orders during several days. The aim is helping the container trucking company operators in their daily operations of assigning container transportation orders to the available fleet of trucks [1], [2].

To this aim, a Mixed Integer Linear Programming problem is formulated: the model describes real problems taking into account the orders to be planned for several days, the types of the containers, the rest periods of drivers and the different types of locations where the containers are picked up or delivered.

The resulting MILP model is very complex and only instances of small dimensions can be solved in reasonable time. Therefore, given the need of addressing real scenarios, a heuristic algorithm based on the rolling horizon approach, and the weighted sum method for the multi-objective optimization is proposed.

Some randomly generated MDCDP instances and a case study of real dimensions show the effectiveness of the proposed solution technique.

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A Periodic Inventory Routing Problem for lean production systems

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Keywords: inventory routing, periodic, clearing policy

We present a mixed-integer linear programming model to determine a periodic routing plan that supports the lean principles of level production planning and standardized work. We consider a lean production system consisting of a single manufacturing plant and a set of geographically-dispersed suppliers that supply a distinct product (component) to the plant. To facilitate level production planning, we require that the pickup amounts at each supplier are multiples of the daily demand and in exact proportion to the number of days since the last pickup. This results in an Inventory Clearing policy in which the inventory level of each supplier in every period is equal to zero after the pick-up. We seek to determine an inbound routing plan that collects component inventory from suppliers and delivers it to the plant at the minimum transportation and inventory holding cost. We present reformulations of the periodic IRP, under the Inventory Clearing policy, derived from the periodic single item Lot Sizing problem with Proportional Shipments. We define a generic family of valid inequalities for which the separation problem of generating violated inequalities can be solved effectively. A Branch-and-Cut algorithm is implemented to demonstrate the strength of the proposed reformulations.

Solving the Multi-depot Inventory Routing Problem in a mega-city context

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In this work a matheuristic algorithm for the solution of an Inventory Routing Problem (IRP) in a Mega-city context is presented. In general, the IRP is a NP-hard problem that aims to optimize inventory and transportation costs in an integrated system. With respect to the state of the art, a different context of analysis is presented, that is characterized by an high level of urban environment complexity. In order to face this situation,the main idea is splitting the urban space into districts allowing to create clusters and to generate sets of feasible routes for the IRP.

In the scientific literature similar approaches were presented by Micheal and Vanderbeck [1] who faced the problem in a tactical way by building clusters of customers on the basis of geographical distance and vehicle capacity, and by Campbell and Savelsbergh [2] who presented a two-phase approach based on decomposing the set of decisions. They generated a delivery schedule first, followed next by the construction of a set of delivery routes.

We propose a two-phase matheuristic algorithm. More precisely, in the first phase an integer programming problem for the clustering process is solved. An indicator is associated to each customer to express its critical level. It should take into account either the demand and the inventory level or the medium cost for delivering. The model associates each customer to a single depot, creating several clusters. In the second phase, the feasible route construction for each cluster is performed. Intra-clusters routes and inter-clusters routes are generated balancing simultaneously several factors: distance customer-depot, demand and inventory levels, time horizon and vehicle capacity. A MILP is solved to find a feasible solution for the problem. Preliminary computational results are presented.

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CORE: a web platform for Infomobility Systems and sustainable Transport Services . An experience supported by Regione Calabria

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One of the most critical needs of Transport Operators are the ones related to the service monitoring and to the improvement of quality of service perceived by the end users. The growing interest in location aware devices allows the development of applications that enable the transport operator to track and monitor its services as well as providing more and more accurate information to their customers. In this paper we present CORE, a web platform for infomobility and sustainable transport system realized by the University of Calabria and the Transport Department of the Regione Calabria (ITALY). CORE supports the processes of the Transport Department and eases the collaboration with the transport operators that are in charge, on behalf of the Department, to deliver the transport service. Moreover it allows to monitor and to certify all the journeys that are run by each operator and provides infomobility functionalities to the end users, such as a trip planner and departure screens. All the transport related data can be manipulated inside the web platform itself by those users who have the privileges to do that, so that all the data remain consistent and the processes related to the service planning and designing are completely dematerialized.

The system is currently deployed in the cloud and it has been recognized by the Regione Calabria as a critical improvement in the overall Transport System: it now comprises all the stop points located in the whole region and the intercity service, for a total amount of 624 lines.

Heuristic Approaches for the Resource Constrained Elementary Shortest Path Problem

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Keywords: Shortest paths, Heuristics, Local search methods

The resource constrained elementary shortest path problem $\mathcal{RCESPP}$ aims to find a minimum-cost path that does not contain cycles from a source to all other nodes in a graph. The shortest path has to satisfy a given set of constraints, defined over a set of resources. The development of solution approaches for the $\mathcal{RCESPP}$ has contributed to the success of column-generation methods for addressing the vehicle routing problem ($\mathcal{VRP}$). Indeed, the $\mathcal{RCESPP}$ occurs as a sub problem in several column generation based algorithms. When the $\mathcal{VRP}$ is formulated in the column-generation, the corresponding *master problem* is formulated as a *set-partitioning* model and the corresponding *pricing problem* can be mathematically represented as a $\mathcal{RCESPP}$. Even though the $\mathcal{RCESPP}$ has been shown to be NP-hard in the strong sense (see [1]), several authors focused their attention on the development of exact solution methods rather than heuristic approaches (see, [2], [3], [4] [5], [6]). Indeed, the former are more effective in many practical applications, but heuristics are very efficient and turn out to be very important, when a good quality solution has to be found quickly. In this work, we focus on heuristic approaches for solving the problem under study and several strategies are developed. In particular, the proposed methods are based on rollout metaheuristic, tabu search and local search strategies. The aims is to find good quality solutions of the problem in a short computation time. Experimental tests are performed on two sets of instances, taken from the scientific literature. In the first set the instances are generated from well known Solomon's benchmark instances used in [7], while the networks in the second set are "*pricing problems*" generated by solving $\mathcal{VRP}$ with Capacity Constraints ($\mathcal{CVRP}$) via column generation algorithms, used in [8]. A study of the behaviour of the implemented solution strategies and a comparison of them is also carried out. The computational results demonstrate

that the developed solution approaches allow to determine good quality solutions in a limited amount of time.

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A stochastic approach for a Production and Inventory Routing Problem under uncertainty for agri-food products

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Keywords: inventory routing, stochastic programming, agri-food supply chain

The aim of this work is to study and explore integrated methods to manage the production, the inventory and the distribution of product with quick perishability. A very important field of application could be the agri-food supply chain (ASC), which includes all the activities from production to distribution that bring food products from the farm to the table. The need for high quality of the products, together with their perishability, are critical issues for take into account. Moreover, the uncertainty due to final customers' demand makes the planning problem very challenging. In order to manage in an effective way all these issues an integrated rolling horizon decision approach, based on a multi-stage stochastic model, has been proposed.

Fair workload assignment to subcontractor companies at a container terminal

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Keywords: maritime logistics, manpower scheduling, integer linear model

Manpower planning and scheduling in a port ambit are very peculiar problems. As explained in [1],[2], due to their specific features, the classical OR models devised for similar problems in different contexts cannot have straightforward application. The scientific literature on this issues is not rich, even though recently some new contributions have been proposed [2],[3]. In this talk we focus on a human resources management problem arising at the transhipment container terminal housed in the Gioia Tauro port. Here a considerable part of the manpower is outsourced, to cope with peak demand, mainly as far as raisers are concerned. Smooth management of the external human resources requires fair assignment of the workload both for individuals and for companies. In fact daily shifts are not equally desirable (night or holiday time shifts are considered particularly heavy). Our model accounts for a well balanced assignment on a given time horizon. It is based on an appropriate composition of individual and group rationality. In addition the model embeds the possibility of taking into account historical data to improve assignment fairness. The resulting problem is an ILP with min-max objective function.

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Set-Covering formulations for routing of heterogeneous trucks with container loads

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This paper addresses a real-world routing problem, where loaded containers must be shipped from a port to importers and from exporters to the port by heterogeneous trucks carrying one or two containers, without separating trucks and containers during customer service.

We describe a basic version of the problem and propose a set covering formulation based on the enumeration of feasible trips, which we perform efficiently due to an appropriate preprocessing. This allows to solve the problem in an exact way with off-the-shelf solvers for realistic and real-world instances, significantly outperforming a previously proposed node-arc formulation.

We then develop new versions of the problem, enlarging the feasible set of routes in order to propose new management policies to the carrier. The Set Covering formulation is extended to this new version, allowing to evaluate the new policies and estimate the potential savings attainable by introducing them in actual operations.

The shipper planning problem in maritime urban areas

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Keywords: Urban freight transportation, City logistics

This study investigates a challenging planning problem faced by shippers in maritime urban areas. In this problem the loads of several customers are grouped into containers and trucks, which are discharged from vessels and moved to satellite facilities strategically located in the city or around. The transhipment of loads is performed at satellites and loads are moved by "environment-friendly" vehicles from satellites to customers.

In this context, shippers are dealing with the assignment of containers and trucks to satellites, and, in turn, of their load units to the vehicles used for the final distribution. We present a mathematical model to minimize assignment costs, while accounting for distribution costs and the fair sharing of workload among all carriers involved in the distribution scheme.

Preliminary computational tests are presented together with possible solution methods.

Minimization of the truck service time in a container terminal via discrete event simulation

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Keywords: terminal productivity, container terminal, discrete event simulation

The increasing volume of goods passing through logistics nodes and ports call for a very efficient use of maritime terminal infrastructures and equipment. Todays, an ambitious expansion project will transform one of the larger container terminals of the port of Genoa, Italy, into a leading port in the north Tyrrhenian sea, making it very attractive for the most prestigious shipping lines.

Simulation tools are well recognized to be among the most suitable methods for analyzing the productivity performance of maritime terminals in the presence of variations of volumes of goods (see e.g. [1, 2]).

In this study we focus on the containerized flow reaching / leaving the terminal from / to hinterland logistic nodes via road; in particular, we address the minimisation of the truck service times.

A discrete event simulation model is developed and implemented using the software simulation environment Witness. The analysis is performed considering different scenarios, referring to various levels of terminal congestions, yard filling and trucks arrivals. The indices under analysis are evaluated and compared with respect to the classical queueing theory parameters and resources allocation policies [3]. The aim is not to affect the productivity of all the activities inside the terminal, mainly concerning trains, ships and internal handlings while analyzing the performance of the overall terminal system.

A preliminary experimentation allows establishing that a careful management of the truck flows at the port gates and inside the terminal areas guarantee short and certain service times to the road transport shipping.

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Graph-clustering to support resilience management in Critical Infrastructures

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Keywords: Graph Clustering, Spectral Clustering, Support Vector Machine, Deep Learning

Graph clustering is widely adopted to analyse the resilience of networked systems (e.g. water distribution, energy grids and transportation) [1-3]. Usually the physical network is mapped into a graph whose properties (e.g. node degree distribution and edge/node betweeness centrality) are analysed while graph clustering is performed to identify the elements whose disruption a)ects the connectivity of the system.

However, there is more to resilience than connectivity: the focus of this paper is to support the capacity of the system to recover from the shock and resume its former service in shorter time. A key part is detection and localization of the disruption: in some networks, such as urban transportation systems, disruptions can be easily localised (e.g. an interruption between two connected underground stations) while in other, such as energy grids, water and oil/gas distribution systems, they are usually hidden and analysis of structural and sensors data is required in order to localize them.

Software simulation allows for the generation of very large training sets of possible disruptions, with the chance to estimate deviations in sensor readings at nodes and links (i.e. "signatures" of the disruption scenarios). A new graph is then built, where every node is a simulated disruption and every link is weighted according to the similarity between the two linked nodes. Performing graph clustering on this new graph allows for grouping disruptions according to their similarity in terms of readings deviation. Spectral Clustering (SC), in particular, permits to infer a relation, which is non-linear in the space of the "disruption scenarios' signatures" and linear in the space spanned by the eigen-vectors of the Normalised Laplacian matrix of the graph. Then, the non- linear relation is inverted by learning a Support Vector Machine classifier which is finally used to infer a limited set of (simulated) disruptions according the deviation of actual sensors readings. This approach has been extensively tested in the case of water

distribution [4,5] and is now going to be tested in time critical task like energy and gas supply.

Finally, since SC is computational intensive, due to the eigen-vector decomposition of the Normalised Laplacian matrix (complexity $O(n^3)$, with n the number of nodes in the generated graph), the adoption of Deep Learning (DL) has been also considered to overcome this limitation. The expected benefit is supported by the results reported in [6], where clustering through the DL-based approach is proved to be equivalent to SC, but less computational intensive.

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Lagrangian Approaches to Large Steiner Tree problems on the Unitary Hypercube

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Keywords: Steiner Tree problems, Lagrangian Relaxation, Bundle Methods

We approach a phylogenies reconstruction problem modeled as a Steiner Tree problem on Unitary Hypercube. Besides being NP-hard to start with, the problem is particularly difficult because the size of the underlying graph is exponential in the input data. Starting from an existing polynomial-size (but rather large) formulation we develop an approach based on Lagrangian relaxation of the constraints linking the Steiner arborescence requirements (on a much reduced, polynomial-size graph that can be identified via an appropriate preprocessing) with the condition that that each arc of the Steiner arborescence links vertices at Hamming distances 1. We use a state-of-the-art exact solver to approach the (still hard) Steiner arborescence subproblem, exploiting the ability of recent Bundle methods to work even with approximate solutions to reduce the computational burden. We also exploit the "easy components" idea [1] to further improve the convergence speed of the approach. Preliminary computational results show that strong bounds can be efficiently obtained, and that the approach can be endowed with appropriate heuristics that produce good-quality feasible solutions of the problem.

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Virtual network embedding with substrate network expansion

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Keywords: graph mapping, network optimization, telecommunications

Network virtualization is one of the most promising future Internet technologies and it has been attracting considerable attention in recent years. The general problem of Virtual Network Embedding (VNE) consists in, given a substrate (physical) network with node and arc capacities and a set of virtual networks with node capacity demands and node-to-node traffic demands, deciding how to embed (a subset of) the virtual networks onto the substrate network (mapping virtual nodes onto substrate nodes and virtual arcs onto substrate paths) so as to optimize some objective function, while respecting the substrate node and arc capacities. We investigate a new variant of the VNE problem in which we consider the possibility of expanding the capacities of the substrate network and determine a fair price for embedding the Virtual Networks (VNs). The focus is on problem versions arising in telecommunications with star-shaped VNs. The point of views of the infrastructure provider and the service providers are considered. After discussing complexity issues and structural properties, we present MILP formulations, heuristics and some computational results.

A Genetic Algorithm for Minimum Spanning Tree Problem with Conflicting Edges

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Keywords: memetic algorithm, minimum spanning tree, conflict constraints

In this paper we study the Minimum Spanning Tree Problem with Conflicting Edge Pairs. The problem consists of finding a spanning tree of the graph with the minimum number of edges in conflict. The problem was proven to be NP-Hard and has application in the optimal design of the offshore wind farm network. We developed a genetic algorithm to solve the problem and some local search procedures used to improve the solutions of the genetic algorithm. We tested our algorithm on the benchmarks instances available in literature. The computational results show that it overcomes the other algorithms both in term of effectiveness and performance.

Optimal Mechanisms for Market Intermediation in Discrete Types Spaces by Linear Programming

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Keywords: Market Intermediation, Mechanism Design, Linear Programming Duality, Ambiguity

We consider the bilateral trading model of Myerson-Satterthwaite (1983) where an intermediary (broker) aims to maximize his/her expected spread for the sale of a good under Bayes-Nash Incentive Compatibility and Individual Rationality constraints for both the seller and the buyer who have discrete valuations for the object to be traded. Initially, we assume that the probability mass functions of the buyer and the seller valuations are known, respectively, and we derive the optimal mechanism using linear programming (more precisely, shortest path and network programming) duality theory inspired by the results of R. Vohra (2012). Then we study the *ambiguous* case where the buyer's valuation probabilities are not known with certainty, and we explore the form of the optimal mechanism for different specifications of the set of probabilities.

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Computing Pareto solutions that maximize the hypervolume in multiobjective problems: an application to portfolio optimization

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Keywords: Multiobjective optimization, Portfolio optimization, Nonlinear programming

In the context of multiobjective optimization, we consider the problem of finding a specific Pareto optimum that enjoys some nice properties. Let us consider the following problem with two objectives:

$$\begin{array}{ll} \underset{x}{\text{minimize}} & (f_1(x),\, f_2(x)) \\ \text{s.t.} & x \in X. \end{array}$$

Each feasible $\bar{x}$ identifies a rectangle defined by the points $(f_1^{\max}, f_2^{\max})$ and $(f_1(\bar{x}), f_2(\bar{x}))$, where $f_1^{\max}$ and $f_2^{\max}$ are the worst values of the objectives on the feasible set X. In the spirit of this observation, we aim at computing point x^*, belonging to X, that maximizes the area of the corresponding rectangle. Such a point turns out to be a Pareto optimum that is independent on the objective functions' scale. For these reasons, the nature of x^* makes it, among all the Pareto optima, particularly worth to be computed.

We prove that the problem of finding such x^* enjoys, under suitable assumptions, some convexity properties. In turn, this fact allows us to resort to standard optimization techniques in order to tackle this problem. We show the effectiveness of our ideas by addressing portfolio selection problems.

The results obtained in this work can be extended to general $n-$objective optimization problems.

A Convergent and Fully Distributable SVMs Training Algorithm

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Keywords: Support Vector Machines, Distributed Learning, Supervised Learning

The Support Vector Machines (SVMs) dual formulation has a non-separable structure that makes the design of a convergent distributed algorithm a very difficult task. Recently some separable and distributable reformulations of the SVM training problem have been obtained by fixing one primal variable. While this strategy seems effective for some applications, in certain cases it could be weak since it drastically reduces the overall final performance. In this work we present the first fully distributable algorithm for SVMs training that globally converges to a solution of the original (non-separable) SVMs dual formulation. Besides a detailed convergence analysis, we provide a simple demonstrative example showing the advantages of the original SVMs dual formulation with respect to the weak separable one and highlights the practical effectiveness of our method. We report further tests to show practical convergence of the proposed method on real-world datasets.

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A novel optimal-control-based model of online learning from data

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Keywords: Online Learning, Optimal Control, Regularization

An optimal-control-based model of online learning from supervised examples is proposed and its solution in closed-form in presented. In this approach, the training data are exploited to learn an unknown vector parameter in the relationship between inputs and outputs. The associated optimization task is a Linear Quadratic Gaussian (LQG) optimal control problem with random matrices. Its solution is compared with the Kalman-filter estimate of the parameter vector to be learned and its advantages over the latter, in terms of smoothness and robustness to outliers, are pointed out. The basic formulation of the proposed online-learning framework refers to a discrete-time setting with a finite learning horizon and a linear model. Extensions are discussed, including the infinite learning horizon and, via the so-called "kernel trick", the case of nonlinear models.

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Port operations under resource blocking, locking and other queuing phenomena

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Keywords: port operations, queuing model, simulation

The container industry is embracing new alliance strategies and pursuing vessel upsizing in the attempt to return to sustainable profits by cutting down on operating costs. As a result, container terminals are expected to comply with the corresponding need of productivity surge by adopting more flexible and effective infrastructures, equipment, policies and practices. If further investments are ruled out, then boosting terminal throughput may be achieved through a better synchronization among operations occurring across all neighboring terminal areas. The objective of introducing synchronization is two-fold. On the quay, it minimizes the blocking and starvation phenomena arising at the feet of the quay cranes when, under limited storage capacity, untimely container handling occurs between shuttle vehicles and cranes. On the yard, it minimizes the blocking and locking phenomena triggered by shuttle vehicles that share, in mutual exclusion, road intersections along the transfer paths and stacking/retrieval locations within the yard rows. To this purpose, we designed and developed an integrated simulation model that reproduces the dynamics of container handling operations among the quay, transfer and yard areas in a transshipment hub. It allows to assess resource activity synchronization and, thus, minimize resource blocking, starvation and locking. The model embodies a multi-step decision process that mirrors the en-route behavior followed by manually-operated shuttle vehicles as a response to the information they receive during their trip. An event-based view, under stochastic conditions, is adopted to mimic the point-to-point transfer process for each vehicle along the internal reticular paths within the Manhattan-like layout of the storage blocks in the yard. Statistical figures are returned for estimating container transfer times and resource productivity as the congestion increases along both horizontal and vertical corridors of the yard, as well as at intersection points. Numerical simulation experiments based on real-life data are presented.

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Solving the train marshalling problem by inclusion-exclusion

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Keywords: Fixed Parameter Tractability, Inclusion-Exclusion Principle, Dynamic Programming.

In the Train Marshalling Problem (TMP) the cars of a train having different destinations have to be reordered in such a way that all the cars with the same destination appear consecutively. To this aim the cars are first shunted on k auxiliary rails, then the sequences of cars present on the different rails are reconnected one after each other to form a new train. The TMP is the problem of minimizing the number k of auxiliary rails needed to obtain a train with the required property. The TMP is an NP-hard problem. Here we present an exact algorithm that solves a graph theoretical model of the problem. The algorithm is a dynamic programming procedure based on the principle of inclusion-exclusion and has polynomial space complexity and time complexity that is polynomial in the number of cars, exponential in the number of destinations. We also show that the TMP is 2-approximable.

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Towards Sustainable Urban Logistics: The Evolution of Digital Marketplace

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Keywords: urban city logistics, digital market place, last mile logistic

Many existing industrial solutions for transportation services are based on optimization strategies for load balancing and vehicle routing and rely on exiting trust relationships between shippers and carriers, in which the price does not take a leading role. However, over the last two decades, a number of solutions have been proposed for logistics marketplaces where supply and demand, modelled as dynamic graph assignment, dictate the price and an auction mechanism ensures market clearing. This new model has the potential to bring about transparent prices and market liberalization in which an online service is acting as a digital broker. Recently there is a growing awareness that these new technology solutions and new business models are needed to support sustainable logistics in urban environments. The newest solutions are built around the basic concept of transportation being a relationship-based business. Indeed, trusted relationships are crucial as they also affect customer service and satisfaction which translates to shipper's brand and reputation. This is the reason why the newest solutions do not exclude the "preferred carriers" concept in order to solve the inefficiency and division of the local trucking industry in urban last-mile logistics. These are the base principles of some of the emerging innovative start-up companies [1].

The overall objectives are aimed at finding a balanced added value proposition for both shippers and carriers that assures maximizing capital efficiency and customer satisfaction while minimizing logistical complexity hence maximizing scalability.

In this paper after an overwiew of the overall of the urban city logistics issues related to the evolution of digital marketplaces will be reviewed the evolution over time of the ideas of digital marketplaces in the transportation industry focusing on their application in the last-mile urban logistics. The goal is to demonstrate the feasibility of applying an auctioning system in day-to-day city logistic activities and to model and improve current business practices in last-mile city logistics with automated strategies. The overall ideas of this approach are not directly to optimize the planning but on automating the market interactions in a multi-actor logistics negotiation that assigns loads to last-mile opera-

tors taking into account their characteristics and not only relying on the price of the shipment. In order to demonstrate and validate the proposed approach, has been developed a client-server platform to simulate a marketplace auction model for urban city logistics which incentivizes carriers to be more competitive not by directly reducing price but by using more sustainable vehicles and better customer satisfaction in the scope of city logistics. The platform has been developed inside the project OPTILOG (OPTImal and sustainable LOGistics in urban areas), financed by Lombardia Region (Italy).

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An exact approach for the routing of trucks with single container load: the algebraic properties of the optimization model

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Keywords: Vehicle Routing, Logistics, Exact Optimization

In this paper we address a real world routing problem, where container loads must be shipped from a port to importers and from exporters to the port by heterogeneous trucks carrying containers, without separating trucks and containers during customer service. We present the optimization model describing the problem in case of multiple container loads. Particularly, we show that, when the capacity of the trucks is one, the model can be simplified and the number of variables can be reduced and associated with one-to-one correspondence to possible routes.

Moreover, we illustrate a conjecture supported by a wide experimentation that an appropriate submatrix referred to the set of feasible solutions of the problem should be totally unimodular and, in the case, the integer constraints could be relaxed.

If proved, the problem could be solved efficiently reaching the exact solution with a reduced computational effort.

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Optimizing time related performance measures in logistic problems under uncertainty

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Keywords: Uncertain travel time, stochastic routing, heuristic approach

In most real-life applications of the logistic problems, the main goal is to serve a set of geographically spread destination nodes by a limited number of servers (vehicles) in a timely fashion. As a time related factor, arrival time is known as determining issue, which highly affects the performance of the logistic system. The routing problems arising in emergency response or delivering perishable products are among the applications in which arrival time plays a key role.

It is easy to recognize that in real situations, travel time (and, thus, arrival time) is uncertain because of many factors, such as roadway capacity, weather condition, and traffic fluctuations. Although the incorporation of uncertainty brings more difficulty into the problem, it provides the decision maker with a more realistic view about the logistic system.

In this talk, we study a routing problem in the logistic field in which travel times are uncertain and the objective function is expressed as a time related criterion. We assume that the uncertain travel times are represented as random variables and we define a stochastic programming formulation of the considered problem.

The introduction of the uncertainty leads to an increase of the computational complexity of the corresponding mathematical problem making the design of a tailored solution approach mandatory. In the talk we present a heuristic solution method that takes advantage of the specific problem structure. Preliminary numerical results are presented and discussed.

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A Solid Waste Management Problem with Stochastic Parameters at a Tactical Planning Level

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Keywords: Waste management, Waste flow allocation, Stochastic Programming

We describe a problem of waste flow allocation [1] in which the uncertainty in the waste generation amounts is explicitly considered in a Two-Stage Multi-period Stochastic Programming formulation [2]. The study is motivated by the availability of historical data of some waste commodity generated in the cities under the responsibility of a large company in the waste treatment in Italy. The main features of the waste management network of the Emilia-Romagna region of Italy was also known from a consulting company. We propose stochastic models for monthly waste flow allocation in a yearly planning horizon. Computational results are referred to a set of scenarios obtained by historical data. Standard stochastic measures such as Expected Valued of Perfect Information and Value of Stochastic Solution are reported [3].

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A two–stage stochastic programming model for a cost–based inventory problem

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Keywords: Stochastic Programming, Inventory Management, Newsvendor Problem

We investigate inventory models for a retailer which faces a single–item single–period stochastic demand. The retailer aims at minimizing the expected total cost, given by the sum of the unit procurement cost, the unit holding cost for the leftover quantity (surplus) and the unit stock-out cost for the shortfall quantity (shortage). Instead of the classical Newsvendor problem [2][3], the retailer does not receive any income for the satisfied demand. We apply this model to solve the problem of dimensioning the number of cars to make available in a car–sharing problem. We formulate a two–stage stochastic programming model with simple recourse [1]. We compare the behaviour of the optimal first–stage solutions obtained by assuming different probability distributions for the stochastic demand. We introduce the new concept of Value of the Right Distribution (VRD) and we propose a methodology for measuring it. We perform a sensitivity analysis of the optimal first–stage solution, of the expected total cost and of the Value of the Stochastic Solution (VSS) on both the unit stock–out cost and the variance of the distributions.

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Worst-case Analysis of Rolling Horizon Approaches for a Stochastic Multistage Fixed Charge Transportation Problem

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Keywords: multistage stochastic programming, rolling horizon, transportation

We consider a Stochastic Multistage Fixed Charge Transportation Problem in which a producer has to ship an uncertain load to a customer over a fixed time horizon minimizing the expected total cost [1]-[2]. The shipment can be performed at discrete times by using transportation procurement services. Different companies offer an uncertain transportation price with realization available at the end of the time period. A penalty is paid for the quantity that remains to be sent.

We prove that this problem is NP-hard, we propose a multistage stochastic integer optimization model formulation [3], and we determine optimal policies for simplified cases under the assumption of deterministic demand and/or the absence of capacity constraints. For this problem we provide theoretical worst-case results of rolling horizon approaches of multistage stochastic programming models with finite time horizon [4]-[5]. A sensitivity analysis of total costs and optimal policies versus increasing values of penalty is also performed. Numerical results are finally provided.

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Waste Flow Optimization with an Application in the Italian Context

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Keywords: waste flow, decision support system, network flow optimisation

Waste management is a priority for urban and rural communities throughout the world. The amount of waste generated each year in industrialized and developing countries, along with the public concern for environmental preservation, is making such a problem one of the most relevant issues in modern societies. An important source of complexity in waste management is given by the typical need to treat waste flows in various kinds of processing facilities before reaching a disposal plant or an external market (e.g. for recyclables). Operations research helps the waste manager to decide how to ship the waste inside the network to minimize logistic costs and maximize possible revenue coming from energy produced or recyclables sold. We propose mixed integer linear formulations, and relative resolution methods, for problems arising in the context of waste logistic management, with an application on a real world case study. In response to the actual needs of an important Italian waste operator, we introduce modeling of some relevant features of these problems, such as digester facilities, transportation economies of scale and temporary storages of the waste. The model has been incorporated into a Decision Support System that helped the waste operator in obtaining remarkable cost savings in the network management.

Optimizing wind farm cable routing considering power losses

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Keywords: Wind energy, mixed-integer linear programming, matheuristics, computational analysis

Wind farms are one of the fastest growing sources for renewable energy, and represent a very interesting innovative application of operation research techniques. In this work we focused on inter-array cable routing, i.e. the optimal connection of offshore turbines to collect their production. The routing should connect all turbines to one (or more) offshore substation(s) while respecting cable capacities, no-cross restrictions, connection-limits at the substation, and obstacles at the site. The objective is to minimize both the capital that must be spent immediately in cable and installation costs, and the future reduced revenues due to power losses along the cables. The latter goal has not been addressed in previous work. We present a Mixed-Integer Linear Programming approach to optimize the Routing using both exact and math-heuristic methods, and compare their performances. In the power losses computation, wind scenarios are handled efficiently as part of the preprocessing, resulting in a MIP model of only slightly larger size. Computational results on real-life instances show the viability of our methods, proving that large savings can be achieved.

A Natural Ventilation Control in Buildings Based on Co-Simulation Architecture and Particle Swarm Optimization

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Keywords: Building Automation, Ventilative Cooling, Particle Swarm Optimization.

This work presents a building automation strategy for natural ventilation control and reducing building energy consumption. An on-off control is proposed in order to manage the windows opening and realize a natural ventilation flow guaranteeing indoor thermal comfort. The control logic is based on activation thresholds that are optimized to reduce the discomfort for overheating and undercooling. In particular, the temperature comfort range dynamically varies according to the adaptive thermal comfort theory. To this aim, a co-simulation architecture is proposed: the thermal building behavior and ventilation dynamics are simulated by TRNFLOW within the TRNSYS software and a Particle Swarm Optimization algorithm is employed to optimize the thresholds of windows opening. A case study focusing on a residential building situated in the Mediterranean climatic context is presented: the thermal comfort analysis shows that the optimized control logic significantly reduces the overheating discomfort.

Future research will investigate both thermal and visual comfort by using building automation systems(BAS). The objective will be to propose a strategy that combines the logic of ventilative cooling control with a suitable control logic for shielding management, determined by MPC according to the enviromental conditions. With this strategy, it will be possible, to ensure visual and thermal comfort in according with regulations.

Algorithms and solutions for a covering problem within the Internet of Things paradigm

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The Internet of Things (IoT) paradigm refers to the network of physical objects and devices provided with sensing capabilities. The possibility of embedding everyday life objects with computing capacities and connecting them poses interesting perspectives and challenges for the modern society. Nonetheless, gathering data from these objects can be a difficult task since it is not always possible to have a specific network infrastructure for connecting them. An emerging trend called opportunistic IoT concerns with the design of solutions based on ad hoc connections provided by mobile devices (e.g. smartphones) by opportunistically considering daily routines or habits of the users.

Within a smart city project we investigate the problem of getting data from garbage bins by exploiting the passage of pedestrians or vehicles. The bins are equipped with sensors of their filling level. We propose solutions for covering the bins which combine different approaches and methods from operations research. More precisely, we devise heuristic algorithms based on the approaches developed for problems such as routing or transportation problems. At the same time we outline an inference procedure in order to deal with the uncertainty which characterizes the variables of the problem, concerning for example the movements of people in a city. We will discuss our procedures and algorithms and compare their performances by providing the results of our computational tests.

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Local electricity markets in smart grid framework

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Keywords: Smart grid, local markets, energy communities

The idea to aggregate different kinds of energy users is becoming common to better manage electrical system. Indeed, the spread of distributed resources especially from renewable not programmable sources, has increased the difficulty to manage economically and in security the electrical system.

A way to face this difficulty can be the opportunity to manage at local level the consumption and the production of energy, aggregating the users in energy communities (EC), both from a physical and economic point of view. In particular, from an economic point of view, the idea is to create local markets: in the local market, the energy demand meets directly the energy availability, that is users who need energy, present offers to buy energy, while users who have energy in surplus on their needs, present offers to sell energy. In this way, skipping intermediaries, users may have more economic conditions both in sale and in purchase, meanwhile, also technical problems as grid congestions can be limited.

Based on local market concept, authors present different optimized models [1-4] to manage the energy exchanges between users aggregated in an EC. In these models, a supervision entity acts as an energy provider: it estimates the energy demand and production inside the EC and the energy that could be purchased or sold outside the EC, in case of an excess of energy production. Then, the

supervision entity organizes and manages local markets, playing the role of the Power Exchange (PEX) with a "pay as bid" rule: it collects the purchasing offers, upwards compared to market-clearing price (MCP), and selects the most convenient one according to a merit order list. The consumers offering higher price will be selected and their offers accepted. Since there might be several consumers concerned, this results in a market auction.

The market auction is based on the difference between the purchasing and selling electricity price. The purchasing price of the energy surplus for EC users in a given hour is higher than MCP, that is the selling price, at the same hour. Since there is a difference between these prices, it can be convenient for a consumer belonging to the EC to buy the available energy surplus at a price lower than the purchasing price, and for the producer to sell at a higher price than the selling price. Session is formalized through auctions slots in which each user presents an offer to buy / sell in terms of price and quantity of energy that he is willing to accept.

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DOMUS: A community energy market based on IOT and Power Computing

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In recent years there was a lot of interest in IoT application in Energy sector in order to obtain interoperability and integration of different vendor multiprotocol devices and in using cloud to share data and applications.

The research project "Home automation system to realize cooperative energy brokerage", promoted by the consortium DOMUS (TIM, University Mediterranea, SI-IES and University of Calabria) and financed by MIUR has the ambition to build a platform, using IoT and cloud resources, able to create an environment where producers and consumers of energy may exchange energy maximizing their benefits simply using their home automation system. In the presentation the architecture of the platform will be discussed and its application to the University of Calabria, as test case, will be illustrated.

A rolling horizon stochastic programming approach for the short-term electricity procurement in smart grids

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Keywords: Stochastic Programming, Rolling Horizon, Energy Smart Grid

Smart grids are emerging aggregations of energy "prosumers" (i.e. consumers and/or producers), both residential and industrial, which can share resources (production plants, storage systems) and use advanced operational and control devices. The users are interested to stay in the aggregation since they have an economic advantage for their energy procurement (or selling). A central energy manager (CEM) has to plan the overall energy procurement, the buy/sell offers on the day-ahead market and the commitment of programmable production units and of storage systems, with the aim of maximizing the aggregation economic wellness. The complexity of the problem is due also to the uncertainty related to users' demand, market prices and production levels of renewable systems. In this work we propose two decision approaches based on the Stochastic Programming framework in order to deal with the dynamics and uncertainty of the planning problem. The first one has been defined for the case in which the CEM has the complete control of all the users' resources, while the second one is related to the more realistic situation in which users allow the CEM to use only the residual capacity/production potential of their resources. Preliminary computational experiments show the potential economic benefits of the proposed approaches w.r.t. other empirical decision policies.

Real-time Delay Management in Local Public Transportation via Vehicle and Crew Re-scheduling: a Case Study

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Keywords: Delay Management, Real-time Optimization, Re-Optimization

Local public transportation companies, especially in large cities, are facing every day the problem of managing delays and small disruptions. Most of the local public transit companies have vehicle monitoring systems able to collect huge quantities of data in real time that typically are used to measure the performance of the transportation system but are not fully exploited to improve it and to tackle disruptions. Although disruption management is an assessed practice in airlines and railways, in the context of local public transport the approaches to these problems, most often, lack in scientific method.

We consider a real world case, in particular the management of urban surface lines of Azienda Trasporti Milanese (ATM) of Milan where the main issues are the service regularity as a measure of the quality of service, and the minimization of the operational costs due to changes in the planned scheduling.

We discuss different ways to assess the regularity of the service, pointing out possible pitfalls of the currently used index of regularity. We present and analyze different types of functions that can be used to effectively evaluate the regularity of the service in a real-time environment and we propose a simulation based optimization system that can be effectively used in a real-time environment taking into account both vehicle and driver scheduling.

In particular, we describe a tabu-search procedure for the online vehicle scheduling optimizing the regularity of the service and a column generation approach for the consequential crew re-scheduling minimizing the driver extra-time.

Finally, we report a detailed analysis of the experimental phase showing the effectiveness of the proposed approach in real world scenarios.

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Improve social care services for minors and disabled people by using multiobjective programming

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Keywords: Social care services for minors and disabled people, multiobjective programming, scheduling, nonlinear programming

Relying on multiobjective programming techniques, we developed an optimization software to improve the services provided by social co-operative OMNIA. OMNIA's mission is to supply home-care assistance to children and disabled people. Our method is intended to optimize the operators' shift scheduling aiming at: on the one hand, maximizing the overall quality of the offered social care services, on the other hand, minimizing costs associated with OMNIA's activity. In particular, our software provides Pareto optima of the resulting (difficult) biobjective model by resorting to both a standard *a posteriori* weighted sum approach and a new MINLP no-preference (hypervolume maximization-type) method. The product of this research is successfully employed by OMNIA.

An appointment scheduling framework to balance the production of blood bags from donation

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Keywords: Blood Donation System, Appointment Scheduling, Production Balancing, Mixed Integer Linear Programming Model, Offline and Online Procedure

Blood is fundamental in several care treatments and surgeries, and plays a crucial role in the health care system. It is provided through the Blood Donation (BD) system, which is in charge of furnishing an adequate supply of blood bags to transfusion centres and hospitals [1]. The BD supply chain can be divided into four steps: *collection*, *transportation*, *storage* and *utilization* [2].

An effective collection of blood bags from donors is fundamental for adequately feeding the entire BD system and optimizing blood usage. Due to the short shelf life, BD system should meet the overall blood demand from hospitals and transfusion centres, but at the same time it should follow the temporal profile of demand to avoid blood shortage and wasted bags. Thus, increasing the number of donations improves the performance of the BD system, but also an effective management of donors' arrivals throughout the days may optimize the daily production of blood bags with respect to the demand. On the contrary, an unbalanced feeding of blood bags may undermine the entire BD supply chain and result in alternating periods of blood shortage and wasted bags.

Many optimization problems are present in managing the BD supply chain, from donation to final utilization of blood bags, and have been addressed in the literature [3]. However, despite its relevance, the donation scheduling is only marginally addressed, as highlighted in [4].

In this work, we define and solve the Blood Donation Appointment Scheduling (BDAS), which aims at balancing the production of the different blood types (combination of group and Rhesus factor) along the days, in order to provide a quite constant feeding of blood bags to the BD system.

We propose an appointment scheduling system to balance the production while taking into account both booking and non-booking donors. The proposed architecture for planning the assignments consists of two phases, i.e., an offline

preallocation of time slots for donation and an online allocation of them. The preallocation phase is responsible of reserving slots to the blood types, while the allocation phase of assigning a suitable preallocated slot to each donor when he/she calls for reservation. In other words, the preallocation phase prepares a number of spare slots for the different blood types, which are then used for the successive online booking.

The core of the architecture is a Mixed Integer Linear Programming (MILP) model for the preallocation phase, while preallocated slots are assigned by means of a prioritization policy.

Computational tests are run considering the real case of the Milan department of AVIS (i.e., the *Associazione Volontari Italiani Sangue*). Tests analyze the behavior of the MILP preallocation model, and evaluate the performance of the proposed approach (preallocation model and prioritization policy) over a long period of time. Good results are found in terms of production balancing and waiting time between reservation and donation.

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