# 5th EUROYoung Workshop

## October 15–17, 2025

## Naples (Italy)

Book of Abstracts

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THE ASSOCIATION OF EUROPEAN OPERATIONAL RESEARCH SOCIETIES

This book contains all the abstracts accepted for presentation at the 5th EUROYoung Workshop, held in Naples from the 15th to the 17th of October, 2025. The Workshop is organized by the EUROYoung Forum of EURO, the European Association of Operational Research Societies. The book of abstracts includes 39 contributions, grouped into 11 sessions, along with 4 additional plenary lectures delivered by internationally renowned professors, addressing highly relevant and timely topics, and 1 panel session featuring all plenary speakers. Abstracts are presented in chronological order, organized by day and by session.

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# Acknowledgments

We sincerely thank all those who contributed to making this workshop possible. We are especially grateful to our partners and sponsors for their invaluable support:

# Contents

# Session I
# Uncertain Optimization

Wednesday, October 15th | 13:10 – 14:30

**Chair:** Antonio Diglio

**Federica Donnini**
On $K$-adaptability for two-stage stochastic programs

**Hossein Babazadeh**
Power Swaps: A Coordination Mechanism for Operation of Jointly Owned Hydropower Reservoirs

**Simon Stevens**
A Branch-and-Cut Approach for Decision-Dependent Robust Optimization Problems

**Xuan Truong Dinh**
Enhancing Multi-Period, Multi-Commodity, Multi-Modal Network Flow Optimization in the Mekong Delta

# On $K$-adaptability for two-stage stochastic programs

**Marianna De Santis[1], Federica Donnini[1], Jannis Kurtz[2]**

[1] University of Florence, Florence, Italy
[2] University of Amsterdam, Amsterdam, Netherlands

**Abstract:** Two-stage stochastic programs are used to model problems with uncertain data, where a decision maker first decides the values of first-stage decision variables, then observes the values of the uncertain data, and finally decides the values of second-stage decision variables. We focus on the case where uncertainty can be modeled by a finite number of scenarios $\ell \gg 0$ and we define and study the so-called $K$-adaptability approach for two-stage stochastic programming. Extending some of the ideas proposed in [1,2], our aim is to detect feasible values of first-stage decision variables and a corresponding set of $K \ll \ell$ second stage solutions so that two goals are achieved. On the one hand, we want that each scenario is *covered* by at least one of the computed $K$ second stage solutions. On the other hand, we want to select the $K$ second stage solutions so that the objective value of the best of these, calculated in each scenario independently, is optimal in expectation. Similarly to [1,2], we present a quadratic programming formulation of the problem. With the aim of defining an exact algorithm for the $K$-adaptability two-stage stochastic problem, a procedure to compute and iteratively improve valid upper bounds is devised. Preliminary numerical results on two-stage stochastic instances from the literature are shown.

*Keywords*: Two-stage stochastic programming; $K$-adaptability; Exact algorithms.

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**Federica Donnini** is a PhD candidate in the Department of Information Engineering at University of Florence (Italy). Their research focuses on optimization problems for humanitarian logistics, modeled as two-stage stochastic programs. Before starting their PhD, they completed a Bsc in Mathematics at University of Florence and a joint Msc in Mathematics from University of Florence and Universidad Complutense of Madrid (Spain).

# Power Swaps: A Coordination Mechanism for Operation of Jointly Owned Hydropower Reservoirs

**Hossein Babazadeh[1], Lennart Hagemann[2], Stein-Erik Fleten[1], Rüdiger Schultz[2]**

[1] Norwegian University of Science Technology, Trondheim, Norway
[2] University of Duisburg-Essen, Essen, Germany

**Abstract:** In the era of global energy transition, hydropower plays a crucial role in balancing intermittent renewable sources. Jointly owned reservoir systems pose operational challenges due to minimal information sharing and misaligned incentives. We analyze a decentralized coordination mechanism, called *power swaps*, enabling cooperative operation among independently owned hydropower plants. The mechanism utilizes virtual reservoir levels and centralized flow adjustment, enabling participants to nominate water discharges. When deviations occur between planned and actual generation, the system compensates producers through contractual energy swaps, preserving financial neutrality. We develop a two-stage stochastic programming model to study nomination behavior under uncertainty and embed this in a simulation framework using Stochastic Dual Dynamic Integer Programming (SDDiP). Applied to Sweden's Ljungan River with partly real data, the model demonstrates that producers participating in the mechanism can achieve near-individual revenue levels while ensuring system-wide efficiency. Our results show economic robustness across nomination strategies and support power swaps as an effective coordination method for resilient, decentralized reservoir management.

*Keywords*: hydropower coordination; stochastic programming; decentralized scheduling; reservoir optimization; power markets

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**Hossein Babazadeh** is a PhD candidate at the Norwegian University of Science and Technology (NTNU). His research focuses on coordination mechanisms and stochastic optimization in energy systems, particularly the operation of shared hydropower resources. He is also interested in data-driven decision support modeling under uncertainty and decentralized energy market design.

# A Branch-and-Cut Approach for Decision-Dependent Robust Optimization Problems

**Henri Lefebvre[1], Martin Schmidt[1], Simon Stevens[1], Johannes Thürauf[2]**

[1] Trier University, Trier, Germany
[2] University of Technology Nuremberg, Nuremberg, Germany

**Abstract:** Compared to classic robust optimization, decision-dependent robust optimization (DDRO) models the uncertainties as being dependent on the decision variables, thus enabling some control over these uncertainties within the model. The literature on DDRO is still limited and most of the existing solution techniques rely on reformulations using duality. Hence, they are naturally restricted to uncertainty sets that can be dualized. Recent results by Goerigk et al. [1] show that DDRO problems can be reformulated as bilevel optimization problems, opening up new possibilities for solving this class of problems. First numerical results by Lefebvre et al. [2] indicate that applying general bilevel solvers like MibS [3] to DDRO problems for which the uncertainty set cannot be dualized is possible in general, though not efficient.

We present a tailored branch-and-cut approach for solving DDRO problems in which the uncertainty set is given by an interdicted knapsack problem. To this end, we tailor an interdiction-like cutting plane from the bilevel literature, which is incorporated in the branch-and-cut framework. We present numerical results on a set of benchmark instances and compare our approach with the existing general bilevel solver MibS. The results demonstrate that our approach is significantly faster and capable of solving larger DDRO instances.

*Keywords*: Robust optimization; Decision-dependent uncertainty sets; Endogenous uncertainty; Bilevel optimization; Branch-and-cut.

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**Simon Stevens** is a PhD candidate in the Department of Mathematics at Trier University. His research focuses on robust optimization problems with decision-dependent uncertainties as well as bilevel optimization and the interfaces between these two fields. Before starting his PhD, he studied Mathematics at Trier University and graduated with a Master's Degree in 2024.

# Enhancing Multi-Period, Multi-Commodity, Multi-Modal Network Flow Optimization in the Mekong Delta

**Xuan Truong Dinh[1], Vedat Bayram[2], Maria Paola Scaparra[3]**

[1] University of Kent, Kent Business School, Canterbury, Kent, United Kingdom
[2] University of Kent, Kent Business School, Department of Analytics, Operations and Systems, Centre for Logistics and Sustainability Analytics, Canterbury, Kent, United Kingdom
[3] University of Kent, Kent Business School, Dean for Research and Innovation, Canterbury, Kent, United Kingdom

**Abstract:** The Multi-Period, Multi-Commodity, Multi-Modal Network Flow Optimization Problem (MPMC-MNFP), which involves developing an optimization model to improve transport network efficiency and guide infrastructure investment, represents a fundamental challenge in various critical transportation systems [1]. The model for MPMC-MNFP minimizes transportation costs and travel times for passengers and goods across multiple periods and commodity types [2–4]. This study integrates strategic planning for future projects, focusing on the optimal placement of major transport hubs, improved connectivity between transport modes, and the enhancement of existing infrastructure. Validated using empirical data, the model assesses scenarios for the expansion and modernization of multimodal transport systems. To demonstrate its practical applicability in complex transportation environments, the model was applied to the Mekong Delta, Vietnam — a region characterized by an extensive multimodal network of roads and inland waterways that serves millions of residents and facilitates regional trade. The findings of this study provide valuable recommendations for optimizing transport networks in the Mekong Delta and similar regions

*Keywords*: Multi-Period Optimization; Multi-Commodity Transport; Multimodal Network Flow.

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**Xuan Truong Dinh** is a Research Fellow at the University of Kent, working on sustainable transport analytics. His research applies machine learning, optimization, and geographic information systems to support investment decisions and sustainability insights in transportation. Before joining the University of Kent, he was a Lecturer at the Posts and Telecommunications Institute of Technology (PTIT) in Vietnam and led research teams focused on social data analysis and AI applications.

# Plenary Session I

Wednesday, October 15th | 15:00 – 16:00

**Chair:** Marta Baldomero-Naranjo

**Martin Schmidt**
A Gentle and Incomplete Introduction to Bilevel Optimization

# A Gentle and Incomplete Introduction to Bilevel Optimization

**Martin Schmidt**

Department of Mathematics, Trier University (Germany)

**Abstract:** Bilevel optimization is a field of mathematical programming in which some variables are constrained to be the solution of another optimization problem. As a consequence, bilevel optimization is able to model hierarchical decision making processes. This is appealing for modeling real-world problems, but it also makes the resulting optimization models hard to solve in theory and practice. The scientific interest in computational bilevel optimization increased alot over the last decade and is still growing - in particular due tomany applications. In this tutorial, we discuss the most important aspects that render bilevel problems more challenging than single-level optimization problems and present the basic structural theory for linear bilevel models as well as the basic techniques for solving them. After these basics, we will also discuss some exemplary recent contribution in the field.

**Martin Schmidt** is a professor of Nonlinear Optimization at Trier University, Germany. His research interests include bilevel optimization, optimization under uncertainty, equilibrium models, and applications in energy markets. He is the speaker of the research training group Algorithmic Optimization at Trier University, a fellow of the Energy Campus Nuremberg, and a member of the International Scientific Committee of the Instituto Universitario de Investigación de Matemáticas y Aplicaciones of Universidad de Zaragoza. Martin currently serves on the editorial board of Optimization Letters and he is an associate editor of the Journal of Optimization Theory and Applications, OR Spectrum, and the EURO Journal on Computational Optimization, as well as a technical editor of Mathematical Programming Computation. Among his recent achievements, Martin (together with his co-authors) was awarded the Optimization Letters Best Paper Award, the Marguerite Frank Award for the best EURO Journal on Computational Optimization paper, and the Mathematical Methods of Operations Research Best Paper Award, all in 2021.

# Session II
# Location

Wednesday, October 15th | 16:10 – 17:30

**Chair:** Thomas Byrne

**Isabel Wiemer**
Enhancing Fairness in Emergency Medical Service: Single- and Bi-Objective Model Formulations

**Felix Rauh**
Dynamic Programming and Block-Cut Tree Decompositions for a Maximum Covering Location-Network Design Problem

**Ricardo Gázquez**
Incorporation of Regional Preferences in Facility Location: Insights into Efficiency and Satisfaction Trade-offs

**Thomas Byrne**
Conditional Facility Location Problems with Continuous Demand and a Rapid Transit Line

# Enhancing Fairness in Emergency Medical Service: Single- and Bi-Objective Model Formulations

**Isabel Wiemer[1], Jutta Geldermann[1]**

[1] Chair of Business Administration and Production Management, University of Duisburg-Essen, Germany

**Abstract:** The primary goal of emergency medical services (EMS) is to respond quickly and efficiently to emergencies within a given area. However, in regions with a heterogeneous demand distribution—such as urban, mixed, and rural areas—coverage levels can vary widely. To reduce inequalities in coverage, many approaches incorporate fairness as model objective when planning EMS locations. One common strategy is to focus on the least-covered area by maximizing its expected coverage [3]. However, this approach does not directly address the coverage levels of the second, third, and subsequent least-covered areas, potentially leaving broader disparities unaddressed. Therefore, we propose explicitly considering not only the worst-covered area but also the second, third, and subsequent least-covered areas. Our goal is to enhance the average coverage level across the set p of worst-covered areas.

To that end, we introduce a novel fairness objective and formulate a single-objective model. Additionally, we integrate this objective with expected coverage in a bi-objective model, utilizing the epsilon constraint method [2] to balance fairness and overall coverage. Both models are based on an extension of the Maximum Expected Covering Location Model (MEXCLP) [1], which accounts for fractional coverage [4].

To evaluate our fairness objective's applicability, we conduct a real-world case study for the city of Duisburg, Germany, with historical emergency data. We analyze various sets p of the worst-covered areas and different epsilon values to evaluate individual coverage levels as well as overall expected coverage. Preliminary results indicate that our proposed fairness objective enhances the average coverage of the worst-covered areas in Duisburg while maintaining a high level of overall efficiency.

*Keywords*: Location Planning; Emergency Medical Service; Fairness.

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**Isabel Wiemer** is working as a research associate at the Chair of Business Administration and Production Management at the University of Duisburg-Essen, where she is also enrolled as a PhD student. She obtained a Master's degree in Management with focus on Operations Research at the Ruhr-University in Bochum. Her main research interest is Operations Research applied to health care with particular focus on location planning of emergency medical services.

# Dynamic Programming and Block-Cut Tree Decompositions for a Maximum Covering Location-Network Design Problem

**Felix Rauh[1], Jannik Matuschke[1], Hande Yaman[1]**

[1] KU Leuven, Leuven, Belgium

**Abstract:** In order to plan accessible public health services and resilient infrastructure, high quality solutions to network design and facility location problems are of utmost importance. We tackle a problem that arises, for instance, when improving health care access in areas that are prone to disruptions such as recurring floods. The specific challenge is that the given budget can be used both for hospital as well as improvements of roads.

Given a graph $G = (V, E_w \cup E_r)$ with weak edges $E_w$ and resilient edges $E_r$, and possible facility locations $F \subset V$, we define the *Maximum Covering Location-Network Design Problem (MCNDP)* as the problem to choose a set of links $X \subset E_w$ and facilities $Y \subset F$ such that the total weight of nodes that are within distance $\overline{d}$ to an open facility is maximized (via edges in $X \cup E_r$), and the total allocated budget is bounded by $\overline{b}$. While there is extensive work on a wide range of variants of network design as well as maximum covering location problems, this combined problem MCNDP has received little attention (e.g., [1]).

In this talk, we present an exact solution framework for the MCNDP based on dynamic programming (DP), and describe its theoretical properties as well as computational performance. First, we show that the problem on trees allows for an optimal solution approach via dynamic programming that is pseudo-polynomial in the given budget. The method is an extension of DP approaches to the maximum covering and $p$-median problem based on [2]. Then, we extend the methods to graphs that have cut vertices (so-called articulation points), thus allowing for a non-trivial decomposition into a block-cut tree (BC tree) [3]. The maximal biconnected components of the graph then correspond to vertices in the BC tree. Motivated by the DP on trees, we introduce an exact approach that identifies the optimal way to combine partial solutions on blocks.

Via computational experiments, we show that the DP on trees is superior to different formulations solved by a commercial solver. Moreover, we present results suggesting in which situations embedding an existing approach into the framework of the DP on a BC tree decomposition outperforms applying the approach to the graph directly.

*Keywords*: maximum covering location problem; network design problem; dynamic programming.

## References

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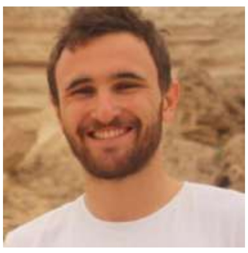

**Felix Rauh** is a PhD candidate at the Faculty of Business and Economics at KU Leuven, supervised by Jannik Matuschke and Hande Yaman. His research focuses on facility location and network design problems, and efficient ways to solve them. The work is motivated by the Analytics for a Better World Institute (ABW) who share Felix' passion for the use of analytics and optimization in high-impact settings tackling the Sustainable Development Goals. Before starting his PhD, Felix studied mathematics at RWTH Aachen University and gained some experiences during stays at universities in Chile and Oman as well as industrial internships in Berlin and Madrid.

# Incorporation of Regional Preferences in Facility Location: Insights into Efficiency and Satisfaction Trade-offs

**Víctor Blanco[1], Ricardo Gázquez[1], Marina Leal[2]**

[1] Universidad de Granada, Spain
[2] Universidad Miguel Hernández, Spain

**Abstract:** Facility Location is an active area of research in Operations Research whose aim is to find the best position of one or more services satisfying the demand of a set of users. One of the most prominent features of a facility location problem is the domain where the facilities are to be located. *Continuous* location problems allow the services to be located in the complete space (or in a region of it) while in *discrete* location, a given finite set of potential positions is provided, and one has to select from such a set the most appropriate facilities. In between, in *network* location the facilities are to be located on the metric space induced by a given network.

In recent years, a few papers have appeared analyzing hybridized continuous-discrete facility location problems and network-continuous problems by combining the existence of both discrete/network and continuous type of facilities. One of the families of problems where this combination has been most prominent lately is the one where *neighborhoods* are incorporated into classical discrete/network location problems. This refers to areas that may represent the geographical place where the different installations are allowed to be located or the (locational) uncertainty on the exact position where the elements are assumed to be located.

In this talk, we present the recent paper in [1] where we consider a continuous facility location problem with multiple facilities with neighborhoods, where a given finite set of demand regions of general shapes is provided, and the goal is to find the *optimal* positions of a given number of services that minimizes a distance-based measure to the different regions. The peculiarity of the problem that we address is that a function is provided for each of the demand regions to represent the utility of the users in the regions to be serviced. This utility can represent the preference of the users for the different positions within the neighborhood or the population mass defined in the region. For that, each of the demand regions is endowed with a continuous preference function where the demand is serviced from its assigned facility. The satisfaction of the users is assured by a minimum preference threshold.

*Keywords*: Continuous facility location; Regions; Neighborhoods; Preferences; Economic production models.

## References

[1] Blanco, V., Gázquez, R. & Leal, M., "Insights into Efficiency and Satisfaction Trade-offs in Facility Location Problems with Regional Preferences," *arXiv preprint arXiv:2412.20074*, 2024.

**Ricardo Gázquez** obtained a PhD in Operations Research (OR) from the Universidad de Granada, Spain. He is currently an Assistant Professor in the Dpt. of Quantitative Methods for Economics & Business at the same university. His research interests include OR, Location Theory, and Stochastic Programming. Previously, he worked as a Postdoctoral Researcher at the University of Málaga, focusing on the location of charging stations for electric vehicles, and as an Assistant Professor in the Department of Statistics at Universidad Carlos III de Madrid. He has participated in various research projects in Operations Research and collaborated with over seven co-authors, currently working with five more.

# Conditional Facility Location Problems with Continuous Demand and a Rapid Transit Line

**Thomas Byrne**

University of Strathclyde, Glasgow, United Kingdom

**Abstract:** The vast majority of planar location problems rely on the assumption that the traversable region is navigable at a uniform speed. However, this supposition is not a realistic one for many real-world applications; differing infrastructure allows journeys to be conducted on routes of variable speeds (e.g. driving along a country road or an autobahn) and using different modes of transfer (e.g. by foot or by bullet train). Additionally, while a discrete set of demand points often adequately reflects industrial problems, for commercial and public service facilities in an urban environment, there can be millions of potential customers, and it is impracticable to represent every customer site as a separate demand point. A more accurate approach is to model customer demand as continuously distributed over the specified area which also lends itself much better to the uncertain and sporadic nature of some demands.

Solving either of these two extensions (continuous demand and a rapid transit line) independently is challenging, but both combined is even more so. Following stipulation of the locations of all $p$ facilities, the demand space has to be subdivided into areas known as 'Voronoi cells' which represent each facility's captured demand; the resulting partition is called the 'Voronoi diagram'. In order to solve the problem, it is essential to study the *structure* of the Voronoi diagram and how it changes dynamically when a facility 'moves around' on the plane. Unfortunately, this structure can alter dramatically, which makes it generally nigh impossible to represent the objective function of the problem in closed form, and renders the formulation of the underlying optimisation problems very challenging [1].

This work closely mirrors that of [2] and explores a variety of conditional location problems (where the optimal location for an additional facility is sought) over a convex polygonal market region in the rectilinear plane. We assume that the demand is continuous and uniform within the market region, with customers being served by the nearest facility only (measured in time). Additionally, contained within the market region is one known rapid transit line (along which paths can travel at a preset constant speed) and we consider separately the properties that the rapid transit line can be accessed only at its endpoints or at any point along its route. A detailed investigation into the structural properties of geodesic Voronoi diagrams enables us to solve the overlying optimisation problems themselves by developing an algorithm which considers restricting the location of the new facility to sub-regions where the resulting geodesic Voronoi diagram is 'structurally identical' for every point in the region.

*Keywords*: continuous location; planar facility location; computational geometry; Voronoi diagrams.

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**Thomas Byrne** is a Chancellor's Fellow in the Department of Management Science at the University of Strathclyde. Their research focuses on continuous and combinatorial optimisation, with a particular focus on urban planning applications and geometric solution approaches. They like to take inspiration from problems of competitive and equitable access, trying to ensure that their research contributes towards addressing the world's most pertinent problems and benefitting society.

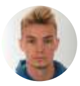
# Session III
# Routing

Wednesday, October 15th | 16:10 – 17:30

**Chair:** Eduardo Pipicelli

**Julien Darlay**
Computing dual bounds of set-based models using column elimination in Hexaly

**Chiara Maragò**
Optimizing Cruise Ship Itineraries: A Sustainable Perspective



**Vid Tomljenovic**
Solving a Multi-Depot Multi-Vehicle Inventory Routing Problem using Column Generation and Branch-and-Price

# Computing dual bounds of set-based models using column elimination in Hexaly

**Julien Darlay**

Hexaly, Paris, France

**Abstract:** Hexaly is a model-and-run solver that integrates heuristics and exact methods. A set-based modeling formalism was introduced to simplify the modeling of some combinatorial problems, like routing or packing problems. For instance, in a routing problem, list variables can be used to model the sequence of visits made by each truck. These decision variables are well suited for a heuristic search but are much more challenging to integrate into a mathematical programming approach to compute lower bounds. A direct MILP reformulation introduces a quadratic number of binary decisions with several big-M constraints, leading to poor scalability and bounds. Hexaly automatically detects such structures in a user model and reformulates them in an extended MILP model to compute lower bounds parallel to a heuristic search. This model is solved efficiently using the literature's state-of-the-art branch-and-cut-and-price techniques [1] and column elimination algorithms [2, 3]. This talk will present the general approach, the algorithms used for the column elimination, and some benchmarks on the classical vehicle routing and packing problems.

*Keywords*: solver, packing, routing, lower bounds.

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**Julien Darlay** is a cofounder and the head of science of Hexaly. He obtained a Ph.D. in computer science from Grenoble University, France (2011). His research was at the intersection of mathematical optimization and machine learning. Now he is leading the development in Hexaly, focusing on heuristics and mathematical programming.

# Optimizing Cruise Ship Itineraries: A Sustainable Perspective

**Chiara Maragò[1], Rosita Guido[1], Francesca Guerriero[1]**

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**Abstract:** The Triple Bottom Line framework, based on the three fundamental dimensions of sustainable development—society, environment, and economy—has become the key to long-term strategy for global industries focused on the transition to sustainability [2]. In such a context, the cruise industry is no exception. Although it accounts for only 2% of international travel, its economic contribution is huge and growing rapidly. Indeed, the number of passengers sailing on expedition itineraries has increased 71% from 2019 to 2023. Furthermore, this number is forecast to grow to almost 40 million by 2027.

However, along with the economic growth, cruise lines are making progress on an ambitious sustainability agenda. They are investing in technologies, infrastructure and operational efficiencies to reduce emissions at berth and at sea in order to achieve net zero emissions by 2050 [3]. Moreover, they are also making great efforts to promote recycling activities and to stop the discharge of untreated wastewater into the ocean [4]. The cruise industry sells itineraries, including destinations and activities previously determined. The main factors that must be taken into consideration when designing an itinerary are: time at destinations, distance between destinations, and traveling speed. At the same time, passengers' requirements and environmental targets must be satisfied. Originally, the problem of cruise itinerary design was to determine the sequence of ports to visit and the speed at which to sail each leg of the itinerary in order to achieve the highest net profit for the cruise line [1]. However, as noted above, the economic dimension is not enough to drive business development from a sustainable perspective, although it remains a challenge for many organizations to measure sustainability performance quantitatively [2].

Our study builds on the work developed in [1], that includes a mixed-integer programming optimization model to find optimal cruise ship itineraries while ensuring maximum profit. A novel multi-objective model is proposed to address the problem of cruise ship itinerary design, including environmental and social indicators. It is then applied to a real-world case study. The main objective is to assess the impact of changes in cruise ship itineraries on costs, resource consumption, waste treatment, environmental pollution, and passengers' satisfaction.

*Keywords*: Cruise industry; Sustainability; Optimization; Itinerary design

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**Chiara Maragò** is a PhD student in Mathematics and Computer Science in the Department of Mechanical, Energy, and Management Engineering (DIMEG) at University of Calabria. Her main area of interest is Operations Research. With a Master's degree in Management Engineering, her academic focus is on the optimization of Water-Energy-Food Nexus (WEF-N) systems. She is currently working on developing innovative models and solution approaches to be applied to real-world WEF-N systems.

# Solving a Multi-Depot Multi-Vehicle Inventory Routing Problem using Column Generation and Branch-and-Price

**Vid Tomljenović[1], Yasemin Merzifonluoglu[1], Juan Vera Lizcano[1]**

[1] Tilburg University, Tilburg, Netherlands

**Abstract:** An emerging trend in logistics is vendor-managed resupply, where suppliers take on the responsibility of monitoring and replenishing inventory directly at customer sites. This strategy streamlines operations and provides significant benefits for both parties: vendors reduce costs through more efficient delivery coordination across multiple clients, while customers benefit from a relieved operational burden related to inventory management.

Take, for instance, a fuel distribution company that effectively monitors fuel levels at a network of gas stations and delivers multiple fuel products from various depots using a fleet of multi-compartment trucks. This scenario falls within the established Inventory Routing Problem (IRP) framework, necessitating the joint optimization of routing and inventory decisions. Our primary objective is to minimize transportation costs—identified as the key cost driver—while satisfying customer inventory requirements, including the strategic management of safety stock levels to buffer against variability.

To tackle this challenge, we develop a mixed-integer linear programming (MILP) model and propose an innovative alternative formulation inspired by [1] that unlocks the potential of column generation for solving the LP relaxation. By leveraging the structure of the resulting pricing subproblem, we craft a novel efficient reformulation suitable for implementation within a branch-and-price framework. We evaluate the proposed approach on real-world data provided by an industry partner, demonstrating its practical effectiveness and adaptability. The problem instances are designed to reflect realistic operational settings, in which a team of planners is tasked with scheduling the routes of a few trucks over a five-day working week. Our results show that the reformulated pricing subproblem leads to a computationally efficient solution procedure for the linear relaxation via column generation. Moreover, the structure of the reformulation enables the implementation of an effective branching scheme, facilitating the generation of high-quality integer solutions.

While most IRP models focus on deterministic demand, they often overlook the uncertainty inherent in real-world operations. We build on our efficient solution for the deterministic case and extend it into a rolling horizon framework to accommodate evolving forecasts. This structured, flexible approach strikes a balance between service level performance and inventory investment—offering a robust alternative to models that either ignore safety stock or impose rigid constraints.

*Keywords*: Inventory routing; column generation; branch-and-price, demand uncertainty.

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[1] L. Wang, J. Kinable & T. van Woensel, "The fuel replenishment problem: A split-delivery multi-compartment vehicle routing problem with multiple trips", *Computers & Operations Research*, vol. 118, 2020.

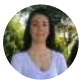
**Vid Tomljenović** is a PhD candidate in the Department of Operations Research at Tilburg University. Their research focuses on optimization problems in transportation and logistics, particularly vehicle routing and scheduling. Before starting their PhD, they worked as a Data Scientist at Cofano Software Solutions, gaining experience and insight into real-world problems of logistics and transportation, as well as the potential and value of data-driven decision-making.

# Session IV
# Machine Learning I

Thursday, October 16th | 08:30 – 09:30

**Chair:** Sebastian Merten

**Daan Otto**
Coherent Local Explanations for Mathematical Optimization



**Marica Magagnini**
Multiple Disperse (generalized) Linear Models

**Sebastian Merten**
Interpretable Surrogates for Optimization

# Coherent Local Explanations for Mathematical Optimization

**Daan Otto[1], Jannis Kurtz[1], Ilker Birbil[1]**

[1] University of Amsterdam, Amsterdam Business School, Amsterdam, The Netherlands

**Abstract:** The surge of explainable artificial intelligence methods seeks to enhance transparency and explainability in machine learning (ML) models. At the same time, there is a growing demand for explaining decisions taken through complex algorithms used in mathematical optimization. One promising idea to do this is to use a method like LIME [1] which fits an explainable ML model that locally approximates the behavior of the black-box ML model. This method can be used to analyze components of the optimization model as well (e.g. the objective function value or the decision variables). Although these ML-based methods are effective and model-agnostic, they usually do not take into account the structure of the underlying optimization problem. While the objective value and the corresponding solution are closely intertwined due to the problem's structure, this relation is not taken into account when approximating both components independently by an ML model.

In response to this need, we introduce Coherent Local Explanations for Mathematical Optimization (CLEMO). CLEMO provides explanations for multiple components of optimization models, the objective value and decision variables, which are coherent with the underlying model structure. Our sampling-based procedure can provide explanations for the behavior of exact and heuristic solution algorithms using regression models. The effectiveness of CLEMO is illustrated by experiments for the shortest path problem, the knapsack problem, and the vehicle routing problem, see also [2]. Currently, we are extending CLEMO to provide explanations using decision trees.

*Keywords*: Explainability; Sensitivity Analysis; Regression.

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[2] Otto, D., Kurtz J. & Bribril, S.I., "Coherent Local Explanations for Mathematical Optimization", *arXiv preprint arXiv:2502.04840*, 2024.

**Daan Otto** is a PhD candidate from the Amsterdam Business School at the University of Amsterdam. His research focuses on defining a general mathematical framework for explainable decision making and introducing models to provide explanations for different classes of optimization problems. In recent years, there has been a rising demand for transparency and explainability in artificial intelligence. Although significant progress has been made in generating different types of explanations for machine learning models, this topic has received minimal attention in the operations research community, due to a larger focus by the public on societal effects of data-driven machine learning models. However, algorithmic decisions in operations research are made by complex algorithms, which also lack explainability. The main goal of his PhD project is to bridge this gap and create a foundation for explainable decision making.

# Multiple Disperse (generalized) Linear Models

**Emilio Carrizosa[1], Renato De Leone[2], Marica Magagnini[2]**

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[2] Università di Camerino, Camerino 62032, Italy

**Abstract:**

Linear models are key in Explainable Machine Learning since they provide an easy-to-understand meaning to their coefficients and the impact of the different features in predictions. However, not all accurate linear models may be equally appealing because of secondary objectives such as sparsity or other measurement costs. For this reason, several methods have been proposed in the literature to address the multiobjective problem of joint optimization of accuracy and other secondary criteria, the lasso [1,2] being the most popular approach.

In this work we propose a different strategy: we explore how different linear models with a good accuracy can be. We do this by considering a biobjective p-dispersion model [3], in which p models are sought jointly maximizing an overall accuracy measure as well as a dispersion measure.

Several metrics are used to measure dispersion, including a function of the distance between their parameters, the set of features used to predict, and the distance between the distribution of the predictions in a set of records. Moreover, different scenarios for the feasible region are considered, e.g. whether the p models are to be chosen from, or added to, a list of pre-selected linear models, like lasso models. All these variants are expressed as biojective nonlinear mixed integer optimization problems, numerically tested. Although we focus on linear models, the paradigm is extended to generalized linear models.

One application of this work may involve a generalization of LIME [4]. LIME is a model-agnostic explainer that builds sparse linear models to locally interpret any black-box model predictions, expressing explanations as feature contributions. While LIME constructs a single local explainer of an instance, our approach enables the generation of multiple local explainers, providing users with a broader range of information and the opportunity to independently assess the quality of the explanations.

*Keywords*: Machine Learning; Linear Explainable models; Conditional P-Dispersion; Multi-Objective Decision Making; Mixed-Integer Programming.

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**Marica Magagnini** is a PhD candidate at the International School of Advanced Studies at the University of Camerino. She is attending the Computer Science and Mathematics curriculum. Her research focuses on optimization problems for explainable and interpretable machine learning methods, particularly counterfactual explanations applied to the k-Nearest Neighborhood classifier and the construction of diverse sparse linear models. Before starting her PhD, she worked on her master's thesis at the University of Sevilla in the Operation Research group, which still results in a strong collaboration.

# Interpretable Surrogates for Optimization

**Marc Goerigk[1], Michael Hartisch[2], Sebastian Merten[1], Kartikey Sharma**

[1] University of Passau, Passau, Germany
[2] University of Erlangen–Nuremberg, Erlangen, Germany

**Abstract:** An important factor in the practical implementation of optimization models is their acceptance by the intended users. This is influenced by various factors, including the interpretability of the solution process. A recently introduced framework for inherently interpretable optimization models proposes surrogates (e.g. decision trees) of the optimization process. These surrogates represent inherently interpretable rules for mapping problem instances to solutions of the underlying optimization model. In contrast to the use of conventional black-box solution methods, the application of these surrogates thus offers an interpretable solution approach.

Building on this work, we investigate how we can generalize this idea to further increase interpretability while concurrently giving more freedom to the decision maker [1]. We introduce surrogates which do not map to a concrete solution, but to a solution set instead, which is characterized by certain features. Furthermore, we address the question of how to generate surrogates that are better protected against perturbations [2]. We use the concept of robust optimization to generate decision trees that perform well even in the worst case. For both approaches, exact methods as well as heuristics are presented and experimental results are shown. In particular, the relationship between interpretability and performance is discussed.

*Keywords*: interpretability and explainability; data-driven optimization; optimization under uncertainty; robust optimization.

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[2] Goerigk, M., Hartisch, M., & Merten, S., "Towards Robust Interpretable Surrogates for Optimization", *arXiv preprint arXiv:2412.01264*, 2024.

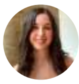
**Sebastian Merten** is a PhD student and research assistant at the Chair of Business Decisions and Data Science at the University of Passau, Germany. As part of his PhD, he is focusing on interpretability, explainability and uncertainty in optimization using concepts of data-driven and robust optimization. Beyond that, Sebastian is most interested in combinatorial optimization problems and the intersections of machine learning and optimization.
Before joining the University of Passau, he obtained a Master's degree in Business Analytics at the University of Siegen.

# Session V
# Machine Learning II

Thursday, October 16th | 09:30 – 10:30

**Chair:** Paula Segura Martínez

**Lorenzo Saccucci**
The Potential of Large Language Models in Solving Optimization Problems: An Empirical Study



**Ilaria Ciocci**
Margin Optimal Regression Trees

**Paula Segura Martínez**
New mathematical optimization models for clusters interpretability

# The Potential of Large Language Models in Solving Optimization Problems: An Empirical Study

**Lorenzo Saccucci[1], Marco Boresta[2], Francesco Romito[3]**

[1] Department of Computer, Control, and Management Engineering "Antonio Ruberti" (DIAG), Sapienza University of Rome - Spindox S.p.A., Rome, Italy
[2] Institute of Systems Analysis and Computer Science "Antonio Ruberti", National Research Council (CNR) - Spindox S.p.A., Rome, Italy
[3] Spindox S.p.A., Rome, Italy

**Abstract:** Large Language Models (LLMs) have recently shown remarkable capabilities in tackling complex reasoning tasks, including optimization problems. Recent advances like FunSearch [2] have demonstrated LLMs' potential in discovering novel programmatic approaches to combinatorial problems, while frameworks such as OptiMUS [1] have established their ability to autonomously formulate and solve mixed-integer programming models. Building on these developments, we present an empirical evaluation of eleven state-of-the-art LLMs across three categories of optimization problems: resource allocation, blending, and vehicle routing. Our study compares two distinct prompting strategies: one-stage prompting, where LLMs directly generate solver code, and two-stage prompting, where the formulation of a mathematical model precedes its implementation. Results reveal that while larger models generally excel with one-stage prompting, smaller models benefit from the decomposed two-stage approach, suggesting that prompting strategy effectiveness varies with model scale. Furthermore, our analysis identifies common error patterns across models, particularly in handling integrality constraints and syntactic code generation. This comprehensive assessment offers valuable insights for practitioners seeking to integrate LLMs into operations research workflows, highlighting both the promise and current limitations of these models in mathematical programming.

*Keywords*: Large Language Models; Mathematical Programming; Mixed-Integer Programming;

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**Lorenzo Saccucci** is a PhD student in Operations Research at Sapienza University of Rome, in the Department of Computer, Control, and Management Engineering "Antonio Ruberti". His research focuses on applying artificial intelligence and machine learning to combinatorial optimization, particularly vehicle routing problems. Before starting his PhD, he joined Spindox S.p.A. as a Mathematical Optimization Research Engineer, contributing to applied research in optimization and data science.

# Margin Optimal Regression Trees

**Ilaria Ciocci[1], Marta Monaci[1,2], Laura Palagi[1]**

[1] Department of Computer, Control and Management Engineering, Sapienza University of Rome, Rome, Italy
[2] Institute for system analysis and computer science "Antonio Ruberti", National Research Council of Italy

**Abstract:** Interpretable machine learning models have gained increasing attention in recent years, as they provide explanatory and transparent insights into their decision-making process. Among these models, decision trees have been widely studied thanks to their intuitive structure and inherent interpretability. Advances in mixed-integer programming (MIP) over the last few decades have led to the development of several formulations for building optimal decision trees [1, 2], offering an alternative to traditional greedy heuristics. Along this research line, we extend to regression tasks the Margin Optimal Classification Trees (MARGOT) approach, introduced in [3], which embeds Support Vector Machines along the binary tree structure. This leads to a quadratic mixed-integer formulation for optimal regression trees. We address the sparsity of the proposed model by introducing cardinality constraints on the features, selecting only the most relevant ones in order to enhance interpretability. To evaluate both the predictive and optimization performances of our approach, we conduct computational experiments on benchmark datasets, comparing it with state-of-the-art optimal tree methods.

*Keywords*: machine learning; optimal regression trees; support vector machines; mixed-integer programming.

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**Ilaria Ciocci** is a PhD student in Operations Research at the Department of Computer, Control and Management Engineering, at Sapienza University of Rome. Her research focuses on optimization methods for machine learning, particularly on block decomposition methods for deep neural network training and mixed-integer programming approaches for interpretable models.

# New mathematical optimization models for clusters interpretability

**Paula Segura Martínez[1], Alfredo Marín[2]**

[1] Department of Mathematics for Economics and Business, University of Valencia, Spain
[2] Department of Statistics and Operational Research, University of Murcia, Spain

**Abstract:** In this work we present a new approach for improving the interpretability of Cluster Analysis [2], one of the most popular unsupervised learning methods, through distance-based explanations. This is an extension of the post-hoc approach for interpreting clusters via means of prototypes developed in [1]. Given a set of predefined clusters, where each individual in the set presents $K$ measures or characteristics, and given a dissimilarity (or distance) between each pair of individuals associated with each of these measures, our aim is to find an explanation that characterizes each cluster by choosing for each of them a set of representative individuals or prototypes. The set of prototypes chosen for each cluster must guarantee that those individuals that are closest to one prototype in at least $q$ out of the $K$ measures are allocated to its same cluster. Specifically, the goal is to select the minimum total number of prototypes that provides an explanation for all the clusters. We present two mathematical optimization models based on a different definition of closeness between individuals, inspired by Classic Location Analysis problems. Some computational experiments are carried out to test our approach.

*Keywords*: clusters; interpretability; prototypes; location; combinatorial optimization.

## References

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**Paula Segura Martínez** holds a PhD in Statistics and Optimization from the University of Valencia, Spain (2023). Currently, she holds a position as an Assistant Professor in the Department of Mathematics for Economics and Business at the University of Valencia. Her research focuses on the study of mixed integer linear programming problems, particularly in transportation and logistics, arc routing, and location.

# Plenary Session II

Thursday, October 16th | 11:00 – 12:00

**Chair:** Andrea Mancuso

**Maria Grazia Speranza**
Optimization in transportation and logistics

# Optimization in transportation and logistics

**Maria Grazia Speranza**

Department of Economics and Management, University of Brescia (Italy)

**Abstract:** Technological advancements over the past few decades have significantly transformed the way people travel and how goods are transported. Today, a systemic approach to problem-solving and the use of advanced analytical methods are more essential than ever. In this talk, we will explore key trends in the application of optimization models and algorithms within transportation and logistics, along with some recent developments in the field.

**Maria Grazia Speranza** is full professor of Operations Research at the University of Brescia. She was President of the International Federation of Operational Research Societies (IFORS), of the association of European Operational Research Societies (EURO) and of the Transportation Science and Logistics (TSL) society of INFORMS. Grazia's research is in the area of mixed integer programming and combinatorial optimization, with a focus on applications to transportation and logistics. She is author of more than 200 papers. She is currently a member of the advisory board of editors for Transportation Science, editor of the series EURO Advanced Tutorials in Operational Research, and a member of the editorial boards of the EURO Journal on Transportation and Logistics, International Transactions in Operational Research, and 4OR. Grazia is cited in the "World's 2% Top Scientists" ranking. She is also recognized as one of the Top 100 Italian Women in STEM. She was awarded with the Laurea honoris causa by the University of Freiburg, Switzerland. She is a member of the Academy of Sciences of the University of Bologna and was awarded as an Italian Knowledge Leader by the Convention Bureau Italia. In 2024 she received the EURO Gold medal and was nominated INFORMS Fellow.

# Session VI
# Bilevel Optimization

Thursday, October 16th | 12:10 – 13:30

**Chair:** Francisco Temprano García

**Alberto Torrejon**
The Measure of Everything, a flexible modeling framework for combinatorial problems

**Riccardo Tomassini**
Equilibrium selection in oligopolistic market

**Martina Gherardi**
A bilevel revenue adequate generation expansion problem with hybrid complementarity condition

**Francisco Temprano García**
A fresh view on the Security Games Problem

# The Measure of Everything, a flexible modeling framework for combinatorial problems

**Victor Blanco[1], Miguel A. Pozo[2], Justo Puerto[3], Alberto Torrejon[1]**

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[2] Institute of Mathematics of the University of Granada, Granada, Spain
[3] University of Sevilla, Sevilla, Spain
[4] Institute of Mathematics of the University of Sevilla, Sevilla, Spain

**Abstract:** Optimization in decision-making is fundamentally driven by the objective function, which can vary depending on the context, ranging from measures of position, dispersion or shape of the distribution to measures of risk, fairness, robustness, or envy, among others. In this work, we introduce a flexible modeling framework based on linear and mixed-integer mathematical programming, designed to accommodate a broad spectrum of optimization criteria in combinatorial problems. We focus on its application to facility location problems, see [1] or [2], while remarking its adaptability to other domains, such as linear regression, see [3]. To this end, we present novel approaches leveraging ordered and bilevel optimization techniques, supported by computational studies which outline the performance of our methods.

Our framework allows for the integration of problem-specific constraints and preferences, making it a versatile tool for decision-makers in various fields. In addition, we explore the theoretical properties of the proposed models and discuss their computational complexity. The results highlight the potential of our approach to improve solution quality and interpretability across multiple optimization settings.

*Keywords*: Robust measures; combinatorial problems; quadratic programming; ordered optimization; bilevel problems

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**Alberto Torrejon** is a PhD candidate in the Department of Operations Research at University of Sevilla. His research focuses on the formulation and solution of complex combinatorial problems with applications in various fields, such as logistics, transport, resource location, statistics and data analysis, on a two-fold basis: enhancing model efficiency while guaranteeing the fairness of algorithms. Before starting their PhD, he worked as a Data Analyst at Company Indorama Venture Quimica, gaining experience in data-driven decision-making.

# Equilibrium selection in oligopolistic market

**Giancarlo Bigi[1], Riccardo Tomassini [2]**

[1] Department of Computer Science, University of Pisa, Pisa, Italy
[2] Department of Computer, Control and Management Engineering Antonio Ruberti, Sapienza University of Rome, Rome, Italy

**Abstract:** We study a Nash equilibrium problem arising in the context of oligopolistic competition among multiple companies producing a variety of differentiated goods. We formalize the corresponding model and provide sufficient conditions for the monotonicity of the underlying Nash equilibrium problem. To address the presence of multiple equilibria, we consider a hierarchical problem to select among the possible solutions. Since the resulting problem violates standard constraint qualification, we introduce inexactness into the lower-level in order to gain regularity [1, 2]. Algorithms to solve the resulting inexact bilevel problem are devised relying on exact penalization techniques and cutting-planes approximations [3]. Numerical experiments employing different selection functions confirm the importance of the equilibrium selection, thereby demonstrating the validity of the proposed model.

*Keywords*: bilevel optimization; semi-infinite programming; continuous optimization; linear and nonlinear programming.

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**Riccardo Tomassini** is a PhD student in Operations Research at the Department of Computer, Control and Management Engineering at Sapienza University of Rome. His research focuses on algorithmic methods for bilevel variational problems.

# A bilevel revenue adequate generation expansion problem with hybrid complementarity condition

**Martina Gherardi[1], Maria Teresa Vespucci[2], Fabrizio Lacalandra[3]**

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**Abstract:** The evolution of electricity systems involves transformative changes aimed at reducing carbon emissions. This requires a high penetration of renewables that is already showing a strong impact on electricity prices. The resulting *missing money problem*, where generators fail to recover investment and operational costs through market revenues, may undermine long-term adequacy and threaten the achievement of decarbonization targets.

This research [1] presents an innovative modeling development for the *Generation Expansion Planning* (GEP) problem, customized to address the forthcoming demand for decision support in the Italian electricity market. The model incorporates detailed market mechanisms, including zonal market clearing prices and side payments that reflect *Capacity Remuneration Mechanism* (CRM)-like auctions, ensuring *Revenue Adequacy* for various generation technologies. Unlike most GEP models in the literature, which overlook the cost recovery issue, our approach explicitly enforces the economic viability of investments and operations. Notably, we overcome the limitations of previous works such as Guo et al. [2], by ensuring meaningful prices.

The bilevel structure of the proposed GEP captures the interaction between a *central planner* — who optimizes investments, unit commitment, and policy targets at the upper level — and the *market operator* — who clears the zonal day-ahead market at the lower level. To account for revenues, the model includes bilinear terms, namely quantities and prices, with the latters defined as the dual variable of the lower level balance constraint. We develop an exact linearization method, and propose two novel constraint blocks: one to prevent strategic withholding of capacity and another to address price indeterminacy.

To enhance the tractability of the reformulated model, which is Mixed-Integer Quadratically Constrained, we introduce specialized cuts and develop auxiliary problems that effectively warm start the model, finding an upper bound of the primal solution by mimicking the hierarchical relationship between levels. Furthermore, to address the task of proving optimality, we propose a 'hybrid' approach that combines different formulations for complementarity slackness conditions of the lower-level problem.

The resulting model is applied to a realistic Italian case study to validate its effectiveness in supporting robust and revenue-adequate investment decisions.

*Keywords*: Generation expansion; Missing money; Revenue adequacy; Side payments; Bilevel model; Mixed-integer bilinear programming; Hybrid complementarity slackness conditions; Warm start.

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**Martina Gherardi** holds a PhD in Engineering and Applied Sciences from the University of Bergamo. Her research focuses on mixed-integer bilevel optimization problems, with a specific interest in the energy sector. During her doctoral studies, her applied research was supported by a leading consulting group and she carried out part of her research at the Denmark Technical University. She currently works with ENI, where she continues to deepen her expertise in market analysis and real-world optimization model development, addressing both short-term operational challenges and long-term planning.

# A fresh view on the Security Games Problem

**Lina Mallozzi [1], Justo Puerto [2], Francisco Temprano [2]**

[1] University of Naples Federico II, Naples, Italy
[2] University of Seville, Seville, Spain

**Abstract:** Security games is a classic problem in Game theory, where two different player roles can be distinguished, attackers and defenders. Indeed, the original problem presented by [1] is defined as a two-player game between a defender and an attacker. Each of the players will make a decision based on its role and its profit/pay-off function in the Security game. Specifically, we have analyzed them as Stackelberg games where the defenders play the leader role and attackers the follower role. The case where there is just one defender and a set of possible attackers to face is deeply studied and analyzed in [2]. In this talk, we consider two variants of the above problem. The first one consists of multiple defenders that can cooperate to increase their benefits, and the second one contemplates the possibility of limiting the attacker decision space as a decision of the defenders. The solution structures of these new problems are analyzed and compared with the ones of the original problems.

*Keywords*: Bilevel optimization; Game theory; Stackelberg equilibrium.

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**Francisco Temprano García** is a PhD candidate in the Department of Statistics and Operations Research at University of Seville, who defended his thesis on March 24th this year. Their research focuses on optimization problems in Complex Networks clustering, transportation and Location, particularly in Community Detection and other combinatorial problems, using pure Mathematical Programming methods and techniques as Decomposition Methods and others.

# Plenary Session III

Thursday, October 16th | 14:30 – 15:30

**Chair:** Adriano Masone

**Dolores Romero Morales**
Local Explainability in Machine Learning: A collective framework

# Local Explainability in Machine Learning: A collective framework

**Dolores Romero Morales**

Department of Economics, Copenhagen Business School (Denmark)

**Abstract:** State-of-the-art Artificial Intelligence (AI) and Machine Learning (ML) algorithms have become ubiquitous across industries due to their high predictive performance. However, despite their widespread deployment, these models are often criticized for their lack of transparency and accountability. Their “black-box” nature obscures the reasoning behind decisions, limiting trust and hindering their integration in critical, data-driven decision-making processes. Moreover, algorithmic decisions can perpetuate or even amplify societal biases, leading to unfair and discriminatory outcomes. This concern is especially pressing in high-stakes domains such as healthcare, criminal justice, and credit scoring, where unfair model behavior can significantly impact individuals’ lives.

In the burgeoning field of Explainable Artificial Intelligence, the goal is to shed light on black-box machine learning models. Local Interpretable Model-Agnostic Explanations (LIME) is a popular tool, that, given a prediction model and an instance, builds a surrogate linear model which yields similar predictions around the instance. When LIME is applied to a group of instances, independent linear models are obtained, which may hinder overall explainability.

In this talk we propose a novel framework, called Collective LIME (CLIME), where the surrogate models built for the different instances are linked, being smooth with respect to the coordinates of the instances. With this collective approach, CLIME enables one to control global sparsity, i.e., which features are used ever, even if sparse models are built for each instance. In addition, CLIME builds Generalized Linear Models as surrogates, enabling us to address with the very same methodology different prediction tasks: classification, regression, and regression of counting data. We will show how classic Operations Research models, such as the Knapsack Problem, are relevant to obtain satisfactory CLIME solutions. We will end the talk illustrating our approach on a collection of benchmark datasets.

**Dolores Romero Morales** is a professor of Operations Research at Copenhagen Business School, Denmark. Her areas of expertise include explainability and fairness in data science as well as sustainable supply chain management. Dolores currently serves as the Editor-in-Chief of TOP and as an associate editor of the Journal of the Operational Research Society as well as the INFORMS Journal on Data Science. Moreover, she is an Honorary SAS Fellow and a member of the SAS Academic Advisory Board. Among her recent achievements, Dolores (together with her co-authors) was awarded the 2024 Spanish Society of Statistics and Operations Research — BBVA Foundation Award for the best contribution in statistics and operations research applied to data science and big data published in the European Journal of Operational Research. Beyond research, Dolores actively supports early-career researchers through initiatives such as YoungWomen4OR, a program within the EURO WISDOM Forum that aims at increasing the visibility of young female researchers in operations research across EURO.

# Session VII

# Advanced Optimization Techniques for Complex Systems

Friday, October 17th | 08:30 – 09:30

**Chair:** Bárbara Rodrigues

**Farzaneh Safari**
Inverse Cauchy problem in the framework of an RBF-based meshless technique and trigonometric basis functions

**Ties Schalij**
Structure-Aware Heuristic Improvement via Policy Iteration

**Bárbara Rodrigues**
Combined Scenario Reduction and Discretization for Time Series Data

# Inverse Cauchy problem in the framework of an RBF-based meshless technique and trigonometric basis functions

**Farzaneh Safari**[1]

[1] Jiangsu Engineering Research Center of Bamboo and Wood Carbon Fixation Materials and Structures, Nanjing Forestry University, Nanjing 210037, China

**Abstract:**The purpose of this paper is to point out that it is possible to evaluate the approximation solution of elliptic Partial differential equations (PDEs) on regular and irregular domains where no boundary conditions are defined on some part of the boundary domain. In the presence of trigonometric basis functions (TBFs), the backward substitution method (BSM) coupled with the radial basis functions neural network (RBFNN) is implemented very easily and works well. As a result, the approximation of the boundary conditions and the approximation of the PDE inside the solution domain is separated. The particular solution with an ungiven part of the inhomogeneous boundary condition is completely analyzed by the RBFNN method, and the efficiency and accuracy of the developed algorithms are discussed [1, 2].

*Keywords*: Complex geometries, Ill-conditioning, Collocation Procedure, Inverse Problem

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**Farzaneh Safari** is currently working as a full-time Associate Professor in Nanjing Forestry University, Nanjing, Nanjing, China. Her research orientation focused on computational mechanics, computational mathematics, inverse problems, neural networks, meshless methods, etc. Prof. Farzaneh earned her Postdoctoral in Mechanics with distinction from, Hohai University, Nanjing, China, in 2020. Dr. Farzaneh has Published 20 well-researched scholarly papers as the first or corresponding author in peer-reviewed, refereed reputed International Journals Indexed in SCI, Q1.

# Structure-Aware Heuristic Improvement via Policy Iteration

**Ties Schalij[1], Cristian Dobre[1], Juan Vera[1]**

[1] Tilburg University, Tilburg, the Netherlands

**Abstract:** Heuristics in combinatorial optimization are usually oblivious to specific instance classes, presenting a clear opportunity for enhancing performance. We introduce an innovative approach that enhances existing heuristics via Reinforcement learning. By encoding the corresponding combinatorial optimization problem as an infinite Markov Decision Process (MDP), we can interpret heuristics as policies for this MDP. By leveraging policy iteration, we provide a principled and systematic way to improve heuristic performance tailored to a given instance class, rather than merely crafting a new heuristic for each class (cf. [2], and references therein). At the core of our strategy is a finite state space approximation of the MDP that reflects the nuances of the execution of the heuristic in the given instance class. We showcase the effectiveness of our approach by enhancing the greedy heuristic for the Knapsack problem across a diverse range of instance classes, including well-established generators from the literature [3] and instances generated through column generation in the Bin Packing problem [1]. Remarkably, our method achieves an average reduction of 20% in the optimality gap for the targeted class of instances.

*Keywords*: heuristic improvement; Markov decision processes; combinatorial optimization; knapsack problem

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**Ties Schalij** is a second-year PhD candidate in the Department of Operations Research at Tilburg University. His research focuses on improving heuristics for combinatorial optimization problems using reinforcement learning. With a background in Econometrics and Business Analytics, he aims to develop general, theoretically grounded methods that make heuristic design more efficient, systematic, and broadly applicable.

# Combined Scenario Reduction and Discretization for Time Series Data

**Bárbara Rodrigues[1], Miguel F. Anjos[2], Luce Brotcorne[1], Marius Roland[1]**

[1] INRIA Lille Nord-Europe, Lille, France
[2] University of Edinburgh, Edinburgh, UK

**Abstract:** Stochastic optimization models often rely on scenario-based representations of uncertainty. However, such representations can become computationally intractable due to the size of the resulting models. This has led to a branch of stochastic programming literature focused on scenario reduction, which aims to improve tractability by approximating the original intractable scenario set with a smaller surrogate set. While this approach has proven effective in practice and received significant attention, it often overlooks the temporal aspect of scenarios, particularly in problems where each scenario represents a time series. Many famous optimization problems, such as unit commitment [4], vehicle routing [2], and nuclear power plant scheduling [3], fall under this category. For such problems, the temporal aspect is traditionally handled in two sequential phases: first, an equidistant discretization of time-steps is selected, and then scenario reduction is applied. However, this sequential approach may lead to a set of surrogate scenarios that poorly approximate the original scenario set. In this work, we address the problem of scenario reduction for time series data by considering the simultaneous reduction of both the number of scenarios and the number of time-steps. We formalize this joint reduction problem as a distance-minimization task over distributions, combining the optimal transport-based scenario reduction framework of [5] with the path-based temporal discretization introduced in [1]. For the continuous scenario reduction problem, we derive a convex mixed-integer reformulation and demonstrate that the underlying model can be significantly simplified. Due to the computational complexity of the novel problem, we also propose a mathheuristic method inspired by the well-known k-means algorithm. We demonstrate the benefits of combining scenario reduction and time series discretization. Specifically, we compare the effect of using different scenario reduction methods to parametrize decision-making problems where scenarios represent time series data.

*Keywords*: Stochastic Optimization; Scenario Reduction; Time Series Discretization Reduction.

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**Bárbara Rodrigues** is a postdoc researcher at the INOCS optimization group of the INRIA Lille Nord-Europe research lab. Before joining INRIA, she submitted her PhD thesis in Optimization and Operational Research at the School of Mathematics of the University of Edinburgh. Her research focuses optimization problems in the energy sector, with a particular interest in hierarchical bilevel decision-making, and stochastic optimization to handle uncertainties.

# Session VIII
# Industrial Applications I

Friday, October 17th | 09:30 – 10:30

**Chair:** Christian Truden

**Nandan Kumar Singh**
Optimal Investment in Resiliency in Presence of Spot Market Demand: A Generalized Distribution Approach

**Vittoria Crotti**
OR and ML techniques supporting security service companies

**Christian Truden**
Service Network Design with Fleet and Emissions Management at Scale

# Optimal Investment in Resiliency in Presence of Spot Market Demand: A Generalized Distribution Approach

**Nandan Kumar Singh[1], Nishant Kumar Verma[2], Milan Kumar[3]**

[1] FORE School of Management, New Delhi
[2] Indian Institute of Management, Bangalore
[3] Indian Institute of Management, Visakhapatnam

**Abstract:** This study examines the value of optimal investment in resilience measures aimed at minimizing the expected financial impact (FI) of supply chain disruptions. We develop a strategy that helps a firm optimally allocate its investment in resilience, ensuring that the cost of investment is justified by a greater reduction in the expected FI. Specifically, we consider the presence of both a primary customer and a spot market. In the event of a disruption, a firm must decide how to allocate its limited buffer between these two markets. While a higher investment enables the firm to hedge against disruption risks, the optimal allocation strategy must balance the trade-off between contractual obligations to the primary customer and potential revenue from the spot market.

Using a two-period stochastic optimization model, we capture the uncertainty in the length of disruption through a generalized probability distribution. We are able to derive closed-form expressions for both the optimal investment in resilience and the optimal allocation of buffer inventory in the second period. The analysis reveals interesting strategic behavior: Under certain conditions, it is optimal for the firm to allocate its entire limited buffer to the spot market, whereas, in other scenarios, the firm completely avoids participating in the spot market and prioritizes fulfilling obligations to the primary customer. These results underscore the importance of understanding disruption characteristics and market conditions when designing resilience strategies.

Our research finds that a firm's investment in resilience is closely tied to its strategic decision on whether to serve the spot market during a disruption. Specifically, our research aids managers in identifying the conditions under which it is optimal to serve both the spot and primary markets or to focus exclusively on one — either the spot market or the primary customer. Furthermore, we show how the optimal investment in resilience varies across these scenarios, providing actionable insights for firms seeking to balance risk mitigation with market opportunities during disruptions.

*Keywords*: Disruption; Investment; Resilience; Spot Market.

**Nandan K Singh** is an Assistant Professor in the Operations Management and Decision Science Area at FORE School of Management, New Delhi, India. He was a postdoctoral fellow in Production and Operations Management Department at the Indian Institute of Management Bangalore. He holds a PhD, Production and Operations Management Area, from the Indian Institute of Management Visakhapatnam and has previously served as a Visiting Research Scientist at New York University, USA. Nandan also holds a Micro Masters credential in Supply Chain Management from the Massachusetts Institute of Technology (MIT), Centre for Transportation and Logistics.

# OR and ML techniques supporting security service companies

**Vittoria Crotti**[1]

[1] Multiprotexion s.r.l., Gropello Cairoli (PV), Italy

**Abstract:** Multiprotexion is a company located in Northern Italy that provides high-security services. The agency has two core business areas: vehicle security and building security.

Vehicle security includes services for the surveillance of international transport vehicles and facilities, with the option of Telematics Escorts for vehicles and companies transporting goods of high monetary value. The company offers multiple services, including a 24/7 Operations Centre that manages alarms received from drivers.

Building security focuses on the surveillance of sensitive sites, such as warehouses and logistics facilities, using advanced technologies like AI-powered cameras, which are constantly monitored by the Operations Centre.

The Data Science team works across several areas. An important focus is the optimization of internal procedures through Operations Research, such as optimized scheduling, as well as services for customers, like route optimization. Additionally, the team provides analytical insights that support data-driven decision-making and helps in the process of constantly renovating procedures. In my talk, I will present an overview of the agency and highlight the Data Science team's work, such as the machine learning techniques we intend to implement to assist operators or the specialized analyses we are carrying out for our clients.

**Vittoria Crotti** has been a member of the Data Science Team at Multiprotexion for two years. She holds a Bachelor's degree in Mathematics from the University of Pavia.
At Multiprotexion, her work focuses on data analysis, project coordination for data-driven initiatives, and process optimization. She is also involved in research projects in collaboration with the Operations Research group of the Department of Economics at the University of Brescia, with which Multiprotexion has maintained an active partnership for several years.

# Service Network Design with Fleet and Emissions Management at Scale

**Christian Truden [1], Mike Hewitt[2]**

[1] Department of Operations, Energy, and Environmental Management, University of Klagenfurt, Klagenfurt, 9020 Austria
[2] Quinlan School of Business, Loyola University Chicago, Chicago, IL 60611, USA

**Abstract:** Less-than-truckload (LTL) carriers often operate transportation networks covering vast geographic areas - frequently spanning the entire contiguous United States - and deploy large fleets of trucks. In these networks, resource prices vary significantly from region to region, especially between states as well as between urban and rural areas. The complexity increases further when carriers consider introducing sustainable power-train technologies such as battery-electric or hydrogen-electric heavy-duty tractors. The Service Network Design problem with Fleet and Emissions Management (SND-FEM) [1] accounts for these factors by including multiple power-train technologies and incorporating spatial variations in fuel prices and Scope 2 emissions associated with the energy sources used by these tractors. However, LTL carriers face very large SND-FEM instances, making exact solution methods inapplicable. To address this challenge, we propose a path-based heuristic that constructs and explores alternative routes between network terminals. Our approach employs a two-level representation of the underlying road network, which simplifies resource-related considerations during path construction. We present initial results demonstrating the effectiveness of our heuristic in solving realistic SND-FEM scenarios.

*Keywords*: Service Network Design; Heuristics; Variable Neighborhood

## References

[1] Truden, C. & Hewitt, M. (2024). "The service network design problem with fleet and emissions management", *Transportation Research Part C: Emerging Technologies*, 166:104769.

**Christian Truden** is a postdoctoral researcher in the Department of Operations, Energy, and Environmental Management at the University of Klagenfurt. His work focuses on complex variants of the vehicle routing problem, employing both exact and heuristic approaches. His research also integrates statistical methods and geo-information technologies. He earned his PhD from the Department of Mathematics at the University of Klagenfurt. Prior to joining his current department, he worked in a research lab specializing in simulation techniques. He also gained industry experience through collaborative projects with an international retailer and by working at a startup dedicated to implementing optimization-driven logistics solutions.

# Plenary Session IV

Friday, October 17th | 11:00 – 12:00

**Chair:** Alan Osorio-Mora

**Maurizio Boccia**
Exact and ML-guided Matheuristic approaches for a Truck-and-Drone delivery problem

# Exact and ML-guided Matheuristic approaches for a Truck-and-Drone delivery problem

**Maurizio Boccia**

Department of Electrical Engineering and Information Technology,
University of Naples Federico II (Italy)

**Abstract:** The growth of e-commerce has increased the demand for fast deliveries, encouraging the use of drones in logistics. Despite benefits such as speed and lower costs, drones have limited range and capacity. To address this, hybrid truck-and-drone systems have been proposed, in which the truck also acts as a drone base. In particular, the Flying Sidekick Traveling Salesman Problem (FS-TSP) is a foundational model aimed at minimizing delivery time through coordinated use of both vehicles. In this talk, we will explore different formulations proposed in literature for this problem and present a comparison between branch-and-cut and branch-and-price approaches to solve the FS-TSP. Finally, we investigate the development of novel matheuristic approaches that, for each instance, address a reduced-complexity version of the original problem, obtained through the application of data science and machine learning methods

**Maurizio Boccia** is a full professor of Operations Research at the University of Naples Federico II, Italy. His research interests include large-scale linear integer programming and the development of exact and heuristic methods for complex combinatorial and network optimization problems, with applications in scheduling, location, routing, and location-routing. He also focuses on truck-and-drone routing problems and has collaborated with several international institutions, including CORE (Belgium), SINTEF ICT (Norway), and the University of Quebec-Montreal. He is a member of the Board of Professors of the Ph.D. program in Information Technology and Electrical Engineering (ITEE) at the University of Naples Federico II. He has been the scientific coordinator of multiple European, national, and regional research units, as well as numerous collaborations with private companies such as OptRail S.r.l., NGI SpA, ITALTEL SpA, Elasis SpA, and ITALDATA SpA.

# Session IX

# Game Theory and Combinatorial Optimization

Friday, October 17th | 12:10 – 13:30

**Chair:** Carmine Sorgente

**Alejandro Bernárdez Ferradás**
Dirichlet Values for Balanced Games

**Mariagrazia Cairo**
Bi-Objective Minimum Spanning Tree Problem: a comparison between a distributed and a parallel approach

**Alberto Boggio Tomasaz**
On the Construction of Resilient Samples for Binary Interdiction

**Carmine Sorgente**
Branch-and-cut algorithms for colorful components problems

# Dirichlet Values for Balanced Games

**Alejandro Bernárdez Ferradás[1], Miguel Ángel Mirás Calvo[2], Estela Sánchez-Rodríguez[3]**

[1,3] SiDOR, Universidade de Vigo, Departamento de Estatística e Investigación Operativa, CITMAga, Vigo, Spain
[2] RGEAF, Universidade de Vigo, Departamento de Matemáticas, Vigo, Spain

**Abstract:** A coalitional game $(N, v)$ is balanced if its core is non-empty, or equivalently, if the linear program $\min \sum_{i \in N} x_i$ subject to $\sum_{i \in S} x_i \geq v(S)$ for each $S \in 2^N \backslash \emptyset$, has a solution and its value is $v(N)$. The solutions of this LP are the core allocations, and that set, when non-empty, is convex and compact [2]. When the game is balanced, finding single-valued solutions in the core that are supported by appealing axioms is a topic of interest. The core-center is the mean of the uniform distribution over the core and thus corresponds to its centroid [3].

In this paper, we introduce a new family of values for positive balanced games, which we call the Dirichlet values. These values are defined using the Dirichlet distribution, a multivariate distribution defined over the regular simplex, so it can be thought of as a probability distribution over the possible divisions of one unit among $n$ agents [4]. The new values are defined as expected values of the conditional distribution of a Dirichlet distribution over the core of the game. A notable member of this family is the core-center, which corresponds to the flat Dirichlet distribution.

We study their basic properties and discuss the interpretation as weighted values. Interestingly, we relate the presence of clone players to the Dirichlet values, and we find a subclass of games where the core-center of each group of clones can be obtained through a Dirichlet value with appropriate parameters. Remarkably, this reduces the dimensionality of the problem in the presence of clones, at the cost of considering the multivariate Dirichlet distribution in the reduced space. In particular, games associated with airport problems belong to that class [1].

*Keywords*: Coalitional games; core; Dirichlet distribution; weighted values; core-center.

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**Alejandro Bernárdez Ferradás** is a PhD candidate in the Department of Statistics and Operations Research at the Universidade de Vigo. His research focuses on game theory, particularly on analyzing the influence of weights and clones in coalitional games, with concrete applications to economic problems. Before starting his PhD, he earned a Bachelor’s degree in Economics and a Master’s degree in Statistics and Operations Research. He also worked as a Data Analyst at Hijos de Rivera, S.A.U.

# Bi-Objective Minimum Spanning Tree Problem: a comparison between a distributed and a parallel approach

**Lavinia Amorosi[1], Mariagrazia Cairo[1], Paolo Dell'Olmo[1], Umberto Ferraro Petrillo[1]**

[1] Department of Statistical Sciences, Sapienza University of Rome, P.le Aldo Moro 5, Rome 00185, Italy

**Abstract:** Multi-objective combinatorial programs are characterized by the simultaneous optimization of multiple objectives over a discrete feasible set. They are often NP-hard and the generation of their complete Pareto frontier is time consuming. This work presents a comparison between a distributed [1] and a parallel approach with respect to their sequential counterpart of a two-phase algorithm [3] for the bi-objective minimum spanning tree (BMST) problem [2]. They are designed to speed up the search for efficient solutions [4]. In the first phase, the extreme supported efficient solutions are computed by resorting to an algorithmic approach (Prim's algorithm embedded in a parametric search implemented according to Aneja and Nair algorithm [5]). In the second phase, the non-extreme supported and non-supported efficient solutions are determined leveraging the information provided by the ones generated in the first phase. In the latter, both distributed and parallel approaches are adopted for the generation of all spanning trees of a connected graph. These are determined via a recursive procedure based on increasing evaluation of reduced costs of associated weighted linear programs. The strengths and potential bottlenecks of these approaches, which emerged during the computational experiments, are discussed.

*Keywords*: Bi-Objective Minimum Spanning Tree; Distributed Algorithm; Parallel Algorithm; Two-phase Methods.

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**Mariagrazia Cairo** is a PhD candidate in the Department of Statistical Sciences at Sapienza University of Rome. Her research mainly focuses on multi-objective discrete optimization (MODO) problems and mathematical optimization for statistics and machine learning.

# On the Construction of Resilient Samples for Binary Interdiction

**Alberto Boggio Tomasaz, Roberto Cordone**

Università degli Studi di Milano, Italy

**Abstract:** Binary interdiction problems are turn-based games involving two agents: the *attacker* (leader) and the *defender* (follower). Both agents act on an instance of an optimization problem, aiming to optimize the same objective function but in opposite directions. The attacker selects a limited set of elements to disable, aiming to deteriorate as much as possible the optimal value that the defender can achieve. The defender then solves a standard combinatorial optimization problem (e.g., shortest path, knapsack, clique, ...) on the residual instance.

These problems have been extensively studied in the literature [3], as they capture a wide range of real-world adversarial scenarios (e.g., military defense, epidemic containment, anti-smuggling operations, ...). A challenging aspect of interdiction problems is computing a narrow range for the optimal solution value. Indeed, to the best of our knowledge, no existing technique or algorithm is capable of efficiently computing a super-optimal estimate with certainty.

In this work, we propose a method to obtain such an estimate, based on the novel concept of a *Resilient Sample*. A Resilient Sample is a set of defender solutions such that no feasible attack can interdict all of them simultaneously. This approach not only yields a meaningful estimate, but also provides a useful initial set of defender solutions for algorithms tackling interdiction problems, many of which rely on sampling such solutions [2]. In addition, it offers the defender a form of "recovery plan", ensuring that after any feasible attack, at least one solution in the set remains available.

We present a polynomial-time technique to compute a Resilient Sample for the Shortest Path Interdiction Problem, based on flow computations and path decompositions. We then generalize the same technique to a broader class of interdiction problems, still ensuring polynomial-time computability.

For more general interdiction problems, where such a specific approach is not applicable, we introduce a heuristic method that attempts to compute a Resilient Sample, although without guarantees of success or polynomial runtime.

Finally, we propose a dedicated technique for problems whose solution space resembles that of the knapsack problem. This method also runs in polynomial time and guarantees the construction of a Resilient Sample.

*Keywords*: binary interdiction; resilient sample; super-optimal estimate; recovery plan; network security.

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**Alberto Boggio Tomasaz** is a Research Fellow in the Department of Computer Science at University of Milan. Their research focuses on algorithms and methods for interdiction problems. The title of their thesis, defended in December 2024, is "Optimisation and Interdiction Problems for Network Safety" [1].

# Branch-and-cut algorithms for colorful components problems

**Claudia Archetti[1], Martina Cerulli[2], Carmine Sorgente[3]**

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**Abstract:** We tackle three optimization problems in which a colored graph, where each node is assigned a color, must be partitioned into *colorful components*, namely, connected subgraphs whose vertices have different colors from others in the same component. The problems differ in the objective function, according to which we: *(i)* minimize the number of removed edges; *(ii)* minimize the number of connected components; or *(iii)* maximize the number of edges in the transitive closure of the output graph [1–3]. These problems have applications in community detection, cybersecurity, and bioinformatics. We present integer non-linear formulations, which are then linearized using standard techniques. To solve these formulations, we develop exact branch-and-cut algorithms, embedding valid inequalities, bounds limiting the number of variables, and warm-start and preprocessing techniques. Benchmark instances are tested to computationally demonstrate the effectiveness of the proposed procedures.

*Keywords*: graphs; colorful components; bioinformatics; social networks.

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**Carmine Sorgente** is a Postdoctoral Researcher in the Department of Mathematics at University of Salerno (Italy). He obtained his PhD from the same university in January 2024, defending a thesis entitled *Network optimization problems under survivability and incompatibility constraints.* His research focuses on graph optimization, with particular reference to graph partitioning and graph modification problems with applications in social networks, as well as optimization problems with conflict constraints. To approach these problems, he primarily employs mixed-integer programming techniques, including branch-and-cut algorithms, as well as heuristic and matheuristic approaches.

# Panel Session

## Challenges and Decisions that Shape Academic Careers in Operational Research

Friday, October 17th | 14:30 – 15:30

**Chair:** Laura Davila Pena

**Maurizio Boccia**

**Dolores Romero Morales**

**Martin Schmidt**

**Maria Grazia Speranza**

# Challenges and Decisions that Shape Academic Careers in Operational Research

**Maurizio Boccia[1], Dolores Romero Morales[2], Martin Schmidt[3], M. Grazia Speranza[4]**

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[2] Copenhagen Business School, Denmark
[3] Trier University, Germany
[4] University of Brescia, Italy

**Abstract:** The development of a career in Operational Research, whether in academia, industry, or the public sector, entails a series of complex decisions, evolving challenges, and formative experiences. Understanding these processes is crucial for supporting the next generation of researchers and practitioners in navigating the dynamic landscape of the field. This panel brings together the conference's plenary speakers for a reflective dialogue with early-career participants, exploring the milestones, turning points, and lessons that have shaped their professional journeys.

Through discussion of their experiences across different sectors, panelists will address the interplay between research, application, and impact in Operational Research, highlighting the skills, strategies, and values that sustain a meaningful career. The conversation will also consider how individual decisions intersect with broader structural and societal factors influencing the profession today.

By fostering interaction between established experts and emerging professionals, this session enhances the conference's commitment to mentorship, professional development, and community building. It aims to inspire reflection on the multiple pathways available within Operational Research and to strengthen the connection between academic inquiry and real-world problem solving.

# Session X
# Industrial Applications II

Friday, October 17th | 15:30 – 16:50

**Chair:** Matteo Cosmi

**Sayeh Fooladi Mahani**
Optimizing electric carsharing systems for sustainable mobility and grid load management

**Paula Terán Viadero**
Exact and Heuristic Approaches for the 2D Cutting Stock Problem with variable-sized stock

**Çiya Aydoğan**
Tail Assignment Problem with Hour-to-Cycle Ratio Constraints: A Branch and Price Algorithm

**Matteo Cosmi**
The profitability-sustainability trade-off in complex chemical value chains under product-specific carbon footprint constraints

# Optimizing electric carsharing systems for sustainable mobility and grid load management

**Sayeh Fooladi Mahani[1], Masoud Golalikhani[1], Beatriz Brito Oliveira[1]**

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**Abstract:** Urbanization is rapidly increasing, presenting significant challenges for sustainable urban mobility, such as rising transportation emissions [3]. European cities aim to reduce greenhouse gas emissions by 2030 to support sustainability [2]. Electric vehicle (EV) car-sharing systems offer a promising solution to more sustainable urban mobility by reducing greenhouse gas emissions [5]. While recent studies have highlighted the ecological benefits of EV carsharing systems in urban environments, designing these systems effectively presents unique challenges, particularly in ensuring adequate electricity supply for charging vehicles [1]. As EV adoption grows, it can strain the electricity grid during peak demand, potentially leading to outages [4].

To support the growth of EV-based car-sharing systems as a sustainable mode of mobility, this research focuses on mitigating grid congestion and improving fleet management to enhance electrical grid stability. To this end, we develop an optimization model that integrates effective grid management strategies, such as incorporating renewable energy sources with grid power. A key aspect of the model is considering the communication between car-sharing companies and Distribution System Operators (DSOs), addressing a crucial yet often overlooked element in this context. The application of the model to a real case study will offer valuable managerial insights into the planning and operations of the EV car-sharing system, empowering carsharing operators to ensure grid stability and ultimately making the business more profitable and sustainable. The model will define key decisions, constraints, and necessary inputs from DSOs to ensure efficient operation and grid stability, focusing on optimizing fleet management and grid load.

*Keywords*: EV-based carsharing; grid load management; renewable energy; Distribution System Operators.

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**Sayeh Fooladi Mahani** is a PhD candidate in Industrial Engineering and Management at the University of Porto. Her research aims to optimize EV carsharing systems for sustainable urban mobility, focusing on grid load management and renewable energy integration. She employs deterministic and stochastic models to address uncertainties in urban transportation. Previously, she worked as a Data Analyst, gaining experience in data-driven decision-making for urban transportation.

# Exact and Heuristic Approaches for the 2D Cutting Stock Problem with variable-sized stock

**Paula Terán Viadero[1, 3], Antonio Alonso Ayuso[2], F. Javier Martín Campo[3]**

[1] Dept. Financial and Actuarial Economics & Statistics, Complutense University of Madrid, Spain
[2] DSLAB - CETINIA, Universidad Rey Juan Carlos, Móstoles, Madrid, Spain
[3] Interdisciplinary Mathematics Institute, Complutense University of Madrid, Madrid, Spain

**Abstract:** The two-dimensional cutting stock problem (2DCSP) involves cutting large rectangular panels into smaller required pieces while minimizing material waste. The problem becomes significantly more complex when the stock dimensions are not predefined and must be decided, leading to the two-dimensional cutting stock problem with variable-sized stock (2DVSCSP). The literature on the 2DVSCSP is limited, the problem was introduced in K. Hadj Salem et al. (2023) [1] applied to the textile sector. Later, P. Terán-Viadero et al. (2024) [2] presented a model for a simplified version where only 1-item patterns were considered and P. Terán-Viadero et al. (2024) [3] presented a mixed-integer linear optimisation model for 2-stage exact guillotine cutting patterns able to generate $n$-item patterns allowing to tackle much more complex problems.

In this work, we present and compare exact algorithms and metaheuristic approaches to efficiently tackle the 2DVSCSP. We analyze the trade-offs between solution accuracy, computational efficiency, and scalability, emphasizing the advantages and limitations of each method. Additionally, we provide insights into how different industry-specific requirements influence the choice of the most suitable approach. Our findings aim to guide decision-makers in selecting the most effective optimization strategy based on practical constraints, computational resources, and production needs.

*Keywords*: Cutting; Variable-sized stock; Mixed integer linear optimisation; 2-stage guillotine.

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**Paula Terán-Viadero** is a PhD in Operations Research, particularly dealing with Cutting and Packing problems. She received her PhD in June 2024 by the Complutense University of Madrid (UCM). She has worked in the private sector, developing integer linear mathematical optimisation models to solve problems arising from real-world applications. Since January 2025 she is an assistant professor at the University Complutense of Madrid.

# Tail Assignment Problem with Hour-to-Cycle Ratio Constraints: A Branch and Price Algorithm

**Çiya Aydoğan[1], Sinan Gürel[1]**

[1] Middle East Technical University/Industrial Engineering, Ankara, Turkey

**Abstract:** Operating leases have become a widely adopted method for aircraft acquisition in the airline industry. However, such leases often impose operational constraints on lessees, including target hour-to-cycle ratios that reflect engine wear and maintenance requirements. Failure to satisfy these targets within designated periods may lead to significant financial penalties in the form of supplementary lease payments. This study addresses the Tail Assignment Problem under hour-to-cycle ratio constraints, as initially introduced in [1]. We propose an exact branch and price algorithm to solve this problem efficiently. To enhance the algorithm's practical performance, we integrate a beam search based method that quickly generates high quality feasible solutions and develop a dancing links based heuristic to provide tight upper bounds. Computational results demonstrate that our branch and price algorithm significantly outperforms a state of the art commercial solver (CPLEX) applied to a connection network-based formulation. The proposed method successfully solves instances involving up to 60 aircraft and 450 flights to optimality.

*Keywords*: Airline Scheduling; Branch and Price Algorithm; Beam Search Algorithm; Dancing Links Algorithm.

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**Çiya Aydoğan** is a PhD candidate in the Department of Industrial Engineering at Middle East Technical University. He received his BS and MS degrees from the same department, where he has been working as a research assistant. His research interests include robotic cell scheduling and airline scheduling problems.

# The profitability-sustainability trade-off in complex chemical value chains under product-specific carbon footprint constraints

**Matteo Cosmi[1], Joachim Arts[1], Steffen Klosterhalfen[2]**

[1] University of Luxembourg/Luxembourg Centre for Logistics and Supply Chain Management, Luxembourg, Luxembourg

[2] BASF/AI Solutions, Stockport, United Kingdom/

**Abstract:** The global effort to combat climate change has led many countries to adopt legally binding net-zero targets for the next 25–30 years. To address this challenge, the United Nations (UN) has led several international agreements over the past decades, including the Kyoto Protocol (1997) and the Paris Agreement (2015) [1], aimed at reducing GHG emissions worldwide. The European Green Deal [2], outlines the European Union's ambition to reach net-zero GHG emissions by 2050. These ambitious targets indicate that, in the coming years, there will be a growing emphasis on developing more sustainable products. Since indirect emissions are also considered in product footprint, a key strategy for companies is to require suppliers to produce cleaner products by meeting strict emissions standards per unit or weight. From a supplier's perspective, this means producing goods with a carbon footprint that falls below a predetermined threshold set by agreements with customers. Given that different customers may impose varying sustainability requirements, the same type of product may need to be manufactured using different processes and input materials, each with a distinct carbon footprint. This study introduces the Product-Specific Carbon Footprint Optimization (PSCFO) problem, a deterministic multi-objective supply-chain model aimed at minimizing $CO_2$ emissions while maximizing a company's total contribution margin. The objective is to achieve these goals while ensuring compliance with external customer demands for product-specific carbon footprint limits. To address the PSCFO problem, we propose a bilinear programming model using a "flow-like" formulation based on existing models for the pooling problem [3, 4] and for chemical value chain optimization [5].

*Keywords*: Sustainable supply chain, green supply chain, production-distribution planning, multi-objective optimization.

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**Matteo Cosmi** is a Postdoctoral Researcher at the Luxembourg Centre for Logistics and Supply Chain Management, University of Luxembourg. His research focuses on linear and mixed integer programming with applications in supply-chain, food-delivery and last-mile delivery. Before starting his PostDoc, he worked as a Research Scientist at LINKS Foundation (Turin, Italy) and as a Quantitative Developer at Ladbrokes Coral (London, UK) gaining experience in optimization and machine learning for applications in transportation and sportsbook industry.

# Session XI
# Scheduling Problems

Friday, October 17th | 17:20 – 19:00

**Chair:** Martina Doneda

**Alex Barrales-Araneda**
A Heuristic Algorithm for Sequential Timetabling and Electric Vehicle Scheduling in Public Transport

**Roberto Maria Rosati**
Multi-Neighborhood Search for the AGV Scheduling Problem with Battery Constraints

**Miguel Chastre**
Joint Optimization for the Scheduled Joint Replenishment Problem

**Martina Doneda**
A data-driven tool for operating rooms advance scheduling

# A Heuristic Algorithm for Sequential Timetabling and Electric Vehicle Scheduling in Public Transport

**Alex Barrales-Araneda[1], Valentina Cacchiani[1] Emanuele Tresoldi[2]**

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[2] Department of Computer Science "Giovanni degli Antoni", University of Milan, Via Celoria 18, 20135, Milan, Italy

**Abstract:** Public transport companies are facing the challenge of achieving passengers' satisfaction and utilizing electric buses to improve sustainability and reducing emissions. This study addresses two problems, namely Timetabling (TT) and Vehicle Scheduling (VS), for public transport systems that employ mixed fleets of electric and internal combustion engine buses. The use of electric buses introduces additional constraints, such as limited travel range and necessity for adequate charging infrastructure, making the bus scheduling problem more complex (see e.g., [2]). We propose a sequential heuristic approach, based on Integer Linear Programming models, that initially optimizes the TT to ensure compliance with service frequencies and operational regularity and then solves the VS, which efficiently assigns vehicles while considering common and electric-specific constraints. The objective function of TT accounts for passengers' satisfaction, while that of VS considers operational costs given by vehicle utilization, idle times, deadhead journeys, and $CO_2$ emissions. TT is modelled in a similar way as in [1], while for VS we employ an exponential-size model. The developed heuristic algorithm provides an effective tool for managing the complexities of electric vehicles and meeting the diverse needs of modern urban transport systems.

*Keywords*: public transport; electric vehicle scheduling; timetabling; heuristic algorithm.

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**Alex Barrales-Araneda** is a PhD student at DEI, University of Bologna, focusing on optimizing sustainable public transportation. He graduated in Industrial Engineering and obtained a Master's in Industrial Engineering from the University of Bío-Bío. His research applies optimization and machine learning to vehicle routing and planning. He has also worked on FONDEF projects related to pattern recognition, crime pattern analysis, and optimization in security and logistics.

# Multi-Neighborhood Search for the AGV Scheduling Problem with Battery Constraints

**Roberto Maria Rosati[1,2], Maurizio Boccia[3], Adriano Masone[3], Claudio Sterle[3]**

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[2] University of Klagenfurt, Austria
[3] Dept. of Electrical Engineering and Information Technology, University of Naples Federico II, Italy

**Abstract:** Automated guided vehicles (AGVs) are driverless vehicles widely used for the horizontal movement of materials in warehousing and production. Proper AGV scheduling is crucial for efficiency and cost saving in warehouse operational management.

In this work, we consider the AGV scheduling problem with battery constraints recently proposed by Boccia et al. [1]. It consists in determining the scheduling of transfer jobs and charging operations of a fleet of homogeneous AGVs such that the makespan of the handling process is minimized.

As a solution method, we propose a Multi-Neighborhood Search based on the composition of three local search neighborhoods: Move, Swap, and Two-Opt. Analogously to Rosati et al. [2], a core characteristic is an implicit solution representation based on a vector containing a global ordering of jobs. To derive an actual solution to the AGV scheduling problem, a greedy decoder processes the jobs vector, assigning them one at a time to the vehicle that minimizes the increase in the makespan. The decoder also schedules recharges so that the remaining battery never goes to zero. Finally, moves are chosen stochastically and move acceptance is guided by a Simulated Annealing metaheuristic.

According to preliminary results, our Multi-Neighborhood Search, properly tuned and engineered, is competitive in comparison with a mathematical model and a matheuristic from the literature [1]. Future work relates to the design of new neighborhoods and the inclusion of a capacity constraint on parallel recharges.

*Keywords*: Automated guided vehicles; scheduling; local search; metaheuristics.

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**Roberto Maria Rosati** is a postdoctoral researcher at the WU Vienna University of Economics and Business and at the University of Klagenfurt, Austria. His research focuses on stochastic local search and matheuristics for timetabling and scheduling problems. He was awarded his PhD from the University of Udine, Italy, in 2024, with a thesis titled "Multi-Neighborhood Search for Combinatorial Optimization".

# Joint Optimization for the Scheduled Joint Replenishment Problem

**Miguel Chastre[1], Christina Imdahl[1], Albert Schrotenboer[1], Tom van Woensel[1]**

[1] Eindhoven University of Technology, Eindhoven, Netherlands

**Abstract:**

In supply chain management, third-party logistics providers (3PL) are often used to consolidate shipments from multiple suppliers to a central warehouse, taking advantage of lower transportation fees for full truckloads. This is a form of Joint Replenishment Problem (JRP) [1], whose optimal solutions can be obtained for small instances. However, larger and more practical scenarios typically require heuristic approaches.

As supply chain networks grow, the number of inbound deliveries increases, yet the warehouse's handling capacity remains limited. This constraint creates a potential bottleneck that can disrupt the supply chain. A coordinated warehouse replenishment schedule is therefore essential. This schedule determines specific periods for 3PL deliveries, and while more frequent delivery opportunities raise scheduling costs, reducing replenishment flexibility can also increase transportation expenses. Moreover, the schedule influences the optimal inventory policy—specifically the timing and quantity of orders from each supplier—needed to meet stochastic demand.

Clearly, decisions in this setting are mutually dependent, and minimizing overall costs involves balancing schedule costs, expected transportation costs, and inventory-related expenses while adhering to warehouse handling limitations. To address this, we follow an integrated framework [2] that links design and operational decisions. The problem is modeled as a bilevel formulation, with the scheduling decision as the leader and the schedule-constrained JRP as the follower. The bilevel formulation is transformed into a single-level MIP formulation for which, for small instances, optimal solutions can be obtained through off-the-shelf MIP solvers. Moreover, we study (meta-)heuristics that can provide competitive solutions to larger instances of the problem.

*Keywords*: Inventory Control, Joint Replenishment Problem, Bilevel Mixed Integer Programming, Genetic Algorithm.

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**Miguel Chastre** is a PhD candidate in the Department of Industrial Engineering and Information Science at the Eindhoven University of Technology. His research focuses on the interface of static and dynamic decision making problems under uncertainty, particularly applied to inventory management, vehicle routing and scheduling. Before starting his PhD, he worked as a Vacuum Engineer at CERN.

# A data-driven tool for operating rooms advance scheduling

**Martina Doneda[1,2], Gabriele Gabrielli[2], Giuliana Carello[2]**

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**Abstract:** In the healthcare sector, effective resource management is essential to ensure high-quality service delivery while keeping costs under control. In particular, the management of operating rooms (ORs) presents unique challenges that have captivated researchers' attention over the years. One of these challenges is the advance elective surgery scheduling problem, which involves assigning surgeries to specific dates and ORs [1]. In fact, efficient advance scheduling can improve both hospital staff working conditions and patient satisfaction: a major challenge in creating effective schedules is the uncertainty in surgery durations, which can lead to either overtime or underutilized ORs, both of which can result in unexpected costs. This work addresses a robust version of the problem, modelling uncertainty in operating times with a data-driven approach. We propose a method for generating robust solutions that can adapt to data variability. Our approach is based on the implementor-adversary (I-A) framework [2], where an *implementor* develops a solution based on known parameters, and an *adversary* iteratively introduces parameter realizations that challenge the solution. These realizations are then incorporated as new constraints. In this framework, our adversary step utilizes historical data to generate realistic parameter realizations, applying probabilistic regression techniques to model surgical time distributions. This allows for complete flexibility in defining the uncertainty set [3].

We validate our methodology with computational tests on realistic data, demonstrating strong performance in terms of both solution quality and computational efficiency. Additionally, we compare our approach with two commonly-used methods for handling uncertainty, namely the budget set approach [4] and chance-constrained programming [5].

*Keywords*: advance scheduling, operating room management, robust optimization, probabilistic regression, uncertainty.

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**Martina Doneda** is a PhD candidate in the Department of Electronics, Information and Bioengineering at the Politecnico di Milano, Italy, and a research fellow in the Department of Management, Information and Production Engineering at the University of Bergamo.
Her research concerns applications of operations research and data science techniques to healthcare problems.