IN PARTNERSHIP WITH:
Ecole Centrale de Lille
Université Libre de Bruxelles

Activity Report 2019

Project-Team INOCS

INtegrated Optimization with Complex Structure

IN COLLABORATION WITH: Centre de Recherche en Informatique, Signal et Automatique de Lille

RESEARCH CENTER
Lille - Nord Europe

THEME
Optimization, machine learning and statistical methods

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Creation of the Team: 2015 May 01, updated into Project-Team: 2019 May 01

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1. Team, Visitors, External Collaborators

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2. Overall Objectives

2.1. Introduction

INOCS is a cross-border “France-Belgium” project team in the Applied Mathematics Computation and Simulation Inria domain. The main goal of this team is the study of optimization problems involving complex structures. The scientific objectives of INOCS are related to modeling and methodological concerns. The INOCS team will focus on:

1. integrated models for problems with complex structure (CS) taking into account the whole structure of the problem;
2. on the development of solution methods taking explicitly into account *the nature and the structure of the decisions as well as the properties of the problem*.

Even if CS problems are in general NP-hard due to their complex nature, exact solution methods or matheuristics (heuristics based on exact optimization methods) will be developed by INOCS. The scientific contribution of INOCS will result in a toolbox of models and methods to solve challenging real life problems.

2.2. Schedule of tasks

The research program development of INOCS is to move alternatively:

- *from problems towards new approaches in optimization*: Models and solution algorithms will be developed to fit the structure and properties of the problem. From them, new generic approaches will be used to optimize problems with similar properties.
- *from innovative approaches towards problems*: The relevance of the proposed approaches will be assessed by designing new models and/or solution methods for various classes of problems. These models and methods will be based on the extension and integration of specific, well studied, models and methods.

Even if these two axes are developed sequentially in a first phase, their interactions will lead us to explore them jointly in the mid-term.

3. Research Program

3.1. Introduction

An optimization problem consists in finding a best solution from a set of feasible solutions. Such a problem can be typically modeled as a mathematical program in which decision variables must:

1. satisfy a set of constraints that translate the feasibility of the solution and
2. optimize some (or several) objective function(s). Optimization problems are usually classified according to types of decision to be taken into strategic, tactical and operational problems.

We consider that an optimization problem presents a complex structure when it involves decisions of different types/nature (i.e. strategic, tactical or operational), and/or presenting some hierarchical leader-follower structure. The set of constraints may usually be partitioned into global constraints linking variables associated with the different types/nature of decision and constraints involving each type of variables separately. Optimization problems with a complex structure lead to extremely challenging problems since a global optimum with respect to the whole sets of decision variables and of constraints must be determined.

Significant progresses have been made in optimization to solve academic problems. Nowadays large-scale instances of some NP-Hard problems are routinely solved to optimality. *Our vision within INOCS is to make the same advances while addressing CS optimization problems*. To achieve this goal we aim to develop global solution approaches at the opposite of the current trend. INOCS team members have already proposed some successful methods following this research lines to model and solve CS problems (e.g. ANR project RESPET, Brotcorne *et al.* 2011, 2012, Gendron *et al.* 2009, Strack *et al.* 2009). However, these are preliminary attempts and a number of challenges regarding modeling and methodological issues have still to be met.

3.2. Modeling problems with complex structures

A classical optimization problem can be formulated as follows:

$$\begin{aligned} \min \quad & f(x) \\ s.t. \quad & x \in X. \end{aligned} \tag{1}$$

In this problem, X is the set of feasible solutions. Typically, in mathematical programming, X is defined by a set of constraints. x may be also limited to non-negative integer values.

INOCS team plan to address optimization problem where two types of decision are addressed jointly and are interrelated. More precisely, let us assume that variables x and y are associated with these decisions. A generic model for CS problems is the following:

$$\begin{aligned} \min \quad & g(x,y) \\ s.t. \quad & x \in X, \\ & (x,y) \in XY, \\ & y \in Y(x). \end{aligned} \tag{2}$$

In this model, X is the set of feasible values for x. XY is the set of feasible values for x and y jointly. This set is typically modeled through linking constraints. Last, $Y(x)$ is the set of feasible values for y for a given x. In INOCS, we do not assume that $Y(x)$ has any properties.

The INOCS team plans to model optimization CS problems according to three types of optimization paradigms: large scale complex structures optimization, bilevel optimization and robust/stochastic optimization. These paradigms instantiate specific variants of the generic model.

Large scale complex structures optimization problems can be formulated through the simplest variant of the generic model given above. In this case, it is assumed that $Y(x)$ does not depend on x. In such models, X and Y are associated with constraints on x and on y, XY are the linking constraints. x and y can take continuous or integer values. Note that all the problem data are deterministically known.

Bilevel programs allow the modeling of situations in which a decision-maker, hereafter the leader, optimizes his objective by taking explicitly into account the response of another decision maker or set of decision makers (the follower) to his/her decisions. Bilevel programs are closely related to Stackelberg (leader-follower) games as well as to the principal-agent paradigm in economics. In other words, bilevel programs can be considered as demand-offer equilibrium models where the demand is the result of another mathematical problem. Bilevel problems can be formulated through the generic CS model when $Y(x)$ corresponds to the optimal solutions of a mathematical program defined for a given x, i.e. $Y(x) = \arg\min \{h(x,y) | y \in Y_2, (x,y) \in XY_2\}$ where Y_2 is defined by a set of constraints on y, and XY_2 is associated with the linking constraints.

In robust/stochastic optimization, it is assumed that the data related to a problem are subject to uncertainty. In stochastic optimization, probability distributions governing the data are known, and the objective function involves mathematical expectation(s). In robust optimization, uncertain data take value within specified sets, and the function to optimize is formulated in terms of a min-max objective typically (the solution must be optimal for the worst-case scenario). A standard modeling of uncertainty on data is obtained by defining a set of possible scenarios that can be described explicitly or implicitly. In stochastic optimization, in addition, a probability of occurrence is associated with each scenario and the expected objective value is optimized.

3.3. Solving problems with complex structures

Standard solution methods developed for CS problems solve independent sub-problems associated with each type of variables without explicitly integrating their interactions or integrating them iteratively in a heuristic way. However these subproblems are intrinsically linked and should be addressed jointly. In *mathematical optimization* a classical approach is to approximate the convex hull of the integer solutions of the model by its linear relaxation. The main solution methods are (1) polyhedral solution methods which strengthen this linear relaxation by adding valid inequalities, (2) decomposition solution methods (Dantzig Wolfe, Lagrangian Relaxation, Benders decomposition) which aim to obtain a better approximation and solve it by generating extreme points/rays. Main challenges are (1) the analysis of the strength of the cuts and their separations for polyhedral solution methods, (2) the decomposition schemes and (3) the extreme points/rays generations for the decomposition solution methods.

The main difficulty in solving *bilevel problems* is due to their non convexity and non differentiability. Even linear bilevel programs, where all functions involved are affine, are computationally challenging despite their apparent simplicity. Up to now, much research has been devoted to bilevel problems with linear or convex follower problems. In this case, the problem can be reformulated as a single-level program involving complementarity constraints, exemplifying the dual nature, continuous and combinatorial, of bilevel programs.

4. Application Domains

4.1. Energy

In energy, the team mainly focuses on pricing models for demand side management. Demand side management methods are traditionally used to control electricity demand which became quite irregular recently and resulted in inefficiency in supply. We have explored the relationship between energy suppliers and customers who are connected to a smart grid. The smart grid technology allows customers to keep track of hourly prices and shift their demand accordingly, and allows the provider to observe the actual demand response to its pricing strategy. We tackle pricing problems in energy according to the bilevel optimization approaches. Some research works in this domain are supported by bilateral grants with EDF.

4.2. Transportation and Logistics

In transportation and logistics, the team addresses mainly integrated problems, which require taking into account simultaneously different types of decision. Examples are location and routing, inventory management and routing or staff scheduling and warehouse operations management. Such problems occur from the supply chain design level to the logistic facility level.

4.3. Telecommunications

In telecommunications, the team mainly focuses on network design problems and on routing problems. Such problems are optimization problems with complex structure, since the optimization of capacity installation and traffic flow routing have to be addressed simultaneously.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- Martine Labbé received the EURO Gold Medal in June 2019. This is the highest distinction in Operations Research in Europe.

6. New Software and Platforms

6.1. HappyChic-ApproPick

KEYWORDS: Operational research - Optimization - Java

FUNCTIONAL DESCRIPTION: This software is a prototype developed for the bilateral contract with the company HappyChic. This software is a solver for an integrated warehouse order picking problem with manual picking operations. More precisely, the following problems are solved: (1) the assignment of references to storage positions, based on the iterative solving of minimum cost flow problems, (2) the division of clients orders into several parcels, respecting weight and size constraints, using a dynamic programming algorithm based on the split algorithm, (3) the batching of parcels into trolleys to perform picking tours, using a dynamic programming algorithm based on the split algorithm. The objective function is to minimize the total walking distance. This software is designed to deal with the large-sized industrial instances of HappyChic (considering hundreds of clients, thousands of positions and product references) in a short computation time (few minutes).

- Contact: Maxime Ogier

6.2. KEOLIS-MEDIATOUR

KEYWORDS: Operational research - Mathematical Optimization - Staff scheduling

FUNCTIONAL DESCRIPTION: This software is a prototype developed under a bilateral contract with the company Keolis. This software is a solver which aims to optimize the schedule of mediation staff. More precisely, for each member of the mediation staff working in a public transportation network, MEDIATOUR determines his/her schedule along the day, i.e. when and where he/she is present. Various operational constraints must be taken into account such as the coverage of the network. This software is designed to solve large-scale industrial instances (the subway network of Lille) in short computation times (less than 1 minute).

- Contact: Frederic Semet

6.3. PARROT

Planning Adapter Performing ReRouting and Optimization of Timing

KEYWORDS: Decision aid - Railway - Scheduling

FUNCTIONAL DESCRIPTION: This is a decision support system addressing the problem of the rescheduling railway schedules on the Belgian network when maintenance operations are planned in the short term (2-3 weeks in advance). The deliverable is a software tool that will take as input: (1) the schedules initially planned for the different trains, (2) the initial routes of the trains, (3) maintenance operations / changes of elements in the form of constraints (unavailable routes etc.). It then provides in output: (1) the new train schedule, (2) the new routing of the fleet. The modifications must respect the constraints corresponding to the operations of maintenance. For example, in some cases it is common to leave at least a few minutes interval between two trains using the same track in the station. This constraint must then be propagated if a maintenance operation delays the arrival of a train. New schedules and routings have to be created following a specific goal. Changes made to schedules and routings must minimize: (1) variations on the time spent at the station, (2) the number of partially canceled trains (additional correspondence (s) or stations that are no longer served), (2) the number of fully canceled trains (no stations served).

- Contact: Martine Labbé

7. New Results

7.1. Large scale complex structure optimization

Joint order batching and picker routing problem: Order picking is the process of retrieving products from inventory. It is mostly done manually by dedicated employees called pickers and is considered the most expensive of warehouse operations. To reduce the picking cost, customer orders can be grouped into batches that are then collected by traveling the shortest possible distance. We proposed an industrial case study for the HappyChic company where the warehouse has an acyclic layout: pickers are not allowed to backtrack.

We developed a two-phase heuristic approach to solve this industrial case [64]. Moreover, we propose an exponential linear programming formulation to tackle the joint order batching and picker routing problem. Variables, or columns, are related to the picking routes in the warehouse. Computing such routes is generally an intractable routing problem and relates to the well known traveling salesman problem (TSP). Nonetheless, the rectangular warehouse's layouts can be used to efficiently solve the corresponding TSP and take into account in the development of an efficient subroutine, called oracle. We therefore investigate whether such an oracle allows for an effective exponential formulation. Experimented on a publicly available benchmark, the algorithm proves to be very effective. It improves many of the best known solutions and provides very strong lower bounds. Finally, this approach is also applied to the HappyChic industrial case to demonstrate its interest for this field of application [67], [45].

Logistics network design problem: Planning transportation operations within a supply chain is a difficult task that is often outsourced to logistics providers, in practice. At the tactical level, the problem of distributing products through a multi-echelon network is defined in the literature as the Logistics Service Network Design Problem (LSNDP). We study a LSNDP variant inspired by the management of restaurant supply chains. In this problem, a third party carrier seeks to cost-effectively source and fulfill customer demands of products through a tri-echelon supply chain composed of suppliers, warehouses, and customers. We propose an exact solution method based on partial Benders decompositions, where the master problem is strengthened by the addition of aggregated information derived from the subproblem. More specifically, we introduce a high-level dynamic Benders approach where the aggregated information used to strengthen the master is refined iteratively. In an extensive computational study, we demonstrate that our dynamic Benders strategy produces provably high-quality solutions and we validate the interest of refining the master problem in the course of a partial Benders decomposition-based scheme [72].

Multi commodity vehicle routing problem: We study vehicle routing problems considering multiple commodities, with applications in the local fresh food supply chains. The studied supply chain contains two echelons with three sets of actors: suppliers, distribution centers and customers. Suppliers are farmers that produce some fresh foods. Distribution centers are in charge of consolidation and delivery of the products to customers. Distribution centers collect products from the suppliers that perform direct trips. Products are delivered to the customers with a fleet of vehicles performing routes. Each customer requires several commodities, and the farmers produce a limited quantity of these commodities. For the minimization of the transportation cost, it is beneficial that a single customer is delivered by several vehicles. However, for the convenience of the customer, it is imposed that a single commodity is delivered at once by a single vehicle. Hence, different commodities have been explicitly considered. The complete problem is named Multi-Commodity two-echelon Distribution Problem (MC2DP). The restricted problem that addresses only the delivery from a single distribution center is named Commodity constrained Split Delivery Vehicle Routing Problem (C-SDVRP). We first propose a heuristic based on the Adaptive Large Neighborhood Search (ALNS) for the C-SDVRP [22]. Then, we address the whole problem (MC2DP) with collection and delivery operations and multiple distribution centers. In order to tackle this complex problem, we propose to decompose the problem: collection and delivery are sequentially solved [53], [54].

Generalized routing problems: We study routing problems that arise in the context of last mile delivery when multiple delivery options are proposed to the customers. The most common option to deliver packages is home/workplace delivery. Besides, the delivery can be made to pick-up points such as dedicated lockers or stores. In recent years, a new concept called trunk/in-car delivery has been proposed. Here, customers' packages can be delivered to the trunks of cars. Our goal is to model and develop efficient solution approaches for routing problems in this context, in which each customer can have multiple shipping locations. First, we study the single-vehicle case in the considered context, which is modeled as a Generalized Traveling Salesman Problem with Time Windows (GTSPTW). Four mixed integer linear programming formulations and an efficient branch-and-cut algorithm are proposed. Then, we study the multi-vehicle case which is denoted Generalized Vehicle Routing Problem with Time Windows (GVRPTW). An efficient column generation based heuristic is proposed to solve it [60], [61], [59], [37].

Joint management of demand and offer for last-mile delivery systems: E-commerce is a thriving market around the world and suits very well the busy lifestyle of today's customers. This growing in e-commerce poses a huge challenge for transportation companies, especially in the last mile delivery. We addressed first a fleet composition problem for last-mile delivery service. This problem occurs at a tactical level when the composition of the fleet has to be decided in advance. It is the case for companies that offer last-mile delivery service. Most of them subcontract the transportation part to local carriers and have to decide the day before which vehicles will be needed to cover a partially known demand. We assumed that the distribution area is divided into a limited number of delivery zones and the time horizon into time-slots. The demand is characterized by packages to be transported from pick-up zones to delivery zones given a delivery time slot. We have proposed an optimization problem aiming jointly to manage the offer and the demand. More precisely, discrete choice models representing the choices made by couriers and customers are integrated into the same optimization model. The originality of the contribution is based on the integration of variables of different natures in the same model and the development of integrated resolution methods. On the basis of a closed form of discrete choice models, we have reformulated the problem as a non-linear optimization problem. The resolution of this model by classical solvers requires coupling exact methods with heuristics in order to define a first initial solution [47], [58].

Delay Management in Public Transportation: The Delay Management Problem arises in Public Transportation networks, and is characterized by the necessity of connections between different vehicles. The attractiveness of Public Transportation networks is strongly related to the reliability of connections, which can be missed when delays or other unpredictable events occur. Given a single initial delay at one node of the network, the Delay Management Problem is to determine which vehicles have to wait for the delayed ones, with the aim of minimizing the dissatisfaction of the passengers. We derived strengthened mixed integer linear programming formulations and new families of valid inequalities for that problem. The implementation of branch-and-cut methods and tests on a benchmark of instances taken from real networks show the potential of the proposed formulations and cuts [20].

Discrete Ordered Median Problem: The discrete ordered median problem consists in locating p facilities in order to minimize an ordered weighted sum of distances between clients and closest open facility. We formulate this problem as a set partitioning problem using an exponential number of variables. Each variable corresponds to a set of demand points allocated to the same facility with the information of the sorting position of their corresponding costs. We develop a column generation approach to solve the continuous relaxation of this model. Then, we apply a branch-price-and-cut algorithm to solve small to large sized instances of DOMP in competitive computational time [21].

Genome wide association studies: We studied the Polymorphic Alu Insertion Recognition Problem (PAIRP). Alu (Arthrobacter luteus) forms a major component of repetitive DNA and are frequently encountered during the genotyping of individuals. The basic approach to find Alus consists of (1) aligning sequence reads from a set of individual(s) with respect to a reference genome and (2) comparing the possible Alu insertion induced by the alignment with the Alu insertions positions already known for the reference genome. The sequence genome of the reference individual is known and will be highly similar, but not identical, to the genome of the individual(s) being sequenced. Hence, at some locations they will diverge. Some of this divergence is due to the insertion of Alu polymorphisms. Detecting Alus has a central role in the field of Genetic Wide Association Studies because basic elements are a common source of mutation in humans. We investigated the PAIRP relationship with the the Clique Partitioning of Interval Graphs (CPIG). Our results [29] provide insights of the complexity of the problem, a characterization of its combinatorial structure and an exact approach based on Integer Linear Programming to exactly solve the correspond instances.

A branch-and-cut algorithm for the maximum k-balanced subgraph of a signed graph: A signed graph is k-balanced if its vertex set can be partitioned into at most k sets in such a way that positive edges are found only within the sets and negative edges go between sets. The maximum k-balanced subgraph problem is the problem of finding a subgraph of a graph G that is k-balanced and maximum according to the number of vertices. This problem has applications in clustering problems appearing in collaborative vs conflicting environments. We provide a representatives formulation for the problem and present a partial description of the associated polytope, including the introduction of strengthening families of valid inequalities. A branch-and-cut algorithm is described for finding an optimal solution to the problem. An ILS metaheuristic is implemented for providing primal bounds for this exact method and a branching rule strategy is proposed for the representatives formulation. Computational experiments, carried out over a set of random instances and on a set of instances from an application, show the effectiveness of the valid inequalities and strategies adopted in this work [75].

Feature Selection in Support Vector Machine: This work focuses on support vector machine (SVM) with feature selection. A MILP formulation is proposed for the problem. The choice of suitable features to construct the separating hyperplanes has been modelled in this formulation by including a budget constraint that sets in advance a limit on the number of features to be used in the classification process. We propose both an exact and a heuristic procedure to solve this formulation in an efficient way. Finally, the validation of the model is done by checking it with some well-known data sets and comparing it with classical classification methods [24].

7.2. Bilevel Programming

Pricing for Energy Management: Power systems face higher flexibility requirements from generation to consumption due to the increasing penetration of non-controllable distributed renewable energy. In this context, demand side management aims at reducing excessive load fluctuation and match the price of energy to their real cost for the grid. Pricing models for demand side management methods are traditionally used to control electricity demand. First, we proposed bilevel pricing models to explore the relationship between energy suppliers and customers who are connected to a smart grid. The smart grid technology allows customers to keep track of hourly prices and shift their demand accordingly, and allows the provider to observe the actual demand response to its pricing strategy. Moreover, we assumed that the smart grid optimizes the usage of a renewable energy generation source and a storage capacity. Results over a rolling horizon were obtained (Léonard Von Niederhausern PhD thesis [76]). Next, we considered four types of actors: furnishers sell electricity, local agents trade and consume energy, aggregators trade energy and provide energy to end-users, who consume it. This gives rise to three levels of optimization. The interaction between aggregators and their end-users is modeled with a bilevel program, and so is the interaction between furnishers, and local agents and aggregators. Since solving bilevel programs is difficult in itself, solving trilevel programs requires particular care. We proposed three possible approaches, two of them relying on a characterization of the intermediary optimization level [13], [76].

Finally, Time and-Level-of-Use is a recently proposed energy pricing scheme, designed for the residential sector and providing suppliers with robust guarantee on the consumption. We formulate the supplier decision as a bilevel, bi-objective problem optimizing for both financial loss and guarantee. A decomposition method is proposed, related to the optimal value transformation. It allows for the computation of an exact solution by finding possible Pareto optimal candidate solutions and then eliminating dominated ones. Numerical results on experimental residential power consumption data show the method effectively finds the optimal candidate solutions while optimizing costs only or incorporating risk aversion at the lower-level [38], [46].

Linear bilevel optimization: One of the most frequently used approaches to solve linear bilevel optimization problems consists in replacing the lower-level problem with its Karush–Kuhn–Tucker (KKT) conditions and by reformulating the KKT complementarity conditions using techniques from mixed-integer linear optimization. The latter step requires to determine some big-M constant in order to bound the lower level's dual feasible set such that no bilevel-optimal solution is cut off. In practice, heuristics are often used to find a big-M although it is known that these approaches may fail. In [69], we consider the hardness of two proxies for the above mentioned concept of a bilevel-correct big-M. First, we prove that verifying that a given big-M does not cut off any feasible vertex of the lower level's dual polyhedron cannot be done in polynomial time unless P = NP. Second, we show that verifying that a given big-M does not cut off any optimal point of the lower level's dual problem (for any point in the projection of the high-point relaxation onto the leader's decision space) is as hard as solving the original bilevel problem.

Market regulation: We proposed a bilevel programming model to study a problem of market regulation through government intervention. One of the main characteristics of the problem is that the government monopolizes the raw material in one industry, and competes in another industry with private firms for the production of commodities. Under this scheme, the government controls a state-owned firm to balance the market; that is, to minimize the difference between the produced and demanded commodities. On the other hand, a regulatory organism that coordinates private firms aims to maximize the total profit by deciding the amount of raw material bought from the state-owned firm. Two equivalent single-level reformulations are proposed to solve the problem. Additionally, three heuristic algorithms are designed to obtain good-quality solutions with low computational effort. Extensive computational experimentation is carried out to measure the efficiency of the proposed solution methodologies. A case study based on the Mexican petrochemical industry is presented. Additional instances generated from the case study are considered to validate the robustness of the proposed heuristic algorithms [28].

Product pricing: One of the main concerns in management and economic planning is to sell the right product to the right customer for the right price. Companies in retail and manufacturing employ pricing strategies to maximize their revenues. The Rank Pricing Problem considers a unit-demand model with unlimited supply and uniform budgets in which customers have a rank-buying behavior. Under these assumptions, the problem is first analyzed from the perspective of bilevel pricing models and formulated as a non linear bilevel program with multiple independent followers. We also present a direct non linear single level formulation. Two different linearizations of the models are carried out and two families of valid inequalities are obtained which, embedded in the formulations by implementing a branch-and-cut algorithm, allow us to tighten the upper bound given by the linear relaxation of the models. We show the efficiency of the formulations, the branch-and-cut algorithms and some preprocessing through extensive computational experiments [73].

Next in [68], we analyze a product pricing problem with single-minded customers, each interested in buying a bundle of products. The objective is to maximize the total revenue and we assume that supply is unlimited for all products. We contribute to a missing piece of literature by giving some mathematical formulations for this single-minded bundle pricing problem. We first present a mixed-integer nonlinear program with bilinear terms in the objective function and the constraints. By applying classical linearization techniques, we obtain two different mixed-integer linear programs. We then study the polyhedral structure of the linear formulations and obtain valid inequalities based on an RLT-like framework. We develop a Benders decomposition to project strong cuts from the tightest model onto the lighter models. We conclude this work with extensive numerical experiments to assess the quality of the mixed-integer linear formulations, as well as the performance of the cutting plane algorithms and the impact of the preprocessing on computation times.

Bilevel Minimum Spanning Tree Problem: Consider a graph G whose edge set is partitioned into a set of red edges and a set of blue edges, and assume that red edges are weighted and contain a spanning tree of G. Then, the Bilevel Minimum Spanning Tree Problem (BMSTP) consists in pricing (i.e., weighting) the blue edges in such a way that the total weight of the blue edges selected in a minimum spanning tree of the resulting graph is maximized. We propose different mathematical formulations for the BMSTP based on the properties of the Minimum Spanning Tree Problem and the bilevel optimization. We establish a theoretical and empirical comparison between these new formulations and we also provide reinforcements that together with a proper formulation are able to solve medium to big size instances [26].

Bilevel programming models for location problems: First, we addressed a multi-product location problem in which a retail firm has several malls with a known location. A particular product comes in p types. Each mall has a limited capacity for products to be sold at that location, so the firm has to choose what products to sold at what mall. Furthermore, the firm can apply discrete levels of discount on the products. The objective of the firm is to find what products to sell at which mall, with what level of discount, so that its profit is maximized. Consumers are located in points of the region. Each consumer has a different set of acceptable products, and will purchase one of these, or none if it is not convenient for her. Consumers maximize their utility. The agents (firm and consumers) play a Stackelberg game, in which the firm is the leader and the customers the follower. Once the firm decides the products to sell at each mall and the possible discounts, consumers purchase (or not) one of their acceptable products wherever their utility is maximized. We model the problem using bilevel formulations, which are compared on known instances from the literature [74]. Second we studied a location problem of controversial facilities. On the one hand, a leader chooses among a number of fixed potential locations which ones to establish. On the second hand, one or several followers who, once the leader location facilities have been set, choose their location points in a continuous framework. The leader's goal is to maximize some proxy to the weighted distance to the follower's location points, while the follower(s) aim is to locate his location points as close as possible to the leader ones. We develop the bilevel location model for one follower and for any polyhedral distance, and we extend it for several followers and any so-called p-norm. We prove the NP-hardness of the problem and propose different mixed integer linear programming formulations. Moreover, we develop alternative Benders decomposition algorithms for the problem. Finally, we report some computational results comparing the formulations and the Benders decompositions on a set of instances [23].

Stackelberg games: First we analyzed general Stackelberg games (SGs) and Stackelberg security games (SSGs). SGs are hierarchical adversarial games where players select actions or strategies to optimize their payoffs in a sequential manner. SSGs are a type of SGs that arise in security applications, where the strategies of the player that acts first consist in protecting subsets of targets and the strategies of the followers consist in attacking one of the targets. We review existing mixed integer optimization formulations in both the general and the security setting and present new formulations for the the second one. We compare the SG formulations and the SSG formulations both from a theoretical and a computational point of view. We identify which formulations provide tighter linear relaxations and show that the strongest formulation for the security version is ideal in the case of one single attacker. Our computational experiments show that the new formulations can be solved in shorter times [18].

Second, we formulate a Stackelberg Security game that coordinates resources in a border patrol problem. In this security domain, resources from different precincts have to be paired to conduct patrols in the border due to logistic constraints. Given this structure the set of pure defender strategies is of exponential size. We describe the set of mixed strategies using a polynomial number of variables but exponentially many constraints that come from the matching polytope. We then include this description in a mixed integer formulation to compute the Strong Stackelberg Equilibrium efficiently with a branch and cut scheme. Since the optimal patrol solution is a probability distribution over the set of exponential size, we also introduce an efficient sampling method that can be used to deploy the security resources every shift. Our computational results evaluate the efficiency of the branch and cut scheme developed and the accuracy of the sampling method. We show the applicability of the methodology by solving a real world border patrol problem [15].

Third, in [39], we discuss the impact of fairness constraints in Stackelberg Security Games. Fairness constraints can be used to avoid discrimination at the moment of implementing police patrolling. We present two ways of modelling fairness constraints, one with a detailed description of the population and the other with labels. We discuss the implementability of these constraints. In the case that the constraints are not implementable we present models to retrieve pure strategies in a way that they are the closest in average to the set of fairness constraints.

Finally, in [65], we focus on Stackelberg equilibria for discounted stochastic games. We begin by formalizing the concept of Stationary Strong Stackelberg Equilibrium (SSSE) policies for such games. We provide classes of games where the SSSE exists, and we prove via counterexamples that SSSE does not exist in the general case. We define suitable dynamic programming operators whose fixed points are referred to as Fixed Point Equilibrium (FPE). We show that the FPE and SSSE coincide for a class of games with Myopic Follower Strategy. We provide numerical examples that shed light on the relationship between SSSE and FPE and the behavior of Value Iteration, Policy Iteration and Mathematical programming formulations for this problem. Finally, we present a security application to illustrate the solution concepts and the efficiency of the algorithms studied.

7.3. Robust/Stochastic programming

Locating stations in a one-way electric car sharing system under demand uncertainty: In [16], we focused on a problem of locating recharging stations in one-way station based electric car sharing systems which operate under demand uncertainty. We modeled this problem as a mixed integer stochastic program and develop a Benders decomposition algorithm based on this formulation. We integrated a stabilization procedure to our algorithm and conduct a large-scale experimental study on our methods. To conduct the computational experiments, we developed a demand forecasting method allowing to generate many demand scenarios. The method was applied to real data from Manhattan taxi trips.

Bookings in the European Gas Market: Characterisation of Feasibility and Computational Complexity Results: As a consequence of the liberalisation of the European gas market in the last decades, gas trading and transport have been decoupled. At the core of this decoupling are so-called bookings and nominations. Bookings are special long-term capacity right contracts that guarantee that a specified amount of gas can be supplied or withdrawn at certain entry or exit nodes of the network. These supplies and withdrawals are nominated at the day-ahead. These bookings then need to be feasible, i.e., every nomination that complies with the given bookings can be transported. While checking the feasibility of a nomination can typically be done by solving a mixed-integer nonlinear feasibility problem, the verification of feasibility of a set of bookings is much harder. We consider the question of how to verify the feasibility of given bookings for a number of special cases. For our physics model we impose a steady-state potential-based flow model and disregard controllable network elements. We derive a characterisation of feasible bookings, which is then used to show that the problem is in coNP for the general case but can be solved in polynomial time for linear potential-based flow models. Moreover, we present a dynamic programming approach for deciding the feasibility of a booking in tree-shaped networks even for nonlinear flow models [25]. Further, in [71], we show that the feasibility of a booking also can be decided in polynomial time on single-cycle networks.

Robust bilevel programs: Bilevel optimization problems embed the optimality conditions of a sub-problem into the constraints of a decision-making process. A general question of bilevel optimization occurs where the lower-level is solved (only) to near-optimality. Solving bilevel problems under limited deviations of the lower-level variables was introduced under the term "ϵ-approximation" of the pessimistic bilevel problem. In [77] the authors define special properties and a solution method for this variant in the so-called independent case, i.e., where the lower-level feasible set is independent of the upper-level decision. In [66], we generalized the approach of *Wiesemann et al. 2013*, to problems with constraints involving upper- and lower-level variables in the constraints at both levels. The purpose of this generalization is to protect the upper-level feasibility against uncertainty of near-optimal solutions of the lower-level. We call this near-optimal robustness and the generalization is a near-optimal robust bilevel problem (NORBiP). NORBiP is a bilinear bilevel problem, and this makes it very hard in general. We have defined and implemented a solution algorithm for the linear linear NORBiP [66].

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

Utocat (2018-2020): Study optimization problems arising in the blockchain

8.2. Bilateral Grants with Industry

- Program PGMO funded by the Fondation Mathématiques Jacques Hadamard. EDF is the industrial partner (2017-2019)
- Program PGMO funded by the Fondation Mathématiques Jacques Hadamard. A generic framework for routing and scheduling problems (2019-2021)
- Program PGMO funded by the Fondation Mathématiques Jacques Hadamard. Integrated models for the dimensioning and location of charging electric vehicles stations in the presence of renewable energy sources: Models and Algorithms (2019-2020)

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

ANR project AGIRE "Aide à la Gestion Intelligente des Ressources dans les Entrepôts - Decision system for smart management of resources in warehouses" in collaboration with Ecole des Mines de Saint-Etienne (Gardanne), IFSTTAR (Champs-sur-Marne), HappyChic (Tourcoing). This project addresses human resources management in warehouses which supply either sale points (B2B) or final consumers (B2C). Nowadays, such warehouses are under pressure. This is mainly due to the no inventory policy at the sale points and to the constant growth of e-commerce sales in France and Europe. In terms of logistics, this translates into an increasing number of parcels to prepare and to ship to satisfy an order, which is known typically a few hours before. Moreover, the total number of products to be packed varies very significantly from day-to-day by a factor of at least 3 (https://fr.wikipedia.org/wiki/Happychic).

The novelty of the project is twofold: (1) The human factor is explicitly be taken into account. It is integrated in the mathematical models and algorithms that are developed for the project. The aim is to improve the quality of employees' work ensuring the efficiency of the logistic system; (2) Problems at different decision levels are integrated and tackled jointly. At the tactical level, the main problematics are workload smoothing and the management of the storage zone. At operational level, the major issues concern the rearrangement of the picking zone, the picking tours, and the dynamic reorganization of activities to manage uncertainties.

ANR project PI-Commodality "Co-modal freight transportation chains: an approach based on physical internet" in collaboration with CGS-ARMINES (Paris), LAAS (Toulouse), DHL (2016 - 2019). The PI-co-modality project aims to design new sustainable logistic services between preset origins and destinations. It is based on innovative approaches both in terms of: (1) Logistics and transportation services: by considering the PI-internet approach, specifically: mesh logistics and transportation networks based on available capacities, by designing consistent integrated co-modal chains; (2) Methodology: by addressing the underlying problems according to two approaches: centralized and decentralized, by proposing news realistic models relevant for practitioner taking into account the consistency, by developing state-of-the-art decision making algorithms.

9.1.2. F.R.S.-FNRS (Belgium)

Bilevel optimization is a branch of mathematical optimization that deals with problems whose constraints embed an auxiliary optimization problem. The F.R.S.-FNRS research project "bilevel optimization" (2018-2019) will study such bilevel problems with bilinear objectives and simple second level problems. Each follower chooses one strategy in a given fixed set of limited size. Two classes of such problems will be studied: Pricing Problems and Stackelberg Security Games.

In pricing problems, prices for products must be determined to maximize the revenue of a leader given specific behaviors of customers (followers). More precisely, we will consider the single minded pricing problem and the rank pricing problem.

In Stackelberg games, mixed strategies to cover targets,must be determined in order to maximize the defender expected payoff given that attackers (followers) attack targets that maximize their own payoffs.

9.2. Regional Initiatives

9.2.1. Lille

The ELSAT research program addresses the issues involved in sustainable transportation and mobility. Within ELSAT, INOCS is involved on two projects devoted to hybrid optimization methods in logistics and to city logistics in collaboration with LAMIH (Université de Valenciennes), LGI2A (Université d'Artois) and LEOST (IFSTTAR). ELSAT is supported by the CPER 2015-2020 (State-Region Contract).

9.2.2. Brussels

ValueBugs is a citizen participatory research project, funded by INNOVIRIS (2018-2020). The objective of ValueBugs is to collectively develop a method for decentralized insect production in cities while enhancing the value of food waste on a small scale. In practical terms, peelings are consumed by insect larvae that have reached the end of their development and offer many promising outlets: feed for hens, farmed fish, pets... and much more! This new, totally innovative sector will be a new tool to be put in the hands of every citizen: we must therefore imagine it collectively.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. BIPLOS

Title: BIlevel Problems in LOgistics and Security

International Partner (Institution - Laboratory - Researcher):

University of Chile - Complex Engineering Systems Institute (ISCI) - Ordonez Fernando

Start year: 2017

See also: https://team.inria.fr/inocs/

This projet is devoted to bilevel optimisation problems with application in the security and logistics domains. Stackelberg games, including one defender and several followers, and competitive location problems will be considered. Mixed integer linear optimisation models and efficient algorithms to solve them will be developed.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. LOBI

Title: Learning within Bilevel Optimization

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Research Group in Decision Analysis (GERAD) - Gilles Savard

Start year: 2018

See also: https://team.inria.fr/lobi/

The interplay between optimization and machine learning is one of the most important developments in modern computational science. Simultaneously there is a tremendous increase in the availability of large quantities of data in a multitude of applications, and a growing interest in exploiting the information that this data can provide to improve decision-making. Given the importance of big data in business analytics, its explicit integration into an optimization process is a challenge with high potential impact. The innovative project is concerned with the interconnection between machine learning approaches and a particular branch of optimization called bilevel optimization in this "big data" context. More precisely, we will focus on the development of new approaches integrating machine learning within bilevel optimization (LOBI: "learning au sein de l'Optimisation BIniveau") for two important practical applications, the pricing problem in revenue management and the energy ressource aggregation problem in smart grids. The applications arise from current industry collaborations of the teams involved, and will serve as testbeds to demonstrate the potential impact of the proposed approach.

9.3.2.2. North-European associated team

Title: Physical-internet services for city logistics

International Partner (Institution - Laboratory - Researcher):

Norwegian School of Economics - Stein Wallace

Start year: 2017

In this project, we consider an urban logistic terminal and new logistics services which could be developed according to a Physical Internet approach. The main objective is to evaluate the services using optimization models created within the project. We are developing optimization models to identify win-win cooperation between carriers based on supply and demand. We aim to explore how to include stochasticity in the description of the supplies and demands, as well as travel times, and to what extent the plans within a day can improve by such knowledge. The second task is to develop solution algorithms for these models. These are real scientific challenges as we are facing stochastic mixed integer problems.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Department of Statistics and Operations Research, University of Vienna, Austria

Centre for Quantitative Methods and Operations Management, HEC-Liège, Belgium

Interuniversity Centre on Entreprise Networks, Transportation and Logistics (CIRRELT), Montreal, Canada

Department of Industrial Engineering, University of Talca, Curicó, Chile

Complex Engineering Systems Institute (ISCI), University of Chile, Santiago, Chile

Department of Mathematics, Trier University, Germany

The Centre for Business Analytics, University College Dublin, Ireland

Department of Electrical, Electronic, and Information Engineering, University of Bologna, Italy

Department of Mathematics, University of Padova, Italy

Department of Electrical and Information Engineering, University of Padova, Italy

Department of Mathematics, University of Salerno, Italy

Department of Control and Computer Engineering, Politecnico di Torino, Italy

Department of Mathematics, University of Aveiro, Portugal

Department of Statistics and Operations Research, Universidade de Lisboa, Portugal

Department of Statistics and Operational Research, University of Murcia, Spain

Institute of Mathematics, University of Seville, Spain

Stewart School of Industrial and Systems Engineering, Georgia Tech Institute of Technology, USA

9.3.4. Participation in Other International Programs

9.3.4.1. Inria International Chairs

IIC ANJOS Miguel

Title: Power Peak Minimization for the Smart Gird

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Miguel Anjos

Duration: 2016 - 2020

Start year: 2016

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Yasemin Arda Da Silveira, HEC-Liège, University of Liège, Belgium, Mar 2019
- Maria Del Carmen Gale Pola, University of Zaragoza, Spain, Feb 2019
- Anton Kleywegt, Georgia Institute of Technology, USA, from Apr 2019 until May 2019
- Daniel Pereda Herrera, University of Chile, Chile, from Nov 2019
- Sebastián Dávila, University of Chile, Chile, from June 2019 until Dec 2019
- Natividad Gonzalez Blanco, University of Sevilla, Spain, from May 2019 until July 2019
- Federica Laureanam, University of Salerno, Italy, from Feb 2019 until May 2019

9.4.1.1. Internships

Sebastián Dávila, Ph.D. student at University of Chile, June to December 2019

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events: Organisation

10.1.1.1. General Chair, Scientific Chair

- 23rd Belgian Mathematical Optimization Workshop, La Roche, Belgium, April 25-26, 2019: Bernard Fortz (Organizer)

10.1.1.2. Member of the Organizing Committees

- 8th Winter School on Network Optimization, Estoril, Portugal, January 14-18, 2019: Bernard Fortz

10.1.2. Scientific Events: Selection

10.1.2.1. Member of the Conference Program Committees

LI Brazilian Symposium on Operational Research (LI SBPO), Limeira/SP - Brazil, September 2019: Martine Labbé

ORBEL 2019, Hasselt, Belgium, January 2019: Bernard Fortz, Martine Labbé

ROADEF2019 - 19ème Conférence de la Société Française de Recherche Opérationnelle et d'Aide à la Décision, Le Havre, France, February 2019: Luce Brotcorne, Diego Cattaruzza, Bernard Fortz, Frédéric Semet

INOC 2019, International Network Optimization Conference, Avignon, France, June 2019: Bernard Fortz

EURO 2019, European Conference of Operational Research Societies, Dublin, Ireland, June 2019: Bernard Fortz

5th JuliaCon, Baltimore, USA, July 22-26, 2019: Mathieu Besançon

TRISTAN X-Triennial Symposium on Transportation Analysis, Jun 2019, Hamilton Island, Australia, June 2019: Frédéric Semet

Workshop of the Transportation and Logistics Society, INFORMS, Jun 2019, Vienna, Austria, June 2019: Frédéric Semet

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- EURO Journal on Computational Optimization: Martine Labbé - Editor in chief, Bernard Fortz - Editor
- Computers and Operations Research: Luce Brotcorne - Member of the Advisory Board
- INFORMS Journal on Computing: Bernard Fortz - Associate editor

- International Transactions in Operations Research: Bernard Fortz, Martine Labbé - Associate editors
- Transportation Science: Martine Labbé - Member of the Advisory Board

10.1.3.2. Reviewer - Reviewing Activities

Annals of Operations Research, Applied Computing and Informatics, Central European Journal of Operations Research, Computers & Operations Research, Computational Optimization and Applications, Discrete Applied Mathematics, EURO Journal on Transportation and Logistics, European Journal of Operational Research, IISE Transactions, INFORMS Journal on Computing, International Journal of Management Science and Engineering Management, Mathematical Programming Computation, Networks, Omega, Operations Research, Optimization and Engineering, RAIRO - Operations Research, Transportation Science, IEEE Transactions on Power Systems, IEEE Transactions on Smart Grids, IEEE Power Engineering Letters: Mathieu Besançon, Luce Brotcorne, Diego Cattaruzza, Bernard Fortz, Martine Labbé, Maxime Ogier, Frédéric Semet.

10.1.4. Invited Talks

- Mathieu Besançon was invited speaker at the JuliaNantes workshop in Nantes, France, June 2019
- Martine Labbé was plenary speaker at CPAIOR in Tessalonik, Greece, June 2019
- Martine Labbé was plenary speaker at AMSI Optimise in Perth, Australia, June 2019
- Martine Labbé was plenary speaker at the 7th International Conference on Variable Neighborhood Search, Rabat, Marocco, October 2019
- Frédéric Semet was invited speaker at the Workshop on the Logistics of Autonomous Vessels, Bergen, Norway, May 2019

10.1.5. Leadership within the Scientific Community

EURO Working Group “Pricing and Revenue Management”: Luce Brotcorne - coordinator

EURO Working Group “European Network Optimization Group (ENOG)”: Bernard Fortz - coordinator

EURO Working Group “Vehicle routing and logistics optimization (VEROLOG)”: Frédéric Semet - Member of the board

INFORMS Women in OR/MS: Luce Brotcorne - International liaison

ORBEL (Belgian Operations Research Society): Bernard Fortz - Member of the board of administration

ORBEL representative for EURO and IFORS: Bernard Fortz

CNRS GdR 3002: Operations Research: Frédéric Semet - Member of the steering committee

10.1.6. Scientific Expertise

Scientific orientation committee of the Interuniversity Centre on Entreprise Networks, Transportation and Logistics (CIRRELT), Canada: Bernard Fortz, Frédéric Semet - Members

Center for Mathematics, Fundamental Applications and Operations Research, University of Lisbon: Martine Labbé - Member

DFG Review Panel “Mathematics” for Clusters of Excellence, 2018: Martine Labbé - Member

Scientific committee of France-Netherlands Exchange Program: Luce Brotcorne - Member

Evaluation committee for Inria/MITACS Exchange Program: Luce Brotcorne - Member

Evaluation committee COST GTRI: Luce Brotcorne - Member

Fund for research training in industry and agriculture (FRIA) PE1 - jury 1: Bernard Fortz - Member

Scientific board of PICOM competitiveness cluster: Frédéric Semet - Member

Agence Nationale de la Recherche (ANR): Luce Brotcorne, Frédéric Semet - Reviewer

Fond de Recherche Nature et Technologie du Québec: Frédéric Semet - Reviewer

Research Council of Norway: Frédéric Semet - Reviewer

Evaluation committee NSERC - EG 1509: Bernard Fortz - Member

10.1.7. Research Administration

Committee for the Technological Development (CDT): Luce Brotcorne - Member

CRIStAL: Frédéric Semet - Deputy-director

Scientific council of Centrale Lille: Frédéric Semet - Elected member

Scientific council of OPTIMA thematic group of CRIStAL: Diego Cattaruzza Member

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master: Bernard Fortz, Recherche Opérationnelle et Applications, 30hrs, M1, University of Mons (Charleroi campus), Belgium

Master: Bernard Fortz, Continuous Optimization, 24hrs, M1 & M2, Université libre de Bruxelles, Belgium

Master: Frédéric Semet, Non-linear Optimization, 30hrs, M2, Centrale Lille

Master: Frédéric Semet, Operations Research, 28hrs, M2, Centrale Lille

Master: Luce Brotcorne, Optimisation, 14hrs, M1, Polytech Lille

Master: Luce Brotcorne, Recherche opérationnelle, 16hrs, M1 apprentissage, Polytech Lille

Master: Diego Cattaruzza, Maxime Ogier, Frédéric Semet, Prescriptive analytics and optimization, 64hrs, M1, Centrale Lille

Master: Diego Cattaruzza, Maxime Ogier, Object-Oriented Programming, 48hrs, M1, Centrale Lille

Master: Diego Cattaruzza, Maxime Ogier, Operations Research, 16hrs, M1, Centrale Lille

Licence: Diego Cattaruzza, Maxime Ogier, Object-Oriented Programming, 36hrs, L3, Centrale Lille

Licence: Frédéric Semet, Advanced programming and Complexity, 24hrs, L3, Centrale Lille

Licence: Diego Cattaruzza, Maxime Ogier, Object-Oriented Programming, 40hrs, L2, Centrale Lille

Licence: Bernard Fortz, Algorithmique 1, 12hrs, L1, Université libre de Bruxelles, Belgium

Licence: Bernard Fortz, Algorithmique et Recherche Opérationnelle, 24hrs, L3, Université libre de Bruxelles, Belgium

10.2.2. Supervision

PhD: Simon Bélières, Mathematical programming for tactical transportation planning in a multi-product supply chain, November 2019, Nicolas Jozefowiez, Frédéric Semet

PhD: Wenjuan Gu, Location routing for short and local fresh food supply chain, November 2019, Maxime Ogier, Frédéric Semet

PhD: Yuan Yuan, Vehicle Routing Problems with Synchronization for City Logistics, October 2019, Diego Cattaruzza, Frédéric Semet

PhD: Léonard Von Niederhausern, Design and pricing of new services in energy in a competitive environment, March 2019, Luce Brotcorne, Didier Aussel

PhD in progress: Luis Alberto Salazar Zendeja, Formulations and resolution methods for network interdiction problems, from November 2018, Diego Cattaruzza, Martine Labbé, Frédéric Semet

PhD in progress: Matteo Petris, Column generation approaches for integrated operationnal problems, from October 2019, Diego Cattaruzza, Maxime Ogier, Frédéric Semet

PhD in progress: Concepción Domínguez Sánchez, Mixed Integer Linear Models and Algorithms for Pricing Problems, from October 2017, Martine Labbé

PhD in progress: Moises Rodriguez Madrena, Problems in data analysis and location Theory, from January 2019, Martine Labbé, Justo Puerto

PhD in progress: Fränk Plein, Models and methods for the robust verification of booked capacities in gas networks in a decentralized setting, from October 2017, Martine Labbé

PhD in progress: Jérôme De Boeck, Optimization problems in energy, from October 2015, Bernard Fortz

PhD in progress: Mathieu Besançon, Approche bi-niveau de réponse à la demande dans les réseaux électriques intelligents, from September 2018, Miguel Anjos, Luce Brotcorne, Frédéric Semet

PhD in progress: Yaheng Cui, Models and methods for decentralized decision in logistics networks, from Oct 2016, Luce Brotcorne, Eric Ballot

10.2.3. Juries

- Ikram Bouras, PhD, Université de Montpellier, 2019, “Fixed Charge Network Design Problem with User Optimal flows”: Luce Brotcorne (reviewer)
- Umar Hashmi, PhD, Université PSL, Paris, 2019, “Optimization and Control of Storage in Smart Grids”: Luce Brotcorne (reviewer)
- Léonard von Niederhäusern, PhD, Centrale Lille, 2019, “Design and pricing of new energy services in a competitive environment”: Bernard Fortz (president)
- Meihui Gao, PhD, Université de Lorraine, 2019, “Models and methods for Network Function Virtualization (NFV) architectures”: Bernard Fortz (reviewer)
- Yuan Yuan, PhD, Centrale Lille, 2019, “Models and Algorithms for Last Mile Delivery Problems with Multiple Shipping Options”: Martine Labbé (member)
- José Neto, HDR, Université Evry, 2019, “Some contributions to mathematical programming and combinatorial optimization”: Bernard Fortz (reviewer)
- Marc-Antoine Coindreau, PhD, University of Lausanne, Switzerland, 2019, “Managing Advanced Synchronization Aspects in Logistics Systems”: Frédéric Semet (reviewer)
- Ruslan Sadykov, HDR, Université de Bordeaux, 2019, “Modern Branch-Cut-and-Price”: Frédéric Semet (reviewer)

10.3. Popularization

- Luce Brotcorne, Journées scientifiques de l’Inria, Lyon, June 2019
- Frédéric Semet, Cité de l’IA - Intelligence Artificielle, MEDEF Lille Métropole, April 2019
- Maxime Ogier, Frédéric Semet, 4ème séminaire humAIn : IA, optimisation et retail - logistique, Polytech Lille, October 2019

10.3.1. Internal or external Inria responsibilities

- Frédéric Semet, 30 minutes de sciences, Inria Lille Nord Europe, April 2019

11. Bibliography

Major publications by the team in recent years

[1] N. ABSI, D. CATTARUZZA, D. FEILLET, M. OGIER, F. SEMET. *A heuristic branch-cut-and-price algorithm for the ROADEF/EURO challenge on Inventory Routing*, in "Transportation Science", 2019, forthcoming, https://hal-emse.ccsd.cnrs.fr/emse-02163171

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Publications of the year

Articles in International Peer-Reviewed Journals

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