2018-00427 - [Campagne Doctorant 2018/CRI LILLE] - Ph.D
Thesis : in bilevel and mixed integer optimization (M/F)

About the research centre or Inria department

The Inria Lille - Nord Europe Research Centre was founded in 2008 and employs a staff of 360, including 300 scientists working in sixteen research teams. Recognised for its outstanding contribution the socio-economic development of the Nord - Pas-de-Calais Region, the Inria Lille - Nord Europe Research Centre undertakes research in the field of computer science in collaboration with a range of academic, institutional and industrial partners.

The strategy of the Centre is to develop an internationally renowned centre of excellence with a significant impact on the City of Lille and its surrounding area. It works to achieve this by pursuing a range of ambitious research projects in such fields of computer science as the intelligence of data and adaptive software systems. Building on the synergies between research and industry, Inria is a major contributor to skills and technology transfer in the field of computer science.

Context

Context

Over the last few decades, the broad development of information and communication technologies has lead to extensive changes in society. The impact of the new technologies and globalization has originated different consumer trends and strong competition in the market. This has forced companies to adapt their marketing strategies in order to fit customer's preferences. In this context, many retail and manufacturing companies have opted for the use of pricing strategies designed to increase their revenue.

Pricing optimization problems aim at determining the prices of a series of products in order to maximize the revenue of the company. Setting a low price can lead to a loss of income if clients were willing to pay a higher price, but it can also make the product available to a greater amount of customers; on the contrary, a high price can generate greater revenue, but clients may not purchase it if it is too high. Therefore, it becomes obvious that a pricing problem is a bilevel program, in other words, has a hierarchical structure with a first optimization problem given by the company, which aims at maximizing its profit, and part of the constraints that force the solution to be optimal to another optimization problem, which is maximizing customers' utility. An equivalent problem in Game Theory is known as the Stackelberg game. In this two-player game, one of the players (known as the leader) plays first and decides his best strategy taking into account that the second player or follower will react to his movement optimally, knowing the leader's choice.

The doctoral research will focus on the family of pricing problems that arises when customers' purchasing decision is modelled by means of a budget, they are interested in several products and intend to buy one of them according to a selection rule. These are called unit-demand customers and the purchasing decision is modelled by means of a budget, they are interested in several products and intend to buy one of them according to a selection rule. These are called unit-demand customers and will be able to purchase a product if its price is at most their budget.

The goal of the doctoral research is an in-depth study of this price optimization problem when the customer ranks the items and purchases the highest-ranked one which fits his budget. This is known as the Rank Pricing Problem.

Scientific environment

The thesis will be carried out within the INOCS team whose primal goal is the study of optimization problems involving complex structures. The scientific objectives of INOCS are related to modeling and methodological concerns. The INOCS team focuses on integrated models for problems with complex structure (CS) taking into account the whole structure of the problem and 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.

The thesis will be supervised by Martine Labbé whose expertise concerns the resolution of bilevel problems using mixed integer linear models and who focuses in particular on pricing optimisation problems.
Assignment

Research project

The first part of this doctoral research project will be devoted to the development of price optimization models to tackle the Rank Pricing Problem. This problem aims at setting the prices of the products of a company taking into account that we deal with unit-demand customers whose rule selection of products is based on preferences. Due to the hierarchical structure of the problem, it will be modelled as a bilevel program. In the first place, unlimited supply will be considered.

The problem will be formulated as a bilevel program and then transformed into a single level optimisation problem with a nonlinear objective. Different linearization techniques will lead to several formulations to compare and the polyhedral structure of the resulting models will be studied. From the bilevel formulations, several single level formulations might be developed and strengthening valid inequalities should be derived. Furthermore, the efficiency of the proposed formulations will be evaluated through an extensive computational study.

Afterwards, the problem will be generalised by considering limited supply. This will lead to new formulations, since the items must be allocated to the customers.

State of the art

Price setting problems stated using bilevel programming fit multiple applications in sectors such as networks (an overview can be found in [1]), the trucking industry and in the context of air traffic management, to cite but a few.

Rusmevichientong et al.[2] are the first to propose maximum and minimum utility objectives, as well as a rank-buying objective for pricing problems with unlimited supply and unit-demand customers. In the first two cases, the customer purchases the item which maximizes or minimizes the difference between his budget and the price of the product, whereas in the rank-buying objective the client buys the product that ranks highest and he can afford. In this case, the authors represent a customer by its budget and an ordered list of recommended products, and capture his purchasing behaviour by means of a choice function. They show that these problems are NP-complete in the strong sense and propose a heuristic approximation algorithm. Variations of the model are considered in [3]. The optimal resolution of these problems by means of Integer Programming techniques has not yet been approached in the literature.

References


Main activities

Main activities:

- Develop bilevel and mixed integer models for rank pricing problems.
- Compare models from theoretical and computational points of view.
- Carry out polyhedral studies of ranks pricing problems.
- Develop solution algorithms based on the previous findings using cutting plane or column generation approaches.
- Carry out computational experiments to determine the best solution approach.

Additional activities:

- write scientific reports and articles.
- Give presentation at scientific meetings.

Skills

Skills

Candidates should hold a Master's degree in Operations research, mathematics, computer science, or similar fields and should ideally have a solid background in discrete optimization, integer programming, decomposition techniques. Computer science skills in algorithmic and C/C++ development are also welcome.

Knowledge of French is not required, but good communication skills and a solid knowledge of English are essential.
Benefits package

Benefits

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Sports facilities
- Flexible working hours

More information about Lille:

http://www.lille3000.eu/portail/
http://www.lillemetropole.fr/mel.html

Remuneration

Remunerating

The gross monthly salary is 1982€ for the 1st and the 2nd year, 2085€ for the 3rd year