Scientific Report

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Nationality	Russian
Name of the *Host Organisation*	INRIA Lille - Nord Europe
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Period of the fellowship	03/12/2012 to 02/12/2013

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During ERCIM Alain Bensoussan Fellowship program I have investigated discrete bi-level problems with multiple criteria at the lower level. My former research was devoted to discrete bi-level problems with one criterion at the lower level. Thus my scientific co-ordinator offered to extend the problem has been considered before. I have explored a new class of problems that is more challenging than before in some sense.

In one of the primary work (Bracken J., McGill J.: Mathematical programs with optimization problems in the constraints. J. Oper. Res., 21, 37 – 44, 1973) bi-level programs were called mathematical programs with optimization problems in the constraints that reflect the gist of these problems. These problems are extremely difficult mostly because of the bi-level nature of the problem, the combinatorial nature of the problem, and the presence of multiple objectives.

To the best of our knowledge there is no any work devoted directly to the problem addressed in this research, however some related works devoted this challenging area have been found (Herminia I. Calvete, Carmen Gale: On linear bilevel problems with multiple objectives at the lower level. Omega, 39, 33 – 40, 2011). But they are not suitable in case of discrete multi-optima lower level problem.

Due to some economic applications and game theory interpretation a class of two levels (or bi-level) mathematical programs are widely considered. In bi-level optimization researches deal with a two level hierarchical structure. There are upper and lower levels. They correspond to two players called a leader and a follower. The leader plays at the upper level, and the follower is at the lower one. An upper level decision is influenced by a decision of a lower level.

For example, a leader and a follower, compete to serve customers by opening a certain number of facilities from given facility location set. At first, the leader decides where to locate his (or her) facilities taking into account the follower's reaction. Later on, the follower opens his (or her) facilities at other places. Each customer chooses the closest opened facility. The leader and the follower obtain a profit from serving a customer. Each player maximizes his (or her) own profit(s). We suppose that the leader maximizes one type of profits and the follower is interested in maximizing two different profits. The problem is to define where the leader’s facilities should be located such that to maximize the leader’s profit. Under facilities we could imply power plants, smart meters or any other objects. The location problems might arise in any area (industry, telecommunications, bioinformatics, economics and so on). And most of these problems are NP-hard even with one player (single level problems) .

The main goal of my research has been to identify and highlight a new challenging field: discrete bi-level multi-objective optimization. The main contributions of my research are the thoroughly definitions of feasible and optimal solutions in case of discrete bi-level optimization with multicriteria at the lower level, the necessary notations and an approach to solve discrete bi-level problem with multiple objectives at the lower level. The approach developed is a hybrid of a metaheuristic that are widely used in operations research, and a new exact approach based on mathematical programming techniques.

The approached has been developed, programmed and tested on the discrete (r|p)-centroid problem with two follower's objectives. Computational experiments on the test instances have been carried out.

We presented our results at two international conferences (EURO|INFORMS and DOOR-2013) and have prepared a paper to European Journal of Operational Research (Impact Factor: 2.038).

In addition, I was continuing working on my former research projects. As a result I prepared one chapter in a book (Metaheuristics for bi-level optimization. Ed. El-Ghazali Talbi, Springer, 2013), a paper to the Journal of Global Optimization (Impact Factor 1.307).
The overview of my former and current research activity was presented during the exchange programs in University of Porto and SINTEF ICT.
Thanks to attending a summer school for smart energy systems I got familiar with new perspective fields in energy distribution grids. My future research direction is to apply the approach developed for bi-level energy pricing models, investigate other discrete bi-level optimization problems with multiple criteria at the upper level that is an interesting and challenging task as well.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

1.
E. Alekseeva, Yu. Kochetov Matheuristics and exact methods for the discrete (r|p)-centroid problem. **Chapter in the book** Metaheuristics for bi-level optimization. Ed. El-Ghazali Talbi. Springer Berlin Heidelberg, 482, p. 189 – 219, 2013 (doi 10.1007/978-3-642-37838-6) ***(published)***
Abstract:
This chapter presents an overview of the recent results concerning the discrete (r|p)-centroid problem. It is a competitive facility location problem with two noncooperative decision makers: a leader and a follower. They compete to attract customers from a given market by opening facilities. At first, the leader opens p facilities. Later on, the follower opens r facilities. Each customer patronizes the closest facility. The problem is to find p facilities for the leader to maximize his market share. It is a noncooperative Stackelberg game which can be formulated as a bi-level mixed integer problem. It is known that the problem is Sigma-P2-hard even for the Euclidean distances. We describe the hybrid algorithms based on matheuristics and present two exact approaches which operate with a single-level reformulation with polynomially many variables and exponentially many constraints. We demonstrate the comparative computational results and discuss the promising directions for further research.
2.
E. Alekseeva, Yu. Kochetov, and Al. Plyasunov An exact method for the discrete (r|p)-centroid problem. **Journal of Global Optimization** ***(accepted**, in press)*
Abstract
This paper provides a new exact iterative method for the following problem. Two decision makers, a leader and a follower, compete to attract customers from a given market. The leader opens p facilities, anticipating that the follower will react to the decision by opening r facilities. Each customer patronizes the closest opened facility. The goal is to find p facilities for the leader to maximize his market share. It is known that this problem is Sigma-P2 -hard and can be presented as an integer linear program with a large number of constraints. Based on this representation, we design the new iterative exact method. A local search algorithm is used at each iteration to find a feasible solution for a system of constraints. Computational results and comparison with other exact methods show that the new method can be considered as one of the alternative approaches among the most advanced exact methods for the problem.
3.
E. Alekseeva, Yu. Kochetov, El-Gh. Talbi A matheuristic for the discrete bi-level problem with multiple objectives at the lower level.

European Journal of Operational Research ***(pending****, in progress)*
Abstract
In this paper we tackle a discrete bi-level problem with multiple objectives at the lower level. In case of multi-objective lower level we deal with a set of Pareto efficient solutions rather than a single optimal lower level solution. To calculate upper level objective function value we need to select one solution out of a potentially large set of efficient lower level solutions. To avoid the enumeration of the whole set of Pareto solutions we formulate an auxiliary mixed integer linear programming problem with a large number of constraints. We propose a new iterative exact method to solve it. To find a near optimal upper level solution we apply a heuristic. The efficiency of the proposed approach is evaluated on a discrete (r|p)-centroid problem with multiple objectives at the lower level.
4.
E. Alekseeva, Yu. Kochetov, El-Gh. Talbi A hybrid matheuristic for the leader-follower facility location problem with two follower's objectives
(published in abstract book *EURO|INFORMS 26th European conference on operational research MMXIII, p. 251)*
Abstract
A leader and a follower compete to serve customers by opening facilities in turn. The players maximize their own objectives in cooperative manner but the follower has two objectives. We propose a metaheuristics for the leader's problem. For a given leader's solution we need the best follower's solution on a Pareto front. This problem is presented as a mixed integer linear program with the large number of constraints. Based on this formulation we design a new iterative exact method. Computational results for Euclidean test instances are discussed.
5.
S. Iellamo, E. Alekseeva, L. Chen, M. Coupechoux, Yu. Kochetov A hybrid matheuristics algorithm for the competitive base stations location problem in Cognitive Radio Networks ***(published in abstract book*** *EURO|INFORMS 26th European conference on operational research MMXIII, p.131)*
Abstract
We present the problem of strategic base stations (BS) placement in Cognitive Radio (CR) Networks. We consider a CR operator (the leader) willing to exploit the unused capacity of a primary network so as to maximize the profits derived from operating the installed BSs and serving Secondary Users (SU). The leader is aware of the future arrival of a second operator (the follower), who is able to capture SUs by appropriately placing his own CR-BSs. We formulate the problem as a mixed integer bi-level program. We show that it is Sigma2P-hard and propose a hybrid matheuristic algorithm to solve it.
6.
E. Alekseeva, Yu. Kochetov, El-Gh. Talbi A matheuristic for the discrete (r|p)-centroid problem with multiple objectives for the follower
(published in abstract book *DOOR- 2013, p. 145)*

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Seminars
ABCDE Seminar

Venue: Athens, Greece, October 30 – November 1, 2013

Seminar at DOLPHIN team (http://dolphin.lille.inria.fr/News/Seminars)
Title: A matheuristic for the discrete (r|p)-centroid problem with multiple objectives for the follower
Venue: INRIA Center. Lille, France, May 14, 2013

Workshops
Young Women in Discrete Mathematics (http://www.or.uni-bonn.de/youngwomen/)
Title: E. Alekseeva Leader-Follower facility location problems
Venue: Research Institute for Discrete Mathematics. Bonn, Germany, June 7 – 9, 2013

Conferences
EURO|INFORMS 26th European conference on operational research MMXIII (http://euro2013.org/)
Title 1: E. Alekseeva, Yu. Kochetov, El-Gh. Talbi A hybrid matheuristics for the leader-follower facility location problem with two follower's objectives
Title 2: S. Iellamo, E. Alekseeva, L. Chen, M. Coupechoux, Yu. Kochetov A hybrid matheuristics algorithm for the competitive base stations location problem in Cognitive Radio Networks
Venue: Sapienza University of Rome. Rome, Italy, July 1–4, 2013

International Conference Discrete Optimization and Operations Research (http://math.nsc.ru/conference/door/2013/index_eng.html)
Title:
E. Alekseeva, Yu. Kochetov, El-Gh. Talbi A matheuristic for the discrete (r|p)-centroid problem with multiple objectives for the follower
Venue: Sobolev Institute of Mathematics. Novosibirsk, Russia, June 24 – 28, 2013
(It was not been attended personally but my report has been presented by a co-author)

Summer school
Summer School for Smart Energy Systems at an EIT ICT Labs
First place award for the project "SMUTH: Smart Measuring Units – Transition Highlights Optimized SMU layout for a smooth transition to smart grids"
Venue: Siemens Technical Academy. Berlin, Germany, August 19 – 30, 2013. Paris Sud University, Supélec, Laboratoire des signaux et systèmes. Gif-Sur-Yvette, France, August 26 – 30, 2013

IV – RESEARCH EXCHANGE PROGRAMME (REP)

Title of the presentation: Discrete bi-level p-median location problems
Venue: Industrial Engineering and Management Research Unit (UGEI) at Faculty of Engineering of the University of Porto, Professor Bernardo Almada Lobo. Porto, Portugal, June 23 – 30, 2013

Title of the presentation: Discrete bi-level optimization problems
Venue: Applied Mathematics department, SINTEF Information and Communication Technology (ICT), Senior Research Scientist Tomas Eric Nordlander. Oslo, Norway, November 24 – 29, 2013