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*Editorial*

# Bilevel Programming, Equilibrium, and Combinatorial Problems with Applications to Engineering 2016

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Even though plenty of applications comply with the bilevel programming (BLP) and bilevel optimal control (BOC) frameworks, not many real-life implementations appear in the literature. The latter can be explained by the clear lack of efficient algorithms solving medium- and large-scale BLP and BOC problems. Indeed, treating a BLP (or BOC) program, even in its simplest setting, is far from being an easy task. Many alternative methods may be used, but there is no general recipe that could provide for convergence or optimality for all problem of the required kind.

Mixed-integer BLPs (MIBLPs) with partly integer variables often produce a real challenge for the conventional optimization techniques. For instance, a replacement of the lower-level (LL) optimization problem with the Karush-Kuhn-Tucker (KKT) conditions may fail if some LL variables are not continuous. Therefore, a solid theoretical base including elements of combinatorial methods is necessary to propose efficient algorithms aimed at finding local or global solutions of such problems.

To this end, a lot of new ideas were proposed and developed into new algorithms by many outstanding researchers in the area of bilevel programming. Among them, we would name Dempe, Mordukhovich and Dutta [1, 2], Labbé, Marcotte, and Savard [3, 4], DeNegre and Ralphs [5], and Liberti and Pantelides [6], whose efforts develop different modes of reducing original bilevel programming problems to equivalent single level ones, as well as new types of algorithms making the solution of mixed-integer BLP a treatable task for the conventional mathematical programming software.

Engineering applications of bilevel optimization and combinatorial problems also include facility location, environmental regulation, energy and agricultural policies, hazardous materials management, and optimal designs for chemical and biotechnological processes.

For instance, many new applied problems in various areas of human knowledge have recently arisen, which can be efficiently solved only as MIBLPs. A very short list of such comprises the virtual desktops placement in distributed cloud computing; a risk-based interval two-stage programming problem for agricultural system management under uncertainty; complementary cycles in irregular multipartite tournaments; a problem of an optimal product family design;

corporate international investment problem; and so forth. Bilevel models to describe migration processes have also become very popular in the area of BLP and BOC.

The primary purpose of this annual special issue is to discuss these problems with the researchers working in the corresponding areas. The papers selected for this special volume deal with three main themes: Mixed-Integer Bilevel Programming, Bilevel Stochastic Control Models, and Combinatorial (Integer Programming) Problems, as well as their Applications to Engineering/Planning.

One of such applications is the well-known bilevel programming problem of the virtual desktops placement in distributed cloud computing. It is well-known that distributed cloud has been widely adopted to support service requests from dispersed regions, especially for big enterprises that request virtual desktops for multiple geodistributed branch companies. The cloud service provider (CSP) usually aims at delivering satisfactory services at the least cost. CSP selects proper data centers (DCs) closer to the branch companies so as to shorten the response time to the user's request. At the same time, it also strives to cut cost considering both DC level and server level. At the DC level, the expensive long distance inter-DC bandwidth consumption should be reduced and lower electricity price is sought by exploiting the geodistribution of DCs. Inside each tree-like DC, servers are trying to be used as little as possible so as to save equipment cost and power. In nature, there exists a noncooperative relationship between the DC level and server level in the selection of DCs and servers. To attain these objectives and capture the noncooperative relation, J. Zhang et al. in "A Unified Algorithm for Virtual Desktops Placement in Distributed Cloud Computing" make use of a multiobjective bilevel programming framework. Then a unified genetic algorithm is proposed to seek the best virtual desktops placement solution which realizes the selection of DC and the server simultaneously. The extensive simulation shows that the proposed algorithm outperforms the baseline algorithm in both the quality of service guaranteed and the total cost.

One of the principal management problems deals with product family design engineering, within which plenty of leader-follower relationships exist. C. Miao et al. in "Genetic Algorithm for Mixed Integer Nonlinear Bilevel Programming and Applications in Product Family Design" study the problem in question by applying the bilevel programming (BLP) techniques. Product family design problems boast important features. For instance, the mixed-integer nonlinear bilevel program (MINLBLP) controlling both continuous and discrete variables and solving multiple independent lower-level problems is widely used in product family optimization. The authors propose a bilevel genetic algorithm (BLGA) to solve these particular MINLBLP problems. They provide results of numerical experiments with several examples to demonstrate the effectiveness and reliability of the developed algorithm. In addition, a reduced family case study is examined in order to demonstrate practical applications of the proposed BLGA.

Equilibrium time-consistent strategy for corporate international investment problem with mean-variance criterion is proposed and founded in "Equilibrium Time-Consistent Strategy for Corporate International Investment Problem with Mean-Variance Criterion" by J. Long and S. Zeng. In this paper, the authors analyze a continuous-time (optimal control) model for corporate international investment problem (CIIP) with mean-variance criterion. Based on the Nash sub-game perfect equilibrium theory, they define an infinitesimal operator and directly derive an extended Hamilton-Jacobi-Bellman equation. Besides, the equilibrium time-consistent strategy for CIIP is derived. In addition, the paper also discusses two possible cases of the risk aversion coefficient. Namely, in case 1 it is constant, whereas in case 2 it is state-dependent. Finally, the simulation results are given to illustrate the conclusions and the influence of some parameters on the optimal solution as well.

A similar stochastic-related bilevel programming problem is studied in the paper "A Risk-Based Interval Two-Stage Programming Model for Agricultural System Management under Uncertainty" by Y. Xu and G. Huang. Nonpoint source (NPS) pollution caused by agricultural activities is the main reason for worsening, up to deterioration, of the water quality in a watershed. Moreover, pollution control is quite costly and usually accompanied with a revenue's fall for the agricultural system. Therefore, to design and generate an economically effective, environment-friendly, and risk-averse agricultural production pattern becomes a critical issue for local managers. To tackle the abovementioned problem, a risk-based interval two-stage programming (RBITSP) model is developed by the authors. Compared to the general ITSP model, a significant contribution made by the RBITSP model is that it emphasized the importance of financial risk under various probabilistic levels, rather than only being concentrated on expected economic benefit (where the risk is considered as the probability of unmeeting the target profit under each individual scenario realization). This way effectively avoids the solutions' deviation caused by the traditional expected objective function. Also, by this mode, a variety of solutions is generated by adjusting the weight coefficients included in the objective function, thus reflecting a kind of trade-off between the system's economy and reliability. A case study of agricultural system management related to the Lake Tai basin is used to demonstrate the superiority of results could serve as a base for designing and determining agricultural development schemes realizing the balance between the system benefit, system failure risk, and water-body protection.

Another work presenting a novel aggregate production planning (APP) model for operations management is "Enhanced Simulated Annealing for Solving Aggregate Production Planning" by M. R. Abu Bakar et al. Since aggregate production planning (APP) is one of the key points in the whole production management, the authors of the paper set the problem as a multiobjective linear programming model and try to optimize it within the means of simulated annealing (SA). While dealing with the optimization of the APP problem, the authors found out that the capability of SA was inadequate and its performance was substandard, especially for a sizable controlled APP problem with many decision variables and plenty of constraints. Because this algorithm works sequentially, the current iteration will generate only one next iteration, which makes the search slow. The other drawback is that the search may stop at a local minimum

representing the best solution only on a part of the feasible set. In order to enhance the method's performance and alleviate the deficiencies in the problem solving, a modified simulated annealing (MSA) technique is proposed. The authors attempt to augment the search region by starting with $N + 1$ approximate solutions instead of only one iterate. To analyze and compare the steps of the MSA against the standard SA and harmony search (HS), the real performance of an industrial company is taken into account, and simulations are made to evaluate the various algorithms' features. The obtained numerical results show that, in comparison to SA and HS, MSA offers better quality procedures with respect to their convergence rates and accuracy.

Finally, the problem of complementary cycles in irregular multidigraphs is examined in "Complementary Cycles in Irregular Multipartite Tournaments" by Z. He et al. Here, a tournament is a directed graph (digraph) obtained by assigning a direction for each edge in an undirected complete graph. A digraph $D$ is cycle-complementary if there exist two vertex-disjoint cycles $C$ and $C'$ such that their vertices form a partition of the set of vertices of digraph $D$. The existence of such a partition with two cycles is an important issue in the graph theory. As their main results, the authors of the paper establish sufficient conditions for such a partition to exist in any locally almost regular multipartite tournament.

We hope that the reader of this annual special issue will find not only new ideas and algorithms dealing with the difficult problems such as Mixed-Integer Bilevel Programming, Bilevel Stochastic Control Models, and Combinatorial (Integer Programming) Problems, as well as their Applications to Engineering/Planning, but also some interesting results concerning the modern simulation techniques and the advanced graph theory.

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