

**Operations Research and Engineering Management  
Seminar Series**

**Research Seminar**

**Dealing with the Lower-level (Follower's) Problem in  
Bilevel Mixed-Integer Linear Programming**



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**<https://smu.zoom.us/j/97906267193>**

**Abstract**

In bilevel optimization, two independent decision-makers (known as the leader and the follower) with their own distinct objective functions are involved in a hierarchical decision-making process. The leader (the upper-level decision-maker) acts first, and then the follower (the lower-level decision-maker) determines the response in terms of their own optimization model, whose feasible region and objective function are parameterized on the leader's decision. Importantly, the follower's response also affects the leader's objective function. Bilevel programming models arise in several important application domains including network design,

revenue management, energy and defense. As we first briefly overview in this talk, complexity of solving bilevel programs depends on the structure of the lower-level problem, in particular, whether the lower-level problem involves integrality restrictions. Our main focus is on bilevel mixed-integer linear optimization problems in which the decision variables of the lower-level problem are all binary. We propose a general modeling and solution framework motivated by the practical reality that in a Stackelberg game, the follower does not always solve their optimization problem to optimality. They may instead implement a locally optimal solution with respect to a given leader's decision. Such scenarios may occur when the follower's computational capabilities are limited, or when the follower is not completely rational. Our framework relaxes the typical assumption of perfect rationality that underlies the standard modeling framework by defining a hierarchy of increasingly stringent assumptions about the behavior of the follower. Associated with this hierarchy is a hierarchy of upper and lower bounds that are in fact valid for the classical case in which complete rationality of the follower is assumed. Two mixed integer linear optimization problem formulations are derived for the resulting bilevel optimization problems. Furthermore, we briefly discuss how the framework can be applied to a general class of bilevel matroid problems. Extensive computational results are provided to demonstrate the effectiveness of our formulations and the quality of the bounds produced. The latter are shown to dominate the standard approach based on a single-level relaxation at a reasonable computational cost. This is a joint work with Xueyu Shi and Ted Ralphs.

### **Biography**

Dr. Oleg Prokopyev is a Professor in the Department of Industrial Engineering at the University of Pittsburgh. He received MS and PhD degrees in industrial and systems engineering from the University of Florida and BS and MS degrees in applied mathematics and physics from Moscow Institute of Physics and Technology (Moscow, Russia). Dr. Prokopyev's research interests are in the areas of combinatorial optimization, bilevel programming, optimization under uncertainty, and applications in health care, bioinformatics and network analysis problems. His research has been supported by the National Science Foundation, Air Force Office of Scientific Research (AFOSR) and Office of Naval Research. Dr. Prokopyev is a recipient of the AFOSR Young Investigator Program Award. He is the Co-Editor-in-Chief of Optimization Letters and serves on the editorial boards of IISE Transactions and Journal of Global Optimization.