Abstracts

Mixed Integer Programming 2012

Speaker: Shabbir Ahmed
Title: Semi-continuous network flow problems

Abstract: We consider network flow problems where some of the variables are restricted to be semi-continuous. We introduce the single-node semi-continuous flow set with variable upper bounds as a relaxation. Two particular cases of this set are considered, for which we present complete descriptions of the convex hull in terms of linear inequalities and extended formulations. We study the efficacy of the polyhedral results on a class of semi-continuous transportation problems. Joint work with Gustavo Angulo and Santanu S. Dey.

Speaker: Gennadiy Averkov
Title: Lattice-free sets and their application in cutting-plane theory

Abstract: A closed, convex set K is said to be lattice-free if K does not contain integer points in its interior. It is well-known that lattice-free polyhedra can be used for generation of cutting planes. In my talk I will discuss recent joint results with Christian Wagner and Robert Weismantel on classification of integral and rational maximal lattice-free polyhedra.

Speaker: Sam Burer
Title: Robust Rankings for American College Football

Abstract: We present a model for calculating robust rankings of American college football teams. Using data from the 2006-2011 seasons, we discover that the top-25 rankings of a well-known computer system are quite sensitive to (hypothetical) changes in the outcomes of games between very weak teams. To alleviate this sensitivity, we propose a robust variant of the rankings based on solving a mixed-integer nonlinear program. We then devise a solution procedure that typically requires about a minute of computation time. Finally, we confirm empirically that our rankings are indeed considerably more robust.

Speaker: Philipp M. Christophel
Title: The Black Art of Pivoting (and Why We Should Care)

Abstract: Linear Programming (LP) and the simplex algorithms are at the heart of most methods to solve (mixed) integer programming (MIP) problems. We MIP researchers often like to think about the LP solver as a black box and don't worry too much about how things are done inside. This talk will try to make a case for looking inside this box. It starts out with a brief introduction to how pivoting works in a modern simplex implementation. Then it gives two examples of pivoting algorithms which explore primal and dual degenerate solutions to assist in solving problems with integer variables. This is joint work with Imre Pólik.

Speaker: Jesus De Loera
Title: Recent advances in the theory of linear programming: new algebraic and topological ideas

Abstract: Linear programming is undeniably a central tool of optimization and a source of many fascinating mathematical problems. In this talk I will present several advances from the past 5 years in the theory of linear optimization. These results include new light on the complexity of the simplex method, the structure of central paths of interior point methods, and about the geometry of some less well-known techniques. We will try to summarize work by many authors and will include results that are my joint work with subsets of the following people A. Basu, M. Junod, S. Klee, B. Sturmfels, and C. Vinzant.

Speaker: Alberto Del Pia
Title: Integral polyhedra with finite inverse Chvtal-Gomory rank

Abstract: Given an integral polyhedron P, a "relaxation" of P is a rational polyhedron Q that contains exactly the same integral points as P. We define the "inverse Chvtal-Gomory (CG) rank of P" to be the supremum of the set of the CG ranks of all relaxations of P. Note that a polyhedron P has finite inverse CG rank if and only if there exists a natural number h such that each relaxation of P has CG rank bounded by h. We show that an integral, non-empty polyhedron P has infinite inverse CG rank if and only if there exists an integral vector v not in the recession cone of P, such that $\mathbf{relint}(P + \langle v \rangle)$ does not contain integral points, where we denote by "relint" the relative interior, and by "$\langle\rangle$" the linear hull.

Speaker: Friedrich Eisenbrand
Title: Diameter of Polyhedra and Sub-Determinants

Abstract: One of the most prominent mysteries in linear programming is the question whether the diameter of a polyhedron can be bounded by a polynomial function in the dimension and its number of facets. The best known upper bound is $n^{\log d+1}$ (Kalai & Kleitman 1992) while no super linear lower bound is known. In this talk, I present a new upper bound on the diameter of polyhedra that is polynomial in the maximum sub-determinant of the defining matrix and the dimension. This new bound improves upon a previous result of Dyer and Frieze in the setting of polyhedra defined by totally unimodular matrices. The talk is based on joint work with N. Bonifas, N. Hähnle, S. Razborov, M. Niemeier and T. Rothvoss.

Speaker: Ricardo Fukasawa
Title: New inequalities for mixing sets arising in chance constrained programming

Abstract: The mixing set with a knapsack constraint arises as a substructure in mixed-integer programming reformulations of chance-constrained programs with stochastic right-hand-sides over a finite discrete distribution. Recently, Luedtke et al. (2010) and Küçükyavuz (2012) studied valid inequalities for such sets. However, most of their results were focused on the equal probabilities case (equivalently when the knapsack reduces to a cardinality constraint). In this talk, we will present our results for the general probabilities case (general knapsack constraint).

We characterize the valid inequalities that do not come from the knapsack polytope and use this characterization to generalize the inequalities previously derived for the equal probabilities case. We also show that one can separate over a large class of inequalities in polynomial time. This is joint work with Ahmad Abdi.

Speaker: Vineet Goyal
Title: Statis v/s Dynamic Optimization

Abstract: Most real world problems require optimization models that handle uncertain parameters. In a dynamic robust optimization framework, uncertainty is modeled as belonging to a set and the goal is to compute a dynamic (fully-adjustable) solution that is optimal for the worst-case realization of the uncertain parameters. This can be computed via a classical DP approach but this is often intractable. Another solution paradigm is to construct a static solution that is feasible for all future uncertainty realizations. This is a tractable approach but is often perceived to be highly conservative. We compare the performance of static solutions with optimal fully adjustable solutions and show that it is a good approximation for the dynamic robust optimization problem under fairly general conditions. In particular, we consider linear and convex dynamic optimization problems and relate the performance of static solutions with the properties of uncertainty set. Our analysis also provides important insights about constructing good uncertainty sets in dynamic robust optimization problems.

Speaker: Marcos Goycoolea
Title: The Bienstock-Zuckerberg Algorithm: From Open Pit Mining to Conic Programming

Abstract: Recently, Bienstock and Zuckerberg (2009,2010) proposed a Lagrangean decomposition framework for solving large-scale LPs. We study this framework and introduce several extensions, including a variant for solving general Conic Programming problems. We present computational experiments suggesting that these extensions can be an effective way of solving conic robust and portfolio optimization problems. We further test these extensions solving large-scale open pit mine production scheduling problems where ore price uncertainty is considered using a robust optimization model.

Joint work with Eduardo Moreno, Gonzalo Muoz and Juan Pablo Vielma.

Speaker: Yongpei Guan
Title: A Branch-and-Cut Algorithm for the Multi-stage Stochastic Unit Commitment Problem

Abstract: Due to the uncertainties from both supply and demand sides, power grid operation is generally a stochastic nonlinear programming problem for the deregulated electricity market. In this talk, we propose a Multi-stage Stochastic Unit Commitment (MSUC) model to address this problem, where we approximate the nonlinear fuel cost functions by piecewise linear functions. Furthermore, we employ a branch-and-cut algorithm to solve MSUC by constructing strong inequalities based on the structure of the constraints.

Speaker: Volker Kaibel
Title: Some Results on Extended Formulations

Abstract: An extended formulation of a polytope is a linear description of a higher dimensional polyhedron that can be projected to the polytope of interest. Such an extended formulation can be significantly smaller and easier to access than any linear description of the polytope in the original space. While trying to give an overview on several aspects of this topic that has attracted some attention during the last few years, we will in particular report on some recent results, for instance on characterizations of slack matrices, extended formulations of alternahedra, extensions by simple polytopes, and practical experiences with extended formulations of spanning trees polytopes for planar graphs. The talk is based on joint works with Elke Eisenschmidt, Roland Grappe, Kanstantsin Pashkovich, Matthias Walter, Stefan Weltge, and Stephan Sorgatz.

Speaker: Kiavash Kianfar
Title: n-step conic MIR and mixed n-step MIR

Abstract: This talk consists of two separate parts with a common theme, i.e. valid inequalities based on n-step MIR for sets with more than one constraint. In the first part, we introduce the "n-step conic MIR inequalities" for the so-called polyhedral second-order conic (PSOC) mixed integer sets. PSOC sets arise in the polyhedral reformulation of the SOCMIPs and are defined by two linear inequalities. We show that the n-step conic MIR inequalities are facet-defining for the general PSOC set under certain conditions. These inequalities are generated using the "n-step conic MIR functions." The simple conic MIR inequalities of Atamtrk and Narayanan (2010) and the n-step MIR inequalities of Kianfar and Fathi (2009) are special cases of these inequalities. We show that the n-step conic MIR inequality strictly dominates the n-step MIR inequalities written for the two linear constraints that define the PSOC set. In the second part, we generalize the mixing procedure of Gnlk and Pochet (2001) to mix the n-step MIR inequalities and introduce the "mixed n-step MIR inequalities." We prove that these inequalities define facets for the n-mixing set (a generalization of the mixing set with n integer variables in each row). We also show that mixed n-step MIR can generate valid inequalities based on multiple constraints for general MIPs. Moreover, we introduce multi-module generalizations of the capacitated lot-sizing and facility location problems and show that mixed n-step MIR generates valid inequalities for these generalizations. Our computational results justify the effectiveness of the mixed n-step MIR inequalities (Joint work with Sujeevraja Sanjeevi and Sina Masihabadi).

Speaker: Mustafa Kilinc
Title: Disjunctive Cutting Planes for Convex MINLP and Extended Formulations

Abstract: The focus of this work is a computationally effective method for generating disjunctive cuts for convex MINLPs. The method solves a sequence of cut-generating linear programs (CGLP). If the constraint functions have a special separability structure, then the polyhedral outerapproximation of the feasible region can be significantly improved by introducing auxiliary variables that separately approximate the elements of the constraint functions. These improved approximations can have significant positive benefits for linearization-based algorithms as well as the performance of the disjunctive cut generation method.

The introduction of auxiliary variables can also improve the strength of the generated cuts. For instance, we have recently shown that, while the conic MIR proposed by Atamturk and Narayanan only uses an LP approximation to generate cuts for conic integer programming, the use of an extended formulation can allow the conic MIR to outperform cuts that use all the nonlinear relaxation. Our computational experiments compare the strength of this and other extended formulations for cutting plane generation and explore the strength of extensions of the conic MIR that use additional nonlinear information. This talk is based on joint work with S. Moderasi, J. Linderoth, J. Luedtke and J.P. Vielma.

Speaker: Fatma Kilinc-Karzan
Title: Properties of Strong Cutting Planes for Mixed Integer Programs with Cone Constraints

Abstract: We study mixed integer conic sets with bounded integer variables and a self-dual cone such as nonnegative orthant, Lorentz cone or positive semidefinite cone. In a unified framework, we introduce minimal inequalities and show that under mild assumptions, minimal inequalities together with the trivial conic inequalities provide complete convex hull description. We also provide a characterization of minimal inequalities by establishing necessary conditions for an inequality to be minimal. Our framework generalizes the results from the mixed integer linear case, so whenever possible we highlight the connections to the existing literature.

Speaker: Dave Morton
Title: Nested Solutions and a Class of Bicriteria Combinatorial Optimization Problems

Abstract: We consider a bicriteria combinatorial optimization problem in which we simultaneously maximize a supermodular gain function and minimize an increasing and submodular cost function. The usual approach would form the efficient frontier of Pareto optimal solutions, trading off gain and cost. We restrict attention to the concave envelope of the efficient frontier. Such solutions can be found in polynomial time and are nested. We provide three motivating examples involving border security, joint chance constraints, and clustering. This is joint work with Michael Nehme.

Speaker: Ted Ralphs
Title: Multi-level/Multi-stage Optimization: Complexity and Algorithms

Abstract: Many real-world optimization problems involve multiple decision-makers, multiple objectives, and/or decisions that are made in multiple stages. Such problems arise both in practical applications (game theory, stochastic programming) and in theoretical contexts (analysis of recursive algorithms). The computational complexity of such problems is often difficult to discern, but can generally be understood in terms of the so-called "polynomial time hierarchy," of which the classes P and NP are the first two levels. In this talk, we discuss the complexity of and relationships between a number of related problem classes, focusing specifically on multi-level/multi-stage problems with discrete decisions at some or all levels/stages. We present a new result that shows that the separation problem for a certain strengthened version of the well-known generalized subtour elimination constraints is not in NP unless the polynomial time hierarchy collapses to its second level. We also discuss at a high level the

algorithmic implications of these complexity results.

Speaker: Ed Rothberg
Title: 1000X MIP Tricks

Abstract: A modern MIP solver is built on several pillars. In addition to a rich theoretical base and a heavy reliance on data structures and algorithms, a MIP solver also builds on simple observations about problem structure found in practical models. This talk will discuss several 'tricks' for exploiting such structure. The unifying theme behind the techniques discussed is simply that each allows us to solve some models at least 1000X faster than without the trick.

Speaker: Siqian Shen
Title: Risk Optimization in Probabilistic Programs with Single or Multiple Chance Constraints

Abstract: Problems of probabilistic programming, also referred to as chance-constrained programming (CCP), evaluate value-at-risks of uncertain events, and permit certain tolerances for such risks. In this paper, we optimize risk tolerances as decision variables in CCP models, which by assumption only contain random discretely distributed right-hand sides. The paper first considers a bilevel interdiction problem, in which an inner problem contains one single-row chance constraint, while an outer problem decides the risk tolerance associated with the constraint, to maximize the minimum objective computed by the inner problem. We re-interpret the risk variable as SOS1 binary variables, associated with finite risk-tolerance thresholds. We also extend our investigation to CCP models with multiple single-row chance constraints, each of which has an associated risk tolerance variable. The goal is to seek an optimal combination of risks to minimize the overall objective value in the resulting CCP. We demonstrate the two model variants by respectively solving a stochastic minimum-cost flow problem and a multicommodity flow capacity expansion problem on a set of randomly generated graph instances. The paper also discusses a hybrid algorithm of integrating Benders decomposition and column generation for optimizing risks in CCP models with multiple joint chance constraints.

Speaker: Renata Sitorov
Title: Reformulation-linearization technique, semidefinite programming and symmetry in combinatorial optimization problems

Abstract: The reformulation-linearization technique (RLT) provides a way to compute linear programming bounds on the optimal values of NP-hard combinatorial optimization problems. It is well known that the second level RLT relaxation often provides significantly better bounds than the first level RLT relaxation, but that it is computationally very expensive to solve.

In this talk we show that, in the presence of suitable algebraic symmetry in the original problem data, it is possible to compute the second level RLT bounds with additional semidefinite programming constraints. As a result we compute the best known bounds for certain graph partitioning problems involving strongly regular graphs. We also provide good upper bounds on the stability number of the Hamming graphs.

Speaker: Dan Steffy
Title: Improving the accuracy of LP solvers with iterative refinement

Abstract: We describe an iterative refinement procedure for computing extended precision or exact solutions to linear programming problems. Arbitrarily precise solutions can be computed by solving a sequence of closely related LPs with limited precision arithmetic. The LPs solved at iterations of this algorithm share the same constraint matrix as the original problem instance and are transformed only by modification of the objective function, right-hand side, and variable bounds. Exact computation is used to compute and store the exact representation of the transformed problems, while numeric computation is used for computing approximate LP solutions and applying iterations of the simplex algorithm. We demonstrate that this algorithm is effective in practice for computing extended precision solutions and that this leads to direct improvement of the best known methods for solving LPs exactly over the rational numbers. We also investigate the use of this method within a framework for computing extended precision or exact solutions to mixed-integer programming problems.
(joint work with Ambros Gleixner and Kati Wolter)

Speaker: Alejandro Toriello
Title: Optimal Toll Design: A Lower Bound Framework for the Traveling Salesman Problem

Abstract: We propose a framework of lower bounds for the asymmetric traveling salesman problem based on approximating the dynamic programming formulation, and give an economic interpretation wherein the salesman must pay tolls as he travels between cities. We then introduce an exact reformulation that generates a family of successively tighter lower bounds, all solvable in polynomial time, and compare these new bounds to the well-known Held-Karp bound. Time permitting, we discuss extensions to a stochastic setting where arc costs are uncertain and revealed dynamically as the salesman traverses the network.

Speaker: Christian Wagner
Title: Convex integer minimization in fixed dimension

Abstract: Recently, it has been shown that minimizing a convex function over the integer points of a bounded convex set is polynomial in fixed dimension. I will sketch the very geometric proof of this result.
