Workshop on Discrete Optimization

in honor of William R. Pulleyblank

IBM T. J. Watson Research Center, May 31-June 1, 2018

Speakers and Abstracts

David Applegate, Google
Title: Some scheduling problems for TensorFlow computations
Abstract: TensorFlow is an open-source software library for dataflow programming, used for machine learning applications such as deep neural networks. Because the execution order is unspecified (beyond the dataflow dependencies), and memory is often an important resource limitation, this gives rise to precedence-constrained scheduling problems with edge-based capacity constraints. I will introduce some of these problems, and present some preliminary solution approaches and results.

Francisco Barahona, IBM Research AI
Title: On two cooperative games related to shortest paths and minimum cuts
Abstract: We study the "Shortest path" and "Path disruption" games. We give combinatorial algorithms to test membership to the core and to compute the nucleolus.

Dimitris Bertsimas, MIT
Title: From Data to Decisions
Abstract: In this talk, I review some developments in my research group at MIT regarding taking decisions directly from data. I discuss both theoretical developments, applications and implementations in clinical practice.

Andrew Conn, IBM Research
Title: An l_1-Augmented Lagrangian algorithm and why, at least sometimes, it is a very good idea.
Abstract: For almost 50 years l_2-Augmented Lagrangian algorithms have been around and they are still frequently used today. One way of looking at them is to

consider them as a modification of the inexact quadratic penalty function (which requires that the penalty parameter becomes unbounded) by adding Lagrangian terms. The resulting advantage is that by way of updating the Lagrangian multipliers one can solve the original constrained problem whilst bounding the penalty parameter.

In this talk I will describe an l_1-Augmented Lagrangian which one could consider as a modification of the exact l_1-penalty function by adding Lagrangian terms. Since the penalty parameter for exact penalty functions remains bounded anyway and furthermore the l_1 exact penalty function is not differentiable, this does not sound like a good idea. I hope to convince you otherwise!

Time permitting I will include, motivation, theory, context and some numerical results.

Gerard Cornuéjols, Carnegie Mellon University
Title: Total Dual Integrality and the Packing Property
Abstract: Total dual integrality of set covering inequalities gives rise to several open problems. In particular, the replication conjecture of Conforti-Cornuejols (1993) and the tau=2 conjecture of Cornuejols-Guenin-Margot (2000) remain open. In this talk, we discuss recent progress made by Ahmad Abdi, Dabeen Lee and myself on this topic.

Jack Edmonds
Title: Blossom Programs and Their Polytopes by Pulleyblank et al.
Abstract: Some reminiscent remarks about facet theory and computer programs for the optimum matching problem by Claude Berge, Alan Hoffman, Guan Mei-Gu, Ellis Johnson, Dick Karp, Bill Pulleyblank, Vasek Chvátal, Bill Cook, Thomas Rothvoss, and others.

Sandor Fekete, Technische Universität Braunschweig
Title: Combinatorial Optimization meets Computational Geometry
Abstract: Many problems of combinatorial optimization can be considered in a geometric context: for the Traveling Salesman Problem, vertices correspond to points, and edge weights arise from geometric cost. Moreover, geometric applications give rise to generalizations and variations: if we need to cover a whole region instead of individual points, a TSP can turn into a Lawnmowing Problem. This makes is interesting to consider the interaction between discrete optimization and computational geometry.

In this talk, I will present a number of results for optimization problems for

which geometric variants provide additional twists. Particular examples include the geometric Maximum Traveling Salesman Problem (for which geometry helps to compute optimal solutions in very fast time) the Art Gallery Problem (where seemingly simple geometric subroutines may become critical for the overall runtime) and covering tours with turn cost. As it turns out, these problems are not only of theoretical interest, but also relevant for a variety of applications, such as robot navigation.

Michel Goemans, MIT
Title: Some of my favorite results of Bill Pulleyblank

David Hartvigsen, University of Notre Dame
Title: Packing k-matchings and k-critical Graphs
Abstract: A (simple) k-matching in a graph is a subgraph all of whose nodes have degree at most k. The k-matching problem is to find a k-matching with the maximum number of edges. Well-known results for the classical 1-matching problem, such as the Tutte-Berge min-max theorem and Edmonds's polynomial-time algorithm, are known to generalize to k-matchings. These 1-matching results are also known to generalize to the problem of finding a subgraph, with a maximum number of nodes, whose connected components are isolated edges and 1-critical (or hypomatchable) graphs from a specified set (e.g., triangles or pentagons). In this presentation, we present a new common generalization of these two generalized 1-matching problems. We present an algorithm, a min-max theorem, and a structure theorem (that generalizes the Edmonds-Gallai theorem for 1-matchings). Even when specialized to k-matchings, our min-max and structure theorems appear to be new.

Brian Macdonald, Florida Panthers
Title: Optimization problems in professional sports
Abstract: We give an overview of how data visualization, analysis, and optimization are used within the Florida Panthers organization, around the National Hockey League, and in the sports industry in general, in a variety of different contexts. We discuss how analytics can be used to assist a teams front office, coaching staff, and scouting department. We also discuss the kinds of data and optimization problems we encounter on the business side of the organization in departments like sales and marketing.

Thomas Magnanti, MIT

Title: A Bit About Bill, A Bit About Scheduling with Testing
Abstract: After offering some comments about my interactions with Bill Pulleyblank, I will summarize some optimization work with Retsef Levi and Yaron Shaposhnik on a practically motivated problem. We wish to schedule jobs whose processing times and weights have common known probability distributions, but we can test any job to determine its actual processing time. The objective is to complete all the jobs with the minimum weighted total processing times. Testing can help to order the jobs and decrease processing times, but testing requires some processing time. So the trade-off is between exploration (testing) and exploitation (processing jobs).

George Nemhauser, Georgia Tech.
Title: Machine Learning for Integer Programming
Abstract: We will show how machine-learning techniques can be used in branch-and-cut algorithms to improve branching variable selection and the use of primal heuristics. Joint work with Elias Khahil, Shabbir Ahmed and Bistra Dilkina.

Bruce Reed, McGill University
Title: Iterative Compaction and the Two Disjoint Rooted Path Problem.
Abstract: An instance of k-DRP consists of a graph G and 2k distinct vertices s1,...,s,t1,...,tk. We are asked to determine if there are k vertex disjoint paths P1,...,Pk such that Pi has endpoints si and ti. We present a linear time algorithm to solve this problem. The tools are also key to linear time algorithms to solve k-DRP for fixed k and to test membership in any minor closed family.

Ajay K. Royyuru, IBM Research
Title: The Sizzle of Simulations in Life Sciences
Abstract: Over the last two decades, we have experienced > 1000x increase in computational capability. This coupled with dramatic advances in algorithmic techniques - e.g. coarse graining, sampling, multi-scale modeling - the field of computational biology is witnessing a bloom of sophisticated simulations. This talk will provide a few examples from research done in IBM Computational Biology Center in areas of molecular, cardiac, and neural tissue modeling.

Baruch Schieber, IBM Research AI
Title: Constrained Submodular Maximization via Greedy Local Search
Abstract: We present a simple combinatorial $(1/2)(1 - 1/(e^2))$-approximation algorithm for maximizing a monotone submodular function subject to a knap-

sack and a matroid constraint. This classic problem is known to be hard to approximate within factor better than 1 - 1/e. We extend the algorithm to yield $(1/k)(1-1/(e^k))$ approximation for submodular maximization subject to a single knapsack and k-1 matroid constraints, for any fixed $k > 1$. Our algorithms, which combine the greedy algorithm of [Khuller, Moss and Naor, 1999] and [Sviridenko, 2004] with local search, show the power of this natural framework in submodular maximization with combined constraints.
This is joint work with Kanthi Sarpatwar and Hadas Shachnai.

Bruce Shepherd, University of British Columbia
Title: When do Gomory-Hu Subtrees Exist?
Abstract: Gomory-Hu (GH) Trees are a classical sparsification technique for graph connectivity. For any undirected graph G = (V, E) and any subset of terminals Z in V , we may find an edge-capacitated tree T = (Z, E(T)) such that for every u, v in Z, the value of the minimum capacity uv cut in G is the same as in T. Moreover, the minimum cuts in T directly identify those in G. It is well-known that we may not always find a GH tree which is a subgraph of G. For instance, every GH tree for the vertices of K3,3 is a 5-star. We characterize those graph and terminal pairs (G,Z) which always admit a GH subtree. We show that these are the graphs which have no K2,3 terminal minor and then discuss applications. This is joint work with Guslain Naves.

Mike Trick, Carnegie Mellon University
Title: Combining Realignment with Scheduling for Sports Leagues

Don Wagner, Office of Naval Research
Title: Nonseparating cocircuits in binary matroids
Abstract: Nonseparating cycles in graphs and their matroid generalization, nonseparating cocircuits, have proved to be useful tools for analyzing structure in graph and matroids. For example, Tutte characterized planar graphs using nonseparating cycles, and Bixby and Cunningham characterized graphic matroids using nonseparating cocircuits. This talk presents an algorithm for finding a nonseparating cocircuit in a "smooth" binary matroid and a new characterization of graphic matroids using nonseparating cocircuits. Based on this characterization, a new algorithm is given for determining whether a binary matroid is graphic.