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IMA NEWSLETTER # 313

October 1–October 31, 2002

2002–2003 Program

OPTIMIZATION

See <http://www.ima.umn.edu/optimization/> for a full description of the 2002–2003 program on Optimization.

IMA schedules are subject to revision, particularly during workshops. See

<http://www.ima.umn.edu/~seminar/sched> and

<http://www.ima.umn.edu/newsletters/> for the latest scheduling information.

PART I: NEWS AND NOTES

Industrial Advisory Board Meeting

The IMA Industrial Advisory Board held its annual meeting on Sunday 8 September 2002. Information was presented to the board by Doug Arnold and by the Dean of IT, Ted Davis. There was a lengthy discussion on upcoming IMA programs. Cynthia Barnhart of MIT gave a presentation entitled “Optimizing Service Networks in Transportation and Logistics”. Doug Arnold led a discussion of special programs and fundraising.

PARTICIPATING INSTITUTIONS: Centrum voor Wiskunde en Informatica (CWI), Consiglio Nazionale delle Ricerche, Georgia Institute of Technology, Indiana University, Iowa State University, Kent State University, Los Alamos National Laboratory, Michigan State University, Mississippi State University, Northern Illinois University, Ohio State University, Pennsylvania State University, Purdue University, Sandia National Laboratories, Seoul National University (BK21 Math-SNU), Seoul National University (SRCCS), Texas A&M University, University of Chicago, University of Cincinnati, University of Delaware, University of Houston, University of Illinois (Urbana), University of Iowa, University of Kentucky, University of Maryland, University of Michigan, University of Minnesota, University of Notre Dame, University of Pittsburgh, University of Wisconsin, University of Wyoming, Wayne State University.

PARTICIPATING CORPORATIONS: Boeing, Ford, General Motors, Honeywell, IBM, Lockheed Martin, Lucent, Motorola, Schlumberger, Siemens, Telcordia Technologies, 3M.

Version of November 5, 2002

IMA Workshop:
Computational Methods for Large Scale Integer Programs

14–19 October 2002

Organizers: William J. Cook (Industrial and Systems Engineering Georgia Tech),
Martin W.P. Savelsbergh (Industrial and Systems Engineering Georgia Tech),
George Nemhauser (Georgia Institute of Technology),
Michel Gendreau (Université de Montreal),

See <http://www.ima.umn.edu/optimization/fall/op2.html>.

IMA Website

Comments or suggestions concerning the IMA website may be addressed to

webmaster@ima.umn.edu.

In particular, we appreciate any information about World-Wide Web links appropriate to current and upcoming IMA programs.

PART II: SCHEDULE FOR OCTOBER 1–OCTOBER 31, 2002

Tuesday, October 1

The 10:30 IMA break will be in Lind Hall 400.

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15am	Mike Siddoway Colorado College and U of M	R-Modules with the Krull-Schmidt Property
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Abstract: A fundamental question mathematicians ask is whether a given structure decomposes in a nice way. For instance, in the ring of integers we know that any number can be written uniquely as a product of primes. If we expand the integers in some simple way we sometimes lose uniqueness. We also know that any finite dimensional vector space is completely characterized by its dimension. That is, there is only one way to write a vector space (up to isomorphism) as a direct sum of indecomposable vector spaces. The indecomposable vector spaces are simply the one dimensional vector spaces. An R-module is just a vector space with the scalar field replaced by a commutative ring. An abelian group can be viewed as a Z-module, a module over the integers. In module theory, we say that a class of modules has the Krull-Schmidt Property if every module in the class is uniquely (up to isomorphism) the direct sum of indecomposable members of the class. By our earlier comments we see that finite dimensional vector spaces have the Krull-Schmidt Property. This idea was first formulated by Krull in the 20's for finite groups. In this talk I will explore decompositions of modules with some finiteness conditions over various rings, and say a few things about when these modules have the Krull-Schmidt Property.

The IMA Postdoc Seminar is organized by Olga Brezhneva and M. Yvonne Ou.

Wednesday, October 2

The 10:30 IMA break will be in Lind Hall 400.

Thursday, October 3

The 10:30 IMA break will be in Lind Hall 400.

APPL. MATH. AND NUM. ANAL. SEMINAR, Vincent Hall 570:

11:30am **Bernardo Cockburn** A new characterization of hybridized mixed methods
Univ. of Minnesota

Mixed finite element methods are a very powerful method for numerically solving second-order elliptic problems. Since their approximate solution is difficult to compute, it is necessary to recast them in a suitable way; this can be achieved by what is called a hybridization procedure. The price to pay, however, is that we must introduce new unknowns, called Lagrange multipliers, which satisfy a matrix equation difficult to compute. In this talk, we give a new characterization of the approximate solution given by hybridized mixed methods for second-order, self-adjoint elliptic problems. We then apply this characterization to obtain an explicit formula for the entries of the matrix equation for the so-called Lagrange multipliers. We also obtain necessary and sufficient conditions under which the multipliers of two well-known methods (the Raviart-Thomas and the Brezzi-Douglas-Marini) of similar order are identical.

Friday, October 4

The 9:40 IMA break will be in the Vincent Hall lounge.

IMA/MCIM INDUSTRIAL PROBLEM SEMINAR, 570 Vincent Hall:

10:10 am **Ron Mahler** Tracking in High Target Densities Using a First-Order
Lockheed Martin Tactical Defense Sys- Multitarget Moment Density
tems

Abstract: This talk addresses the problem of detecting and tracking large numbers of non-cooperative targets in a cluttered background. The usual approach, which is computationally intractable in general, would be to attempt to detect and track each and every target or potential target. The proposed approach uses the opposite strategy: it attempts to track only what is knowable (initially, geometrical shape and target density) and only later attempting to resolve individual targets out of the "multitarget background" as (and if) more data becomes available. From a mathematical point of view the approach is novel because the multitarget scenario is modeled as a random measure (specifically, a multidimensional random point process) and the optimal (but intractable) recursive Bayes filter is approximated by propagating the first moment measure (more accurately, its density function) instead of the full multitarget posterior density function.

Monday, October 7

The 10:30 IMA break will be in Lind Hall 400.

OPTIMIZATION SEMINAR, Lind Hall 409:

11:15am **TBA**

Tuesday, October 8

The 10:30 IMA break will be in Lind Hall 400.

IMA Workshop:
Computational Methods for Large Scale Integer Programs

14–19 October 2002

Organizers: William J. Cook (Industrial and Systems Engineering Georgia Tech),
 Martin W.P. Savelsbergh (Industrial and Systems Engineering Georgia Tech),
 George Nemhauser (Georgia Institute of Technology),
 Michel Gendreau (Université de Montreal),

See <http://www.ima.umn.edu/optimization/fall/op2.html>.

In the past decade there have been significant theoretical and computational advances in the field of integer programming. As a result there has been a greatly increased use of integer programming software in industry. However, the need to solve even larger and more complex problems continues to grow. In this workshop, we will bring together experts in various areas of integer programming and its applications. Theoretical and methodological topics included in the workshop are approximation algorithms for large scale linear programs, stochastic integer programming, branch-and-cut and branch-and-price, algebraic and combinatorial methods, decomposition, constraint programming and parallel implementation. Application areas include supply chain design and management, telecommunications, manufacturing, transportation, scheduling, and finance. The workshop will be of interest to mathematicians and operations researchers working in discrete and combinatorial optimization, computational scientists working in parallel computing, search, and constraint programming. Goals of the workshop include building a research agenda for the next decade, defining new areas of application, and stimulating cooperation among the different disciplines that contribute to the field.

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30 am	Coffee and Registration	Reception Room EE/CS 3-176
9:15 am	Douglas N. Arnold, Scot Adams, and Organizers	Welcome and Introduction
9:30–10:20 am	Daniel Bienstock Columbia University	Subset Algebra Lifting

Abstract: More than ten years ago, Lovasz and Schrijver proposed a formal framework for solving 0-1 integer programs that relies on the idea of “lifting” n -dimensional 0-1 vectors to 0-1 vectors in a space of much higher dimension. This process is advantageous in that the lifting reveals the structure of a 0-1 integer program in a more explicit way than the original formulation. The work of Lovasz and Schriver was itself motivated by earlier (special-case) work by Balas, Pulleyblank, Barahona and others. In the Lovasz-Schrijver approach, the target space of the lifting is the subset lattice of an n -element set. This method, and related work by Sherali and Adams (and later by Lasserre) have attracted attention in that the resulting relaxations provably satisfy nice properties.

In this talk we present a procedure that instead lifts to the subset-algebra of an n -element set. This method yields far stronger algorithms. For example, we obtain polynomial-time algorithms for solving the relaxation of a set-covering problem over the convex hull of all inequalities with small coefficients.

This is joint work with Mark Zuckerberg (Columbia).

10:20– 10:30 am	Coffee Break	Reception Room EE/CS 3-176
10:30– 11:20 am	Dimitris Bertsimas MIT	TBA

11:20–1:30 pm **Lunch Break**

1:30–2:20 pm **David Applegate** Solving Random Euclidean TSPs
AT&T

Abstract: I will present computational results on solving random euclidean TSPs, with up to 2500 nodes, using the TSP solver Concorde. This is joint work with Bob Bixby, Vasek Chvátal, and Bill Cook.

2:20–2:30 pm **Coffee Break** Reception Room EE/CS 3-176

2:30–3:00 pm **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

3:00 pm **IMA Tea/Reception** IMA East, 400 Lind Hall

A variety of appetizers and beverages will be served.

SPECIAL LECTURE, WALTER LIBRARY, DIGITAL TECH. CTR. 402:

11:15-12:15 **Stephen Cook** The P vs NP Problem and Propositional Proof Complexity
Univ. of Toronto

The question whether $P = NP$ is the first of seven million-dollar “Millennium Prize Problems” listed by the Clay Mathematics Institute. We discuss the importance of the problem by imagining a world in which $P=NP$, and explain why most complexity theorists believe $P \neq NP$. We show how this question is related to other fundamental problems in complexity theory, including the entangled problems of whether NP has polynomial size circuits, and whether some problems are inherently easier to solve using a source of random bits. The question whether $NP = coNP$ motivates the important field of propositional proof complexity.

Tuesday, October 15

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00–9:30 am **Coffee** Reception Room EE/CS 3-176

9:30–10:20 am **Karen Aardal** Lattice Basis Reduction and Integer Programming
Georgia Institute of Technology

Abstract: We will review some of the main algorithmic ideas behind the use of lattice basis reduction to solve integer programming and related problems. We also discuss some computational issues related to the use of such methods. One issue is the amount of work spent in determining good branching directions. We present some computational results, useful computer packages available, and a number of open problems.

10:20–10:30 am **Coffee Break** Reception Room EE/CS 3-176

10:30–11:20 am **Rekha R. Thomas** The Structure of Group Relaxations
 University of Washington, Seattle

Abstract: This talk will survey the main results on the structure of group relaxations that come from commutative algebra and discrete geometry. In particular, I will explain some of the open questions in this subject area and more generally, in the algebraic approach to integer programming. No familiarity with any of the algebraic methods is needed.

11:20–1:30 pm **Lunch Break**

1:30–2:20 pm **William R. Pulleyblank** Caratheodory’s Theorem and Cutting Planes
 IBM Research

Cutting plane methods are well established as effective tools for solving many classes of integer programming problems, including Traveling Salesman Problems and Vehicle Routing Problems. A key to their success is the creation of effective cuts which can be introduced to eliminate infeasible solutions. We discuss an approach, jointly developed with Ralphs, Kopman and Trotter, that uses convex decompositions of fractional solutions to find violated structured cuts. It provides a general paradigm applicable to a broad range of combinatorial problems and is particularly well suited to massively parallel computer systems.

2:20–2:30 pm **Coffee Break** Reception Room EE/CS 3-176

2:30-3:20 pm **Pascal Van Hentenryck** Local Search Programming
 Brown University

Abstract: We present a three-level architecture for local search and its applications to large-scale optimization. The architecture is compositional and automates many of the tedious aspects of local search algorithms. In particular, it enables declarative specifications of the neighborhood which are compiled into efficient incremental algorithms. It also supports very high-level constructs for implementing heuristics and metaheuristics. The architecture is illustrated on several large-scale optimization problems in facility location and routing. (Joint work with L. Michel).

3:20–3:30 pm **Coffee Break** Reception Room EE/CS 3-176

3:30–4:00 pm **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

4:00 pm **Coffee Break** Reception Room EE/CS 3-176

Wednesday, October 16

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00-9:30 am **Coffee** Reception Room EE/CS 3-176

9:30–10:20 am **Ismael Regis de Farias Jr.** Semi-Continuous Cuts for Mixed-Integer Programming
 Carnegie Mellon University

Abstract: We study the convex hull of the feasible set of the semi-continuous knapsack problem, in which the variables belong to the union of two intervals. Besides being important in its own right, the semi-continuous knapsack problem

is a relaxation of general mixed-integer programming, problems with partial integer variables, and discrete optimization. We show how strong inequalities valid for the semi-continuous knapsack polyhedron can be derived and used in a branch-and-cut scheme for mixed-integer programming, problems with partial integer variables, discrete optimization, and problems with semi-continuous variables. We present computational results that demonstrate the effectiveness of these inequalities, which we call collectively semi-continuous cuts. Our computational experience also shows that dealing with semi-continuous constraints directly in the branch-and-cut algorithm through a specialized branching scheme and semi-continuous cuts is considerably more practical than the “textbook” approach of modeling semi-continuous constraints through the introduction of auxiliary binary variables in the model.

10:20– 10:30 am	Coffee Break	Reception Room EE/CS 3-176
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10:30– 11:20 am	Alexander Martin TU Darmstadt	Mixed Integer Models for the Optimization of Gas Networks
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Abstract: A gas network basically consists of a set of compressors and valves that are connected by pipes. The task of the transient technical optimization is to optimize the drives of the gas and to set in the compressors cost-efficiently such that the required demands are satisfied. This problem leads to a complex mixed integer nonlinear optimization problem. We approach it by approximating the non-linearities by piece-wise linear functions leading to a huge mixed integer program. We study the polyhedral consequences of this model and present some new cutting planes. Our preliminary computational results show the benefits when incorporating these cuts into a general mixed integer programming solver.

11:20–1:30 pm	Lunch Break	
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1:30–2:20 pm	Zonghao Gu ILOG, Inc.	One Size Fits All? Computational Tradeoffs in a Commercial Mixed Integer Programming Solver
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Abstract: Mathematical modelers approach MIP software from a variety of different angles. Models can be challenging for a variety of reasons, some due mainly to combinatorial issues and others due to the difficulty of the relaxations. Modelers also often have different goals, with some requiring proven optimal solutions, others requiring good feasible solutions, and still others simply wanting to know if feasible solutions exist. A variety of techniques and strategies are available for addressing these problems, each of which is appropriate for some but often entirely inappropriate for others. Modelers are generally not interested in understanding the internal workings of the MIP solver, so the task of choosing a reasonable set of techniques to apply to a particular model falls to the MIP solver itself. This talk will discuss some of the more important and interesting computational tradeoffs that result.

2:20–2:30 pm	Coffee Break	Reception Room EE/CS 3-176
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2:30–3:00 pm	Panel Discussion: Robert Bixby, Sebastian Ceria, Martin Groetschel, Ellis Johnson, George Nemhauser, William R. Pulleyblank	
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3:20–3:30 pm	Coffee Break	Reception Room EE/CS 3-176
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3:30–4:00 pm	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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4:00 pm	Coffee Break	Reception Room EE/CS 3-176
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IMA Public Lecture:
The Traveling Salesman Problem

William J. Cook

School of Industrial and Systems Engineering
Georgia Institute of Technology

Wednesday, October 16, 7:00 pm,

Moos Tower, Room 2-650

University of Minnesota, East Bank

See <http://www.ima.umn.edu/public-lecture/tsp/index.html>

The traveling salesman problem, or TSP for short, is easy to state: given a number of “cities” along with the cost of travel between each pair of them, find the cheapest way of visiting all the cities and returning to your starting point. The simplicity of the statement is deceptive - the TSP is one of the most intensely studied problems in computational mathematics and yet no effective solution method is known for the general case. Indeed, the resolution of the TSP would settle the P versus NP problem and fetch a \$1,000,000 prize from the Clay Mathematics Institute.

Although the complexity of the TSP is still unknown, for over 50 years its study has led the way to improved solution methods in many areas of mathematical optimization. We will discuss the history of the TSP and examine the role it has played in modern computational mathematics. We will also present a collection of TSP applications, ranging from genome sequencing to on-line grocery shopping. Finally, we will present a survey of recent progress in algorithms for large-scale TSP instances, including the solution of a million-city instance to within 0.09% of optimality and the exact solution of a 15,112-city instance.

This talk is based on joint work with David Applegate, Robert Bixby, and Vasek Chvátal. It is partially supported by the Institute of Technology Alumni Society.

INFORMAL PRESENTATION, EE/CS 3-180:

4:15 pm

Eduardo Uchoa
Universidade Federal Fluminense

Solving the crude oil distribution problem at PETROBRAS

PETROBRAS is a state owned by company that controls all the Brazilian oil production and refining, by constitutional monopoly. The objective of ALOPE project is to build an operational tool to plan the whole Brazilian crude oil supply over an horizon of 2 months. Since Brazil produces almost no oil in land, the crude oil is transported by tankers from off-shore platforms to ports, which is then sent by pipelines to refineries. Docking restrictions, vessel discharge rates, intermediary tank capacities and pipeline delays must be taken into account. Besides, each refinery requires an specific blend of the many crude oils types available. This talk presents a MIP model to minimize the total distribution cost. Such model has about one million binary variables, current MIP solvers alone are not able even to find a feasible solution to it in reasonable time. New practical techniques that allow to find solutions guaranteed to be within 1% away from optimal are described.

Thursday, October 17

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00-9:30 am **Coffee** Reception Room EE/CS 3-176

9:30-10:20 am **Robert Weismantel** Column Operations for Mixed Integer Programs
University of Magdeburg

Abstract: This talk deals with algorithmic approach for linear mixed integer programs. The essence of the algorithms to be discussed is a procedure that erases columns of the given program at the expense of introducing new columns corresponding to non-decomposable partial solutions. We discuss the general setting as well as a number of special cases such as the stable set problem. Computational results demonstrate the power and the generality of the approach.

10:20-10:30 am **Coffee Break** Reception Room EE/CS 3-176

10:30-11:20 am **Ellis Johnson** Cyclic Group and Knapsack Facets
Georgia Tech

Abstract: Any pure integer program can be relaxed to a cyclic group problem. We consider the master cyclic group problem and three versions of master knapsack problems, show the relationship between these problems, and give several classes of facet-defining inequalities for each problem, as well as mappings that take facets from one type of master polyhedron to another.

11:20-1:30 pm **Lunch Break**

1:30-2:20 pm **Francisco Barahona** Network Reinforcement
IBM T.J. Watson Research Center

Abstract: Given a weighted graph $G=(V,E)$, we study the question of finding a minimum cost subgraph that contains k disjoint spanning trees. We give an algorithm whose complexity is the same as solving $|V|$ minimum cut problems. Previously known algorithms for this require solving $|E|$ minimum cut problems.

2:30-3:00 pm **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

3:00 pm **Coffee Break** Reception Room EE/CS 3-176

6:00 pm **Workshop Dinner** Loring Pasta Bar, 327 14th Avenue S.E.

APPL. MATH. AND NUM. ANAL. SEMINAR, Vincent Hall 570:

11:30am **TBA**

IMA POSTDOC SEMINAR, EE/CS 3-180:

3:15	Igor Vasil'ev University degli Studi Salerno, Italy	Computational experience with large-scale p-Median problems
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Given a directed graph, the p-Median problem consist of determining p nodes (the median nodes) minimizing the total distance to the other nodes of the graph. We present a Branch-and-Cut algorithm yielding provably good solutions for instances up to 3795 nodes of complete graphs, proving in most the cases their optimality. The key ingredients of our approach are: lagrangian relaxation, a simple procedure to choose the "promising variables", preprocessing, a column-and-row generation strategy to solve LP-relaxation, cutting planes.

The IMA Postdoc Seminar is organized by Olga Brezhneva and M. Yvonne Ou.

11:30	Qi Wang E.S.U.	Modeling flows of nematic liquid crystalline polymers using kinetic theory
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I will present a general Doi-type kinetic theory for nematic liquid crystalline polymers (LCPs) accounting for the molecular aspect ratio, excluded volume interaction, long-range intermolecular interaction, and chirality of the molecules. I will derive an approximate intermolecular potential for LCP molecules of the spheroidal shape and the elastic as well as the visocus stress expression corresponding to the shaped molecule being transported in viscous solvent. I will then show the theory obeys the second law of thermodynamics and "reduces" to the well-known Ericksen-Leslie theory for nematic liquid crystals in the weak flow, weak elasticity, and slow time limit. Applications of the theory and its moment approximations in simple flows will be discussed in the end.

Friday, October 18

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00-9:30 am	Coffee	Reception Room EE/CS 3-176
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9:30-9:55	Jacques Desrosiers Ecole des Hautes Etudes Commerciales	Stabilized Column Generation Based on Primal and Dual Strategies
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Abstract: The perturbed version of a linear problem introduces bounded surplus and slack variables. To account for an available trust region on the dual space, these additional variables are penalized in the objective function of the primal formulation. This results in a stabilized version of the problem to solve. We present several theoretical aspects of a stabilized column generation approach and some recent computational results. The proposed procedure is also suitable for the so-called crossover from an optimal interior point solution to an optimal extreme point or basic solution.

9:55-10:20	Jean-Phillipe Vial University of Geneva	Solving Lagrangian Relaxations with a Proximal Analytic Center Cutting Plane Method
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Abstract: Lagrangian relaxation, or its dual equivalent "column generation," is often used to generate lower bounds for integer programming problems, but solving the Lagrangian dual efficiently is sometimes an issue in itself. We propose a new cutting plane method, that can be interpreted as a compromise between the Analytic Center Cutting Plane Method (ACCPM, in short) and the Bundle method. We analyze the performance of the new method on the p-median problem, a special instance of partitioning problems.

(Joint work with O. du Merle, Air France).

10:20–10:30 am	Coffee Break	Reception Room EE/CS 3-176
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10:30– 11:20 am	Ralph Gomory Sloan Foundation	T-Space and Cutting Planes
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In this paper we show how knowledge about T-Space translates directly into cutting planes for general integer programming problems. After providing background on Corner Polyhedra and on T-Space, this paper examines T-Space in some detail. It gives a variety of constructions for T-Space facets, all of which translate into cutting planes, and introduces continuous families of facets. In view of the great variety of possible facets, no one of which can be dominated either by any other or by any combination of the others, a figure of merit is introduced to provide guidance on their usefulness. T-Spaces based on higher dimensional groups are discussed briefly as is the idea of going beyond cutting planes to iterated approximations of Corner Polyhedra.

11:20–1:30 pm **Lunch Break**

1:30–2:20 pm	Vasek Chvatal Rutgers University	TSP Cuts that Do Not Follow the Template Paradigm
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Abstract: The first computer implementation of the Dantzig-Fulkerson-Johnson cutting-plane method for solving the traveling salesman problem, written by Martin, used subtour inequalities as well as cutting planes of Gomory’s type. The practice of looking for and using cuts that match prescribed templates in conjunction with Gomory cuts was continued in computer codes of Miliotis, Land, and Fleischmann.

Groetschel, Padberg, and Hong advocated a different policy, where the template paradigm is the only source of cuts; furthermore, they argued for drawing the templates exclusively from the set of linear inequalities that induce facets of advocated a different policy, where the template paradigm is the only source of cuts; furthermore, they argued for drawing the templates exclusively from the set of linear inequalities that induce facets of the TSP polytope. These policies were adopted in the work of Crowder and Padberg, in the work of Groetschel and Holland, and in the work of Padberg and Rinaldi; their computer codes produced the most impressive computational TSP successes of the nineteen eighties. Eventually, the template paradigm became the standard frame of reference for cutting planes in the TSP.

I will outline a technique for finding cuts that disdains all understanding of the TSP polytope and bashes on regardless of all prescribed templates. Combining this technique with the traditional template approach in Concorde – a computer code written by David Applegate, Bob Bixby, Bill Cook, and myself – was a crucial step in our solution of a 13,509-city TSP instance and a 15,112-city TSP instance.

2:20–2:30 pm	Coffee Break	Reception Room EE/CS 3-176
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2:30–3:00 pm	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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3:00 pm	Coffee Break	Reception Room EE/CS 3-176
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Saturday, October 19

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00-9:30 am	Coffee	Reception Room EE/CS 3-176
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9:30–10:20 am	Francois Vanderbeck Université Bordeaux 1	Dantzig-Wolfe Decomposition for MIP
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Abstract: The presentation aims at highlighting the scope of the Dantzig-Wolfe decomposition approach in Mixed Integer Programming (MIP). We briefly review the decomposition principle and the column generation reformulation it leads to. We see how to handle MIP as opposed to pure IPs. In particular, we discuss alternatives generating sets and the associated ways to enforce integrality. We introduce state space relaxation and the concepts of proper columns and base patterns. We consider multiple and nested decomposition and ways in which column generation can be combined with other efficient approaches to MIP. We conclude with a brief presentation of our generic branch-and-price code, *BaPCod*.

10:20–10:30 am **Coffee Break** Reception Room EE/CS 3-176

10:30–11:20 am **Michel Gendreau** A Column Generation Approach for Vehicle Routing with
Université de Montréal Time Windows and Split Deliveries?

Abstract: In this talk, we will discuss the Split Delivery Vehicle Routing Problem with Time Windows (SDVRPTW), a variant of the well-known Vehicle Routing Problem with Time Windows in which a customer's demand can be split among several vehicles. We will first examine some properties of split delivery solutions and restate a direct mixed integer programming formulation for the problem. The main part of the presentation will be devoted to the description of a new column generation approach for solving the SDVRPTW without imposing any restrictions on the split delivery options. Computational results on problems with up to 50 customers will be reported and analyzed.

11:20–11:30 pm **Coffee Break** Reception Room EE/CS 3-176

11:30–12:20 **Jean-Louis Goffin** Analytic Centers Cutting Plane Methods and Mixed Integer
McGill University Programming, with Extensions to Semi-definite Cuts

Abstract: The most effective way to solve realistic MIPs (mixed integer programs) is branch and price, which is based on Lagrangean relaxation. Lagrangean relaxation provides better bounds than the traditional branch and bound method, which relax the integer requirement.

At every node of the B&B tree, a nondifferentiable convex function (NDO) needs to be optimized. The classical NDO techniques, such as the Dantzig-Wolfe decomposition algorithm or subgradient optimization, have weaknesses, such as unreliable convergence or the lack of a rigorous termination criterion. The analytic center cutting plane method (ACCPM) attempts to improve over this.

We will sketch a full branch and price method that uses extensions of ACCPM, including Ryan and Foster branching and hot starts at the child nodes, using a dual Newton method.

Numerical results will be presented in problems arising in supply chain optimization.

Extensions of Dantzig-Wolfe column generation to semi-definite cuts will also be described, and numerical results in eigenvalue optimization will be reported. This could be used in a branch and sdp-cut framework.

Joint work with Samir Elhedhli, Assistant Professor, Dept. of Management Sciences, University of Waterloo, 200 University W., Waterloo, On. and Mohammad R. Oskoorouchi, College of Business Administration, California State University, San Marcos, 333 S. Twin Oaks Valley Rd., San Marcos, California 92096-0001 USA.

12:20–12:30 pm **Coffee Break** Reception Room EE/CS 3-176

12:30–1:00 pm **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

Monday, October 21

OPTIMIZATION SEMINAR, Lind Hall 409:

11:15am **TBA**

The 3pm (NOTE TIME CHANGE) IMA break will be in Lind Hall 400.

Tuesday, October 22

The 10:30 IMA break will be in Lind Hall 400.

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15 **Lisa Evans** An Overview of Gomory's Group Approach to Solving
IMA IMA Integer Programs

This talk will give an overview of Gomory's group approach to solving integer programs, including some of the key theorems. It will also describe how facets of master cyclic group problems can be used to generate cutting planes for general IP's. A related method that generates cutting planes from piecewise-linear subadditive functions that approximate the facets of master cyclic group problems will also be presented. Some new classes of facets for the master cyclic group problem will be described, as well as preliminary computational results using subadditive functions to generate cutting planes.

The IMA Postdoc Seminar is organized by Olga Brezhneva and M. Yvonne Ou.

Wednesday, October 23

The 10:30 IMA break will be in Lind Hall 400.

Thursday, October 24

The 10:30 IMA break will be in Lind Hall 400.

APPL. MATH. AND NUM. ANAL. SEMINAR, Vincent Hall 570:

11:30am **Alexander Alekseenko** Hyperbolic formulations in linearized gravity
Univ of Minnesota

The problem of running stable evolution for the Einstein's equation keeps challenging scientists for many years. With the development of Laser Interferometer Gravitational Observatories whose main purpose is the detection of the gravity waves, the need in reliable computations had grown tremendously. At the same time, difficulties of numerical relativity are so intense and various that one can hardly expect a real success without the deepest analysis of the subject. What are the challenges that make the discretization of the relativity equations difficult? Possibly, many questions will drop out once we know a natural way of writing the Einstein's equation. Indeed, in terms of curvature and stress-energy tensors the Einstein's equation is short, but when translated into a coordinate system, it turns into a system of 10 nonlinear PDE's with a huge amount of terms, and from 10 unknown components of the space-time metric only 6 can be determined. Due to this one and due to other reasons which will be addressed in the talk various reformulation were proposed to write the Einstein's equation in a manner suitable for numeric computations. The most promising approach is to write the Einstein equation in the form of a symmetric hyperbolic system. In this talk we will discuss examples of well-known symmetric hyperbolic formulations and introduce a new one which is the result of our work with Professor Arnold during the last year. Finally, we will briefly mention the future challenges in particular, the admissible boundary conditions and approaches to discretization.

Friday, October 25

The 9:40 IMA break will be in the Vincent Hall lounge.

IMA/MCIM INDUSTRIAL PROBLEM SEMINAR, 570 Vincent Hall:

10:10 am **TBA**

Monday, October 28

The 10:30 IMA break will be in Lind Hall 400.

OPTIMIZATION SEMINAR, Lind Hall 409:

11:15am **TBA**

Tuesday, October 29

The 10:30 IMA break will be in Lind Hall 400.

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15 **Daniel Kern** Multispecies Competition and Traveling Waves
IMA

The consideration of spatial factors in ecological modeling has led to a variety of interesting problems in the current literature. Besides better explaining the development of biological phenomena, the resulting models can lead to interesting mathematics. Here, the spread of two invasive plant species and the corresponding replacement of a single native species is examined as a competition model with spatial considerations. The general model is a system of three nonlinear reaction-diffusion equations of the Lotka-Volterra type. A model is developed for a specific case involving cottonwoods and two invasive plants in New Mexico. The existence of a traveling wave solution is then examined, leading to possible restrictions on the propagation speed of the exotic species.

The IMA Postdoc Seminar is organized by Olga Brezhneva and M. Yvonne Ou.

Wednesday, October 30

The 10:30 IMA break will be in Lind Hall 400.

BROWN BAG SEMINAR, Lind Hall 409:

12 noon **Balaji Gopalakrishnan** An active set Non-Negative Least-Squares algorithm
IMA

Thursday, October 31

NO MORNING BREAK because of afternoon party

APPL. MATH. AND NUM. ANAL. SEMINAR, Vincent Hall 570:

APPL. MATH. AND NUM. ANAL. SEMINAR, Vincent Hall 570:

11:30 am

John Lowengrub
Univ of Minnesota

Numerical simulation of drop coalescence with surfactant
in 3D

In the processing of emulsions and polymer blends, the drop size distributions are determined by two coexisting processes: drop breakup and coalescence. Here we study the effects of surfactants, e.g. block copolymers, on coalescence. We use a newly developed 3D adaptive finite-element algorithm. The method is based on unstructured adaptive triangulated and tetrahedral meshes that discretize the interfaces and the bulk respectively, and on an efficient parallelization of the numerical solvers.

A nonlinear Langmuir equation of state for the surfactant is used and Van der Waals forces, which are responsible for coalescence, are included in the numerical method. Surfactants are transported by convection-diffusion on the drop/matrix interface and between the interface and the bulk phases. Our accurate and robust numerical method features parallel computation and adaptive reconstruction of the finite element meshes describing the bulk phases and the interface.

Our results reveal a nontrivial dependence of the critical capillary number Ca_c , below which coalescence occurs, on the surface coverage of surfactant. Marangoni stresses inhibit coalescence and thus decrease Ca_c with respect to the clean-drop case. However, at large surfactant coverages close to the maximum packing of surfactant molecules, surfactant redistribution is prohibited (the surfactant is nearly incompressible) and thus the effect of Marangoni stresses is weakened, leading to an increase of Ca_c . In some cases, Ca_c at high coverages is even higher than in the clean-drop case: surfactant near-incompressibility renders the interface more rigid which results in less drop deformation and thus coalescence can occur at higher capillary number.

Finally, our results also reveal a nontrivial dependence of Ca_c on surfactant solubility in the bulk. At moderate surfactant concentration, diffusion in the bulk decreases surfactant redistribution on the interface and thus weakens Marangoni stresses resulting in higher Ca_c than in the insoluble case. However, when the surfactant bulk concentration is large, high adsorption fluxes maintain a higher surface concentration in equilibrium than for the insoluble case, thus resulting in larger drop deformation and in lower Ca_c .

This work is joint with H. Zhou, V. Cristini and C. W. Macosko.

Hallowe'en Party at 3 pm in Lind Hall 400

PART III: CURRENT IMA PARTICIPANTS

POSTDOCTORAL MEMBERS FOR 2002–2003 PROGRAM YEAR

NAME	PREVIOUS INSTITUTION
Yusuf Bilgin Altundas	Pittsburgh University
Olga Brezhneva	Russian Academy of Sci.
Dacian Daescu	University of Iowa
Gregory S. Duane	University of Colorado
Michael Efroimsky	Harvard and Oxford
Lisa Evans	Georgia Tech
Balaji Gopalakrishnan	Georgia Tech
Lili Ju	Iowa State University
Herve Kerivin	University Blaise Pascal-France
Daniel Kern	University of Illinois-Chicago
Aurilia Minut	Michigan State University
Haewon Nam	Texas A& M University
M. Yvonne Ou	University of Delaware
Tamon Stephen	University of Michigan
Jing Wang	University of Minnesota
Toshio Yoshikawa	University of Utah
Jun Zhao	Texas A& M University

POSTDOCTORAL MEMBERS IN INDUSTRIAL MATHEMATICS

NAME	PREVIOUS INSTITUTION	INDUSTRIAL AFFILIATION
Yusuf Altundas	University of Pittsburgh	Schlumberger
Lili Ju	Iowa State University	VA Hospital
Aurelia Minut	Michigan State University	3M
Haewon Nam	Texas A & M University	Schlumberger
Jun Zhao	Texas A & M University	GE

VISITORS IN RESIDENCE (as of 20 August 2002)

AARDAL, KAREN	Utrecht Univ	OCT 13, 2002 – OCT 19, 2002
ADAMS, SCOT	Univ of Minnesota	SEP 1, 2002 – JUN 30, 2003
AHMED, SHABBIR	Georgia Tech	OCT 13, 2002 – OCT 19, 2002
ALLEN, BETH	Univ of Minnesota	AUG 15, 2002 – DEC 31, 2002
ALTUNDAS, YUSUF BILGIN	Schlumberger	SEP 3, 2002 – SEP 2, 2004
APPLEGATE, DAVID	AT&T Labs-Research	OCT 13, 2002 – OCT 19, 2002
ARNOLD, DOUG N.	IMA	SEP 1, 2002 – JUN 30, 2003
ARONSON, DON	Institute for Mathematics	SEP 1, 2002 – JUN 30, 2003
ATAMTURK, ALPER	Univ of Calif. at Berkeley	OCT 12, 2002 – OCT 19, 2002
BALAS, EGON	Carnegie Mellon Univ	OCT 13, 2002 – OCT 19, 2002
BARAHONA, FRANCISCO	Watson Research Center	OCT 13, 2002 – OCT 19, 2002
BERGER, MARSHA	New York Univ	OCT 5, 2002 – OCT 6, 2002
BERTSIMAS, DIMITRIS	MIT	OCT 13, 2002 – OCT 19, 2002
BERTSIMAS, DIMITRIS	MIT	OCT 4, 2002 – OCT 6, 2002
BIENSTOCK, DANIEL	Columbia Univ	OCT 13, 2002 – OCT 19, 2002
BIXBY, ROBERT E.	ILOG, Inc.	SEP 22, 2002 – OCT 19, 2002
BREZHNEVA, OLGA	Univ of Minnesota	SEP 3, 2002 – SEP 2, 2004
BROWN, DAVID B.	MIT	OCT 13, 2002 – OCT 18, 2002
CALDERER, M. CARME	Univ of Minnesota	SEP 1, 2002 – JUN 30, 2003
CHVATAL, VASEK	Rutgers Univ	OCT 17, 2002 – OCT 19, 2002
COOK, WILLIAM	Georgia Tech	OCT 13, 2002 – OCT 19, 2002
COULLARD, COLLETTE	Northwestern Univ	SEP 1, 2002 – JUN 30, 2003
DAESCU, DACIAN	IMA	SEP 1, 2002 – JUN 30, 2003
DAWANDE, MILIND	Univ of Texas at Dallas	OCT 13, 2002 – OCT 19, 2002
DE FARIAS JR., ISMAEL	SUNY at Buffalo	OCT 13, 2002 – OCT 19, 2002
DESROSIERS, JACQUES	Ec. Hautes Etudes Comm.	OCT 13, 2002 – OCT 19, 2002
DIETRICH, BRENDA	IBM Corporation	OCT 13, 2002 – OCT 19, 2002
DUANE, GREGORY S.	IMA	SEP 1, 2002 – JUN 30, 2003
EFROIMSKY, MICHAEL	IMA	SEP 1, 2002 – JUN 30, 2003
EVANS, LISA	Georgia Tech	SEP 3, 2002 – AUG 31, 2003
FEIGENBAUM, JOAN	Yale Univ	OCT 5, 2002 – OCT 6, 2002
GEAR, CHARLES W (BILL)	NEC Res. Inst.	OCT 5, 2002 – OCT 6, 2002
GENDREAU, MICHEL	Universite de Montreal	OCT 13, 2002 – OCT 20, 2002
GOFFIN, JEAN-LOUIS	McGill Univ	OCT 13, 2002 – OCT 20, 2002
GOMORY, RALPH E.	Sloan Foundation	OCT 17, 2002 – OCT 19, 2002
GOPALAKRISHNAN, BALAJI	Georgia Tech	SEP 3, 2002 – SEP 2, 2004
GRAHAM, FRAN CHUNG	Univ of Calif. San Diego	OCT 5, 2002 – OCT 6, 2002
GROETSCHHEL, MARTIN	Konrad-Zuse-Zentr fur Inf.	OCT 13, 2002 – OCT 18, 2002
GU, ZONGHAO	ILOG	OCT 13, 2002 – OCT 19, 2002
GUNLUK, OKTAY	Watson Research Center	OCT 13, 2002 – OCT 19, 2002
JAMES, RICHARD D.	Univ of Minnesota	OCT 5, 2002 – OCT 6, 2002
JOHNSON, ELLIS	Georgia Tech	OCT 15, 2002 – OCT 19, 2002
JU, LILI	Iowa State Univ	SEP 3, 2002 – SEP 2, 2004
KERIVIN, HERVE	France Telecom R&D	SEP 3, 2002 – SEP 2, 2004
KERN, DANIEL	IMA	SEP 1, 2002 – JUN 30, 2003
KETTENRING, JON	Telcordia (Bellcore)	OCT 5, 2002 – OCT 6, 2002
KRYLOV, NICOLAI	Univ of Minnesota	SEP 1, 2002 – AUG 31, 2003
KURTZ, THOMAS G.	Univ of Wisc. Madison	OCT 5, 2002 – OCT 6, 2002
LADANYI, LASZLO	Watson Research Center	OCT 13, 2002 – OCT 19, 2002
LOWENGRUB, JOHN	Univ of Minnesota	SEP 1, 2002 – JUN 30, 2003
MARDAN, SETAREH	Univ of Minnesota	OCT 14, 2002 – OCT 19, 2002
MARGOT, FRANCOIS	Univ of Kentucky	OCT 13, 2002 – OCT 20, 2002
MARTIN, ALEXANDER	Darmstadt Univ Tech.	SEP 29, 2002 – OCT 19, 2002
MINUT, AURELIA	IMA	SEP 1, 2002 – AUG 31, 2003

NADDEF, DENIS	INSIMAG	OCT 13, 2002 – OCT 19, 2002
NAM, HAEWON	Univ of Minnesota	SEP 3, 2002 – SEP 2, 2004
NAU, RICHARD	Carleton College	SEP 1, 2002 – DEC 31, 2002
NEMHAUSER, GEORGE L.	Georgia Tech	OCT 13, 2002 – OCT 19, 2002
NG, PEH	Univ of Minnesota-Morris Campus	AUG 1, 2002 – JUL 31, 2003
OU, M. YVONNE	IMA	SEP 1, 2002 – AUG 31, 2003
PULLEYBLANK, BILL	Watson Research Center	OCT 13, 2002 – OCT 19, 2002
QUEYRANNE, MAURICE	Univ of B. C.	SEP 2, 2002 – DEC 20, 2002
ROTHBERG, ED	ILOG, Inc. W10/14-19	OCT 13, 2002 – OCT 19, 2002
SANTOSA, FADIL	Univ of Minnesota	SEP 1, 2002 – JUN 30, 2003
SAVELSBERGH, MARTIN	Georgia Tech	OCT 13, 2002 – OCT 19, 2002
SENDIL, M. NURI	Northwestern Univ	SEP 2, 2002 – JUN 30, 2003
SETHIAN, JAMES A.	Univ of Calif. Berkeley	OCT 4, 2002 – OCT 6, 2002
SIM, MELVYN	MIT	OCT 13, 2002 – OCT 18, 2002
STEPHEN, TAMON	IMA	SEP 3, 2002 – SEP 2, 2004
SUBRAMANIAN D.	Honeywell Labs	OCT 14, 2002 – OCT 18, 2002
SUMNERS, DE WITT L.	Florida State Univ	OCT 4, 2002 – OCT 6, 2002
SVERAK, VLADIMIR	Univ of Minnesota	SEP 1, 2002 – AUG 31, 2003
SYMES, WILLIAM W.	Rice Univ	OCT 5, 2002 – OCT 6, 2002
TATALIAS, KOSMO D.	AHPCR Ctr.	OCT 14, 2002 – OCT 18, 2002
THOMAS, REKHA R.	Univ of Washington	OCT 13, 2002 – OCT 19, 2002
TROTTER JR., LESLIE EARL	Cornell Univ	OCT 13, 2002 – OCT 19, 2002
UCHOA, EDUARDO	Univ Federal Fluminense	OCT 13, 2002 – OCT 18, 2002
VAN HENTENRYCK, PASCAL	Brown Univ	OCT 13, 2002 – NOV 13, 2002
VANDERBECK, FRANCOIS	Univ de Bordeaux 1	OCT 12, 2002 – OCT 19, 2002
VASIL'EV, IGOR	Univ Studi di Salerno	OCT 13, 2002 – OCT 20, 2002
VENUTURUMILLI, VAMSEE	Univ of Minnesota	OCT 14, 2002 – OCT 19, 2002
VIAL, JEAN-PHILIPPE	Univ of Geneva	OCT 12, 2002 – OCT 19, 2002
WANG, JING	IMA	SEP 3, 2002 – SEP 2, 2004
WEISMANTEL, ROBERT	Otto-v-Guericke-Univ	OCT 12, 2002 – OCT 18, 2002
YORKE, JAMES	Univ of MD College Park	OCT 4, 2002 – OCT 6, 2002
YOSHIKAWA, TOSHIO	IMA	SEP 1, 2002 – JUN 30, 2003
ZEITOUNI, OFER	Univ of Minnesota	SEP 1, 2002 – AUG 31, 2003
ZHAO, JUN	Univ of Minnesota	SEP 3, 2002 – SEP 2, 2004

See also URL: <http://www.ima.umn.edu/people/>