Department of Industrial Engineering & Operations Research

IEOR264 Computational Optimization

Semester: Spring 2008 *Instructor: Alper Atamtürk*

Prerequisite: IEOR262A or consent of instructor.
Textbook: G.L. Nemhauser and L.A. Wolsey, *Integer and Combinatorial Optimization*, Wiley, 1999.
Other suggested books:

- R. Fourer, D. M. Gay, and B.W. Kernighan, *AMPL: A Modeling Language For Mathematical Programming*, Boyd & Fraser, 1993.
- L. A. Wolsey, *Integer Programming*, Wiley, 1998.

Instructor: Alper Atamtürk (email: `atamturk@berkeley.edu` phone: 642–4559)
Lectures: Mon Wed 9-11:30 AM (3117B Etcheverry)
Office hrs: TBA (4175 Etcheverry) and by appointment.
Web page: `http://ieor.berkeley.edu/∼atamturk/ieor264`

Course description

In this course we develop effective computational methods for large-scale optimization problems in which some or all of the variables must take on integral values. Examples of such problems include telecommunication/transportation network design, integrated circuit layout, vehicle/crew routing and scheduling, production and distribution, facility location and capacity allocation problems. Most of these problems are hard to solve (both theoretically and practically). Commercial optimization software are far from satisfying the ever increasing demand from industry for solving large instances of such problems.

The key for developing successful methods for these challenging problems is to effectively integrate relaxation, decomposition, and search algorithms that exploit structural properties of the problems of interest. Such methods often yield provably optimal solutions or good approximate solutions to large-scale problems in practice.

The course starts with a review of modeling aspects in integer programming and continues with a survey of relaxation, decomposition, and cutting plane methods for solving large–scale integer programming problems. Applications to practical problems are introduced throughout the course, with an emphasis on problems in the logistics of production, distribution, transportation, and telecommunication systems.

Students will work on theoretical as well as computational problems. Grading is based on problem sets (30%), a midterm exam (30%), course project (30%), and *class participation* (10%). The aim of the computational project is to develop confidence in designing and implementing advanced optimization methods using software packages. CPLEX will be the major software package used in the course. Computational projects will require programming. Students are encouraged to work in groups of two members on the projects and expected to write papers based on their projects to be submitted for journal publication. To see sample papers based on student projects in previous years, visit `http://ieor.berkeley.edu/∼atamturk/ieor264`.

Outline

Effective modeling in integer programming

Week 1	Modeling with integer variables: correct formulations
Week 2	Optimality, relaxation, bounds, search: branch–and–bound
Week 3	Choices in modeling: strong formulations, extended formulations Preprocessing of formulations

Relaxation and decomposition methods for large–scale problems

Week 4	Describing polyhedra with extreme points and extreme rays Connections between integer programming and polyhedra
Week 5	Lagrangian relaxation Subgradient optimization
Week 6	Applications: traveling salesman problem, facility location problems, generalized assignment problem
Week 7	Dantzig–Wolfe decomposition, column generation Applications: generalized assignment and multicommodity flow problems
Week 8	Benders decomposition Applications: facility location, network design problems

Cutting plane methods for unstructured problems

Week 9	Integer and mixed–integer rounding
Week 10	Gomory cuts, disjunctive cuts

Cutting plane methods for structured problems

Week 11	Affine independence, dimension and faces of polyhedra Strong valid inequalities, facets
Week 12	Valid inequalities for set packing and 0–1 knapsack problems and their separation
Week 13	Sequential lifting Sequence independent lifting
Week 14	Applications: airline crew scheduling, production lot–sizing, facility location problems, network design
Week 15	Project presentations