

OM 380: Network Optimization

Spring 2013

Unique No. 04250

Professor Anant Balakrishnan

Classroom: CBA 4.338

Class time: Mon. 11:00 a.m. to 2:00 p.m.

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Hours: Mondays, 3 p.m. to 4 p.m.

or by appointment

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Course Description and Goals

OM 380 is a graduate course on network flow optimization models and extensions. Network flow problems, a class of linear programs, have wide-ranging applications in domains such as transportation, logistics, supply chains, computer science, project management, and finance. This course will focus on the *theory* and specialized *algorithms* for the minimum cost network flow problem and its special cases, such as the shortest path and maximum flow problems, as well as some extensions.

Network flow problems are defined on graphs, and so have special structure and properties. The main thrust of the field of network optimization is to discover these underlying properties, and design effective solution methods that can exploit them. Algorithms specifically designed for each class of network flow problems can solve these problems much more efficiently than standard linear programming methodologies. The field, therefore, emphasizes developing tailored algorithms, paying careful attention to the data structures used to implement the methods and characterizing the algorithms' computational complexity. Consistent with this approach, for each class of models, we will discuss some representative applications, cover the relevant concepts and underlying theory, identify appropriate data structures, discuss algorithmic development and refinement, and study problem complexity. The course requires prior knowledge of optimization, particularly linear programming. Exposure to topics such as graph theory, analysis of algorithms, and data structures will be helpful, but not essential (we will selectively review these topics in class).

The goal of the course is to help students develop a deep understanding of the field by:

- learning the theory underlying network flow problems, including special cases and some extensions;
- illustrating algorithmic development strategies that exploit special problem structure; and
- analyzing the computational complexity of network algorithms.

An auxiliary goal is to expose students to formal proof techniques in the context of establishing properties and results to confirm the validity of algorithms and improve their performance.

Course materials

Required textbook: “*Networks Flows: Theory, Algorithms, and Applications,*” by R. K. Ahuja, T. L. Magnanti, and J. B. Orlin, Prentice-Hall.

The instructor will provide additional materials in class or via Blackboard.

Other books of interest:

- “*Network Programming*” by Katta Murthy, Prentice-Hall
- “*How to Read and Do Proofs*” by Daniel Solow, Wiley

Course preparation and student evaluation

Students are expected to read before each class the relevant sections from the textbook and other assigned readings (listed in the course schedule). Active class participation—responding to questions, offering explanations and insights, raising interesting issues, and so on—is strongly encouraged. The course grade will be based on class participation and homework assignments (30%), course examinations (40%), and term paper and presentation (30%).

Homework assignments, approximately one per week, must be turned in at the beginning of class on the day they are due. Unless specified otherwise, written homework assignments are **individual** (not group) assignments. Students are permitted to discuss with classmates the broad approach for solving the homework problems, but each student must work out the details (e.g., proofs, algorithms) and write up the assignment on their own. **Do not copy** answers from other students or other sources (e.g., material from past years or from the web). All questions in each assignment must be answered, but only selected problems may be graded. Homework grades will be based on clarity of work (including specifying assumptions and providing explanations), completeness, and correctness.

In addition to written homework assignments, we will have around four **computer implementation assignments** during the semester. These assignments require students, working in teams of two, to implement and test select network algorithms (e.g., using C, C++, Java, Python) to gain appreciation for the importance of data structures and algorithmic design on solution efficiency.

The course **exams** may include in-class and/or take-home components. For in-class exams, students are permitted to bring one 8.5 x 11 inch sheet (two-sided) of handwritten notes. Take-home exams must be completed individually, without any discussions or help from other individuals and without consulting resources or materials (including online content) other than the textbook and class notes.

Each student must also complete a **term paper**, and present this paper in class at the end of the course. The topic and type of work needed for the term paper is quite flexible. The following topics illustrate the range of term paper choices:

- Survey of models and algorithms for a particular class of network flow models (e.g., hop-constrained network design, multi-commodity flow, Steiner network problem);
- Study of network flow applications in a specific industry or function (e.g., airlines, railroads, supply chain management, telecommunications, finance, marketing, electricity distribution, disruption management);
- Implementation and testing of specific algorithms for a particular problem class (e.g., auction algorithms, dual ascent methods);
- Study of new classes of problems (e.g., robust network optimization, multi-objective network models);
- Development of new solution approaches for known problems;
- Applying (solving) a network optimization model or method to a specific practical application context (e.g., routing service resources, design of survivable networks);
- Use of network models within large scale optimization (e.g., decomposition) methods; or,

- Contemporary and novel uses of network flow models (e.g., for data mining, community identification in social networks, humanitarian logistics, health care, environmental issues).

These topics are just representative examples; students may choose network-related topics (subject to the instructor's approval) that best fit their interests. By mid-semester, students must select their term paper topic (in consultation with the instructor), and submit a brief ***term paper proposal*** describing the topic, focus of the paper, nature of work to be done, and timeline. The instructor may suggest modifications before approving the proposal. The final term paper, around 30 pages long (11 point, 1.5 line spacing), is due during the last week of class. Each student must also present his/her paper in class to hone presentation skills and educate the class about the selected topic. Grades of the term paper will be based on clarity of exposition, thoroughness of literature review, learnings from the project, and novelty of work.

Feedback

Your feedback is valuable, and facilitates continuous course improvement. Please do not hesitate to let me know, throughout the semester, how to improve the course and the learning experience it provides.

Academic Integrity

By enrolling in this class, you agree to abide by the Honor System. In particular, for individual assignments, examinations, and term papers, **do not copy from other students or from other sources**, e.g., from previous solutions, published papers, web sites, etc. If the application of the Honor System to this course is unclear in any way, it is your responsibility to ask for clarification. Thank you in advance for your cooperation on this very important issue.

Students with Disabilities

Upon request, the University of Texas at Austin provides appropriate academic accommodations for qualified students with disabilities. Information on how to request such accommodation and other policies is available from the Office of the Dean of Students (SSB 4th floor, (512)-471-6259) or online at <http://deanofstudents.utexas.edu/ssd/index.php>.