Some issues in classical and multiobjective combinatorial optimization

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In classical combinatorial optimization, many algorithms have been designed in order to optimize many sorts of optimality criteria in a wide variety of applications. Various algorithm design techniques have been developped and have succeeded to obtain optimal or near optimal solutions for important optimization problems. One of the most fundamental approaches is based on linear programming. In the first part of this course, we will focus on a special category of this approach, the *primal-dual method* which has been used in the design of both, optimal polynomial time algorithms for classical optimization problems like the maximum flow problem, and polynomial-time approximation algorithms for many $\mathcal{NP}$-hard optimization problems (set cover, Steiner forest,...). We will present the principle of the method and some applications to some classical (e.g. set cover) and more modern optimization problems (e.g. Steiner tree game).

If in the classical combinatorial optimization the objective is the optimization of a single optimality criterion, in multiobjective optimization a solution to a combinatorial optimization problem is evaluated with respect to several optimality criteria. Multiobjective optimization problems have been widely studied in the past, especially in the areas of Operations Research and Microeconomics, and more recently in Theoretical Computer Science. The results in this field can be categorized under three classes. In the first class, we study the optimization of one criterion given a fixed value for a second criterion. In the second one, one tries to obtain results about the quality of approximation that might be obtained simultaneously for the various optimality criteria. Finally, in the third class we are interested in obtaining a tradeoff (Pareto curve) between the optimality criteria. In the second part of the course, we will discuss these issues and give some applications for some bi-criteria scheduling problems.

Bibliography

The first part of the course is essentialy based on the book of V.V. Vazirani (*Approximation Algorithms*, Springer 2001), and a recent paper by K. Jain and V.V. Vazirani (*Applications of approximation algorithms to cooperative games, Proc. STOC'2001, 364-372*). The second part is based on the PhD thesis of H. Hoogeveen, (CWI, 1992), on a paper by C. Stein and J. Wein (*On the existence of schedules that are near-optimal for both makespan and total weighted completion time, Operations Research Letters, 21, 1997*), on a recent paper by C.H. Papadimitriou and M. Yannakakis (*On the approximability of trade-offs and optimal access of web sources, Proc. FOCS'2000, 86-92*, and a paper by E. Angel, E. Bampis and A. Kononov (*A FPTAS for approximating the unrelated parallel machines scheduling problem with costs, Proc. ESA'2001, 194-205*).