CO759: Algorithmic Game Theory
(Topics in Discrete Optimization)

Spring 2015 TTh 10:30-11:50pm

http://www.math.uwaterloo.ca/~cswamy/courses/co759/

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Course Outline

This is a graduate-level introductory course on algorithmic game theory. Algorithmic game theory applies algorithmic reasoning to game-theoretic settings. A prototypical motivating example for the problems we will consider is the Internet, an artifact that was not designed by any one central authority, or optimized for one specific purpose, but rather emerged from the interaction of several entities, such as network operators, ISPs, users, in varying degrees of coordination and competition. This course will investigate a variety of questions that arise from looking at problems (often classical optimization problems) from this point of view. We will examine, in part, algorithmic issues in games, and in part, algorithmic problems that arise in settings with strategic players. A significant subset of the following topics will be covered.

1. **Introduction to Games and Algorithms.**
2. **Algorithmic Mechanism Design.** The theory of the design of computationally tractable games (now termed *mechanisms*) whose equilibria are efficient. Topics include:
   - Social-choice functions and the implementation problem. Dominant-strategies incentive compatibility, Bayesian incentive compatibility: truthful mechanism design with various (often *NP*-hard) social-choice functions
   - Combinatorial auctions: social-welfare maximization and profit maximization
   - Mechanisms with good Nash equilibria: Simultaneous first- and second-price auctions
   - Cost-sharing mechanisms
3. **(In)Efficiency of Equilibria.** Quantifying the efficiency-loss in game-versions of various optimization problems due to uncoordinated behavior. Topics include:
   - Network routing or congestion games: flow/traffic controlled by strategic agents is routed between source-sink pairs
   - Smoothness analysis of price of anarchy
   - Load balancing games: agents are jobs that need to be distributed across machines
   - Bandwidth sharing games: a common resource is to be shared across several agents
4. **Computational Aspects of Equilibria.**
   - Existence, complexity, and algorithmic aspects of Nash equilibria
   - Correlated equilibria and their computation
   - Markets and the computation of market equilibria