Management Science and Engineering 336
Market Models for Networked Systems

Mondays and Wednesdays, 1:15 PM–2:30 PM
Terman Engineering Center, Room 453
3 units

Instructor:

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Course webpage:

The course webpage is accessible through `http://coursework.stanford.edu`.

Course description:

This course aims to provide a rigorous introduction to problems at the interface between economics and engineering, for doctoral students with a research interest in the area. Students will be introduced to key concepts from game theory and market design, with an emphasis on network applications. The course will particularly emphasize constraints placed on market mechanisms due to the architecture of data networks. While the course will primarily be taught in lecture format, the focus will be on encouraging discussion of open questions and modeling issues.

Outline of topics:

The first 5-6 weeks of the course will cover the following foundational material, supplemented by examples drawn from network applications:

1. Motivating applications for economic analysis in engineering applications, such as: resource allocation in communication networks and electric power systems; interdomain routing in the Internet; and free riding in peer-to-peer systems.

2. Basic elements of economic modeling: utility, efficiency, and some elementary social choice theory (particularly Arrow's impossibility theorem).

3. Notions of equilibrium for static settings: competitive equilibrium, Nash equilibrium, correlated equilibrium, Bayesian equilibrium, and dominant strategy equilibrium; as well as the different knowledge assumptions made by various notions of equilibrium.

4. Dynamic models for engineering contexts: the dynamics of competitive equilibrium, basics of dynamic and repeated games, learning.

5. An introduction to mechanism design: implementation theory in dominant strategy equilibrium, Bayesian equilibrium, and Nash equilibrium; and a thorough discussion of the problems in adapting traditional mechanism design to network contexts.

The final 4-5 weeks of the course will be devoted to a discussion of recent research results in the field and development of more advanced models, with a view towards open problems and interesting directions for future study.

Grading

The grade will be based on the following:

- 30% 2-3 problem sets
- 70% final project

The choice of topics for the final project will be quite broad: students can choose to either discuss and present recent research results in the field, or develop their own problem statement and analysis. Since the focus of the course will be on modeling, many opportunities for game theoretic problem formulation and analysis should be possible throughout the quarter.

Prerequisites

The listed prerequisite is a basic course in optimization, such as MS&E 211 or equivalent. Because the course will have significant mathematical depth, real analysis at the level of Mathematics 115 is recommended (see below).

Since this is a doctoral course with a strong focus on developing theoretical tools, students should bear the following in mind:

- While no prior exposure to game theory or mechanism design will be assumed, the basic elements will be covered rather quickly; thus, students with no prior experience should be prepared to devote time outside of class to master the basics.
- Students will be expected to demonstrate a significant degree of mathematical maturity, particularly in reading and writing rigorous proofs. Basic real analysis concepts will be assumed, such as continuity, limits, convergence, open and closed sets, compactness, convexity, etc.

Textbooks

There will be no required textbook for this course. However, you may find some of the following books helpful. The first three books that are listed are highly recommended; the remainder are a list of various books that I have found useful.

Highly Recommended

1. *A Course in Game Theory*, Osborne and Rubinstein. This is a good introductory level text in game theory, that still is quite rigorous. Although many game theory books are out there, I have found that this one is a good introduction for engineers.

2. *Microeconomic Theory*, Mas-Colell, Whinston, and Green. This very large textbook is an encyclopedic reference on the subject, and in particular has one of the best introductory chapters on mechanism design (Chapter 23).

3. *Putting Auction Theory to Work*, Milgrom. This recent text by Stanford's own auction theory expert is an excellent way to learn the essentials of the theory; using a few basic technical ideas, he presents a mathematically unified account of all the key results.

Other Useful Reading

1. *Game Theory for Applied Economists*, Gibbons. This is a basic undergraduate level text in game theory, appropriate if you have never seen the subject before; it provides an elementary treatment of most of the major topics.

2. *Game Theory*, Fudenberg and Tirole. This encyclopedic reference should be on the shelf of every game theorist, but it is not necessarily the easiest book to learn from.

3. *Auctions: Theory and Practice*, Klemperer. This is another survey book on auction theory, but most of the material can be found online on Klemperer's web page, and through earlier papers.

4. *Auction Theory*, Krishna. This is a standard introductory text book on auction theory.