

General Course Information:

ELEN E6767x or y: INTERNET ECONOMICS, ENGINEERING AND THE IMPLICATIONS FOR SOCIETY

Instructor Information

Debasis Mitra

Senior Research Scientist and Adjunct Professor

Department of Electrical Engineering

<http://www.ee.columbia.edu/debasis-mitra>

email: debasismitra@columbia.edu

Prerequisites

Recommended preparation: CSEE W4119 or E6761, ability to comprehend and track the development of sophisticated mathematical models and analyses of economic and network interdependencies in the Internet and industry. Knowledge of basic microeconomics and communication network engineering, including models, their analyses and optimizations. Interest in the economics of markets, applications of economic principles in policy and regulations for the Internet, environment and industry, and their societal impact.

Course Description

The Internet has become an integral part of modern life and also an essential enabler of technological innovations. Its future is the subject of intense public interest, e.g., Net Neutrality, in which engineering and economics are intertwined. The goal of the course is to obtain a fundamental understanding of major issues involving the Internet, and also related societal topics, by combining knowledge of economics, networking, and industry structure. Course topics include pricing for various models of the communication industry, market structures in which subscribers, bandwidth providers and content providers are players, network engineering, regulation and also longer-term issues, such as investments in the infrastructure of the future Internet. Mathematical models and their analyses are basic tools. Future research directions and open problems are highlighted.

The course starts with basic microeconomics of pricing, market structures, e.g., competition and monopoly, and reviews of past regulatory approaches to monopolies in the communications industry. This is followed by game theory concepts, methods and analyses of revenue allocations in network coalitions, ISP settlements, network externalities, two-sided markets and their ubiquitous presence in the Internet. Also covered are economic principles in networking and network design, decentralized vs. centralized resource allocation, “price of anarchy”, “tragedy of the commons”, congestion control, and the Internet. The methodologies developed are also explored for application in environmental protection and the deregulated electric power industry. Students do projects researching and applying concepts learnt in the course to topical issues, such as the regulation of Big Tech, privacy protection and the societal impact of automation. A review of approaches taken by governments and regulators around the world concludes the course.

Course requirements: Two papers; project and oral presentation; homework

Approximate schedule:

Weeks 1-3: Basic Economics, including Pricing, Fairness, Efficiency, and Stability; Market Models; Natural Monopoly and Regulation

Weeks 4 - 6: Internet - Fundamental Models, Relations and Structures: Network Externalities; Two-Sided (Platform) Market Economics

Weeks 7-8: Applications of Economic Principles in Networking (e.g., Coalitions, Core of the Game, Shapley Value, Routing, Centralized vs. Distributed Control), Environmental Policy, Power Industry

Week 9-10: Students' presentations on projects

Week 11: Topics in Economic Principles in Internet Engineering (e.g., Content Delivery)

Week 12: Societal, Industry and Network Issues in Net Neutrality

Week 13: Approaches to Internet governance from around the world

Grading policy:

10% active participation

20% homework

20% mid-term paper

25% project and oral presentation

25% final exam paper

For CVN students, the "active participation" component is eliminated, and its percentage is distributed equally over the remaining components.

Reading:

Basic Communication Network Economics, Pricing & Regulation

Hal Varian, "Intermediate Microeconomics, A Modern Approach", Eighth Edition, W.W. Norton
Review of basic economic concepts: utility, demand, consumer's surplus, social welfare, monopoly behavior, price discrimination

R. Braeutigam, "Optimal Policies for Natural Monopolies", chapter in "Handbook for Industrial Organizations", Vol. 2, Ed. R. Schmalensee and R. Willig, North-Holland, 2007

Impact of Monopolies and Regulations

E.E. Zajac, "Sustainability or Stability of Regulated Prices", Chapter 7 in "Fairness or Efficiency: An Introduction to Public Utility Pricing", Ballinger, 1978

H. Averch and L.L. Johnson, "Behavior of the firm under regulatory constraint", American Economic Review, 52, 1962, 1053-1069

D. P. Baron, "Design of Regulatory Mechanisms and Institutions", chapter 24 in "Handbook of Industrial Organization", Vol. 2 Ed. R. Schmalensee and R. Willig, North-Holland, 2007

R.J. Gilbert and D.M.G. Newbery, "Preemptive Patenting and the Persistence of Monopolies", *The American Economic Review*, June 1982

K. Arrow, "Economic Welfare and the Allocation of Resources for Invention", RAND Corp, 1962

Network Coalitions, Cooperation and Revenue-Sharing Concepts from Game Theory

M.O. Jackson, "Allocating the Value", Sec 12.1.2 in "Social and Economic Networks", Princeton University Press

P. Linhart, R. Radner, K.G. Ramakrishnan and R. Steinberg, "The Allocation of Value for Jointly Provided Service", *Telecommunication Systems*, 4 (1995), 151-175

R.J. Gibbens, F.P. Kelly, G.A. Cope and M.J. Whitehead, "Coalitions in the International Market", *Proc. ITC-13*, 1991, 93-98

R.T.B. Ma, D.M. Chiu, J.C.S. Liu, V. Mishra and D. Rubenstein, "Internet Economics: The Use of Shapley Value for ISP Settlement", *IEEE/ACM Trans. Networking*, 18 (3), June 2010, 775-787

Internet Models: Network Externalities, Two-Sided Markets

J. Rohlfs, "A Theory of Interdependent Demand for a Communications Service", *Bell J. Economics*, 5(1), 16-37, Spring 1974

A. Gersho and D. Mitra, "A Simple Growth Model for the Diffusion of a New Communication Service", *IEEE Trans. Systems, Man and Cybernetics*, SMC-5 (2), March 1975, 209-216

M. Armstrong, "Competition in Two-Sided Markets", May 2005

J.-C. Rochet and J. Tirole, "Two-Sided Markets: An Overview", March 12, 2004

D.S. Evans and R. Schmalensee, "The Industrial Organization of Markets with Two-Sided Platforms", *Competition Policy International*, 3(1), Spring 2007

Economic Principles in Networking, Environmental Policy, Power Industry, the Internet

R.A. Berry and R. Johari, "Economic Modeling in Networking": Chapter 2, "Welfare"; Chapter 3, "Static Games", "Nash Equilibrium", "Efficiency Loss"; Sec. 5.2, "Pigovian Taxes"

D. Mitra and A. Sridhar, "Consortiums of ISP-Content Providers Formed by Nash Bargaining for Internet Content Delivery", *Proc. IEEE INFOCOM 2019*

D. Autor, "Externalities, the Coase Theorem and Market Remedies", MIT, 2010

E.E. Sauma and S.S. Oren, "Alternative Economic Criteria and Proactive Planning for Transmission Investment in Deregulated Power System", in "Economic Market Design and Planning for Electric Power Systems", IEEE & Wiley, 2010

Projects Concerning Society and the Internet

- (i) Is wealth inequality a grave social problem, and, if so, what remedial actions should be taken?
- (ii) Is the impact on society and the workforce of automation and AI going to be severe, and, if so, what action should be taken in the short and long terms?
- (iii) Should the balance of environment protection be tilted more towards market-based mechanisms or by rules and regulations set by Congress and government agencies?
- (iv) Do anti-trust laws and regulations need to be updated to address societal interests with the growth of Big Tech?
- (v) Do the nation's laws governing social media require updating?
- (vi) As AI and Big Data become more prevalent in society, should the ethics of AI theory and practice be examined more extensively and rigorously, and, if so, where should the priorities lie?

Societal, Industry and Network Issues in Network Neutrality

R.S. Lee and T. Wu, "Subsidizing Creativity through Network Design: Zero-Pricing and Net Neutrality", J. Economic Perspectives, Vol. 23, No. 3, Summer 2009, pp. 61-76

C.S. Hemphill, "Network Neutrality and the False Promise of Zero-Price Regulation", The Social Science Research Network Electronic Paper Collection, The Center for Law and Economic Studies, Columbia University School of Law, Working Paper No. 331, 2008

E.W. Felton, "Nuts and Bolts of Network Neutrality", 2006

J. Crowcroft, "Net Neutrality: The Technical Side of the Debate- A White Paper", Int. J. Communication 1, 2007, 567-579

S. Greenstein, M. Peltz and T. Valletti, "Net Neutrality: A Fast Lane to Understanding the Trade-Offs", J. Economic Perspectives, Vol. 30, No. 2, Sept. 2016, pp. 127-149

D. Mitra and Q. Wang, "Preservation of Best-Effort Service on the Internet in the Presence of Managed Services and Usage-Generated Applications" Proc. TPRC43, Research Conference on Communications, Information and Internet Policy, Washington, Sept. 2015.

Essential background: FCC, Report and Order: In the matter of preserving the open internet broadband industry practices, FCC 10-201, 2010. Retrieved from http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-201A1.pdf

FCC, Report and Order: Restoring Internet Freedom, January 4, 2018
<https://www.fcc.gov/document/fcc-releases-restoring-internet-freedom-order>

Industry Structure, Approaches from Around the World

“Next Generation Connectivity: A review of broadband Internet transitions and policy from around the world”, Berkman Center, Harvard University, Feb 2010

S. Crawford, “Captive Audience: The Telecom Industry and Monopoly Power in the Gilded Age”, chapter 1-4, 13

Stokab, “Stockholm IT-Infrastructure”, 2012

Singapore: IDA Fact Sheet Next Generation Nationwide Broadband Network (June 2012)
<http://www.ida.gov.sg/images/content/Infrastructure/nbn/images/pdf/NextGenNBNFACTSHEET.pdf>

R. Tucker, “Rise and Fall of Australia’s \$44 Billion Broadband Project”, IEEE Spectrum, Nov. 2013