

General Course Information:

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

Instructor Information

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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. Knowledge of basic microeconomics and communication network engineering, including models, their analyses and optimizations. Interest in Internet policy, regulation and 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 debates, e.g., Net Neutrality, in which engineering and economics are intertwined. Issues include pricing for various models of the communication industry, market structures in which subscribers, communication bandwidth providers and content providers are players, the roles of network engineering, regulation and also longer-term issues, such as investments in the infrastructure of the future Internet. The goal of the course is to obtain a fundamental understanding of major issues of current interest by drawing on knowledge of communication networks and micro-economics, as well as industry structure. Mathematical models and their analysis are basic tools. Future research directions and open problems are highlighted.

We start with the basic microeconomics of pricing and regulation in the communications industry, adding historical perspectives. We proceed to revenue allocations in network coalitions, related game theory concepts, ISP settlements, network externalities, two-sided markets and their manifestations in the Internet. Next, economic principles in networking and network design, decentralized vs. centralized resource allocation, “price of anarchy”, “tragedy of the commons”, and congestion control. Next, societal and industry implications of possible trajectories of Internet evolution. Students do several case studies of topical industry and Internet issues. Conclude with approaches taken by other governments and regulators.

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

Approximate schedule:

Weeks 1-3: Basic Communication Network Economics, including Pricing, Fairness, Efficiency, Stability and Regulation

Weeks 4 - 5.5: Internet - Fundamental Models, Relations and Structures: Network

Externalities, Two-Sided Markets

Weeks 5.5 - 7: Economic Principles in Networking - Coalitions; Prices; Design, Congestion Control, Routing; Selfish vs Societal Objectives

Week 8: Case Studies of Internet Issues

Week 9: Students' presentations on Case Studies

Week 10 - 11: Societal, Industry and Network Issues in Net Neutrality

Week 12: Net Neutrality Surveys

Week 13: Industry Structure, Regulators' Approaches

Grading policy:

15% active participation; 25% homework; 60% papers, projects and oral presentations

References (see also Reading below):

(i) Basic economic concepts from Hal Varian, "Intermediate Microeconomics: A Modern Approach", Eighth Edition, W.W. Norton Co.

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

(iii) Costas Courcoubetis and Richard Weber, "Pricing Communication Networks: Economics, Technology and Modelling", Wiley Interscience, 2003

(iv) R.A. Berry and R. Johari, "Economic Modeling in Networking, A Primer", now, 2013

(v) D. Easley and J. Kleinberg, "Networks, Crowds and Markets", Cambridge University Press, 2010

(vi) Research papers

Reading:

Basic Communication Network Economics, Pricing & Regulation

Hal Varian, "Intermediate Microeconomics, A Modern Approach", Eighth Edition, W.W. Norton Co.

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 Regulation

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

E.E. Zajac, "A Geometric Treatment of Averch-Johnson's Behavior of the Firm Model", American Economic Review, 60(1), 1970, 117-125

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 Services", 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 Network Design & Control

D. Mitra, K.G. Ramakrishnan and Q. Wang, "Combined Economic Modeling and Traffic Engineering: Joint Optimization of Pricing and Routing in Multi-Service Networks", Proc. 17th International Teletraffic Congress, 2001, 73-85

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"

S.H. Low and D.E. Lapsley, "Optimization Flow Control, I: Basic Algorithm and Convergence", IEEE/ACM Trans. Networking, 7(6), Dec. 1999, 861-875

F.P. Kelly, A.K. Maulloo and D.K. Tan, "Rate Control for Communication Networks: Shadow Prices, Proportional Fairness, and Stability", J. Operational Research Society, 49, 1998, 237-252

Topics in Internet Engineering

V. Valancius, C. Lumezanu, N. Feamster, R. Johari and V.V. Vazirani, "How Many Tiers? Pricing in the Internet Transit Market", Proc. SIGCOMM '11, 2011, 194-205

Y. Liu, H. Zhang, W. Gong, and D. Towsley, "Understanding the Interaction between Overlay Routing and Traffic Engineering", U Mass report; also, Proc. IEEE INFOCOM 2005, 2543-2553

V.K. Adhikari, Y. Guo, F. Hao, M. Varvello, V. Hilt, M. Steiner, Z-L. Zhang, "Unreeling Netflix: Understanding and Improving Multi-CDN Movie Delivery", Proc. IEEE INFOCOM 2012, 1620-1628

arstechnica, "Netflix's many-pronged plan to eliminate video playback problems"
<http://arstechnica.com/information-technology/2014/05/netflixs-many-pronged-plan-to-eliminate-video-playback-problems/>

Case Studies Concerning the Internet

- (i) Is there excessive concentration of market power in broadband access in the USA today?
- (ii) Should fast and slow lanes be allowed on the Internet?
- (iii) Are the Broadband Access Providers behaving anti-competitively, like monopoly incumbents, towards Netflix, an innovator in video content streaming?
- (iv) Is Google a "free rider" on the Internet? What is the impact of its large and growing private network on the Internet?
- (v) Should mobile Internet operators continue to be exempt from Net Neutrality regulations?
- (vi) How big is the projected growth of traffic on the Internet? Is it so big that it will need extraordinary investments in the infrastructure to meet demand and may require changes to its governance?

Societal, Industry and Network Issues in Network Neutrality

J.M. Peha, "The Benefits and Risks of Mandating Network Neutrality, and the Quest for a Balanced Policy", Proc. 34th Telecommunications Policy Research Conference, Sept.2006

W.H. Lehr, S.E. Gillett, M.A. Sirbu and J.M. Peha, "Scenarios for the Network Neutrality Arms Race", 34th Research Conference on Communications, Information and Internet Policy (TPRC), 2006

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

FCC, "Specialized Services: Summary of Findings and Conclusions", Specialized Services Working Group, Open Internet Advisory Committee, Aug 20, 2013

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

D. Mitra and Q. Wang, "A Model-based Study of the Impact of Managed Services and the Spawning of Applications in Broadband Networks", Workshop on Telecom Economics, Engineering and Policy, 24th International Teletraffic Congress, Krakow, Poland, Sept.2012

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

Network Neutrality: Surveys

J. Kramer, L. Wiewiorra, C. Weinhardt, "Net Neutrality: A Progress Report", Telecommunications Policy, 37(9), 2013, 794-813

G.R. Faulhaber, "Economics of Net Neutrality: A Review", Communications & Convergence Review, 2011, Vol. 3, No. 1, 53-64

Background: Industry Structure, Regulators' Approaches

"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/NextGenNBFACTSH EET.pdf>

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