

**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 and industry. Knowledge of basic microeconomics and communication network engineering, including models, their analyses and optimizations. A keen interest and desire to learn about the economics of markets enabled by the Internet, applications of economic principles in communications, industry and society.

**Course Description**

The Internet has become an integral part of modern life. The goal of the course is to provide fundamental understanding of the workings of the Internet and its societal impact, and this requires combining elements of economics, engineering, and the theory of organizations. Course topics include models of the communications industry, market structures in which subscribers, service and content providers are players, network engineering, and regulation. Mathematical models and analyses are used extensively as tools for understanding. Future research directions and open problems are highlighted.

The course starts with basic microeconomics of pricing, market structures, i.e., competitive, oligopoly and monopoly, social welfare maximization and the theory underlying regulations of large firms. This is followed by game theory concepts, revenue allocations in network coalitions, ISP settlements, and network externalities, which lead up to the role of the Internet in two-sided markets, i.e., platform economics, that are ubiquitous today. Also covered are economic principles in networking and network design, i.e., the network as an economic system, which includes “price of anarchy”, and the “tragedy of the commons”. Economic models are used to investigate net neutrality, market-based alternatives to regulation, and deregulation of the power industry. Also, the societal impact of AI is examined via the EU’s 2024 AI Act and the mechanics of AI in algorithmic pricing. Students do projects researching and applying concepts learnt in the course to topical issues, such as the societal impacts of AI, renewable energy, and the regulation of Big Tech. A review of approaches taken by governments and regulators around the world concludes the course.

**Course requirements:** Two papers; project with 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 Economics and Game Theory (e.g., Core of the Game, Shapley Value) to networking, climate change, the deregulated electric power industry

Week 9-10: Students' presentations on projects

Week 11- 12: Economic Principles in Engineering and Society

Week 13: Approaches to Internet Governance 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

S. Borenstein, "The Private Net Benefits of Residential Solar PV: The Rise of Electricity Tariffs, Tax Incentives, and Rebates", National Bureau of Economic Research Working Paper 21342, July 2015

**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

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", Rand J. Economics, 37, no.3, Autumn 2006, 668-691

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

### **Economics in Networking, Power Industry, Content Delivery**

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"

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

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

### **Economic Reasoning and Models for Engineering and Society**

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

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

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

European Commission, Working Document, Impact Assessment, "Laying Down Harmonised Rules on Artificial Intelligence (AI Act) and Amending Certain Union Legislative Acts", 2021

E. Calvano, G. Calzolari, V. Denicolo, S. Pastorello, "Artificial Intelligence, Algorithmic Pricing, and Collusion", American Economic Review, 2020, 110 (10):3267-3297

### **Projects Concerning Society and the Internet**

- (i) Is the impact on society and the workforce of AI and automation going to be severe, and, if so, what action should be taken in the short and long terms?
- (ii) As AI and Big Data become more prevalent in society, should the ethics of AI theory and practice be examined more closely, and, if so, where should the priorities lie?
- (iii) Is the growth of renewable energy production best served by market-based mechanisms or by rules and regulations set by regulatory agencies and Congress?
- (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?

### **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

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, 2013