Information and Communications Technology

Economics 3270, Fall 2023

Monday and Wednesday, 2:30 – 3:45, Buttrick Hall 202

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Course Description

Advances in information and communications technology (ICT) have had a transformative effect on our society and economy. The first Internet browser was developed by Marc Andreessen of the NCSA (National Center for Supercomputing Applications) in 1993, and now cloud computing, social networks, ecommerce, streaming content, big data, analytics, informatics, VOIP, MMOG, and universal wireless connectivity part of our daily lives. Emerging technologies such as machine learning, artificial intelligence, the Internet of Things, blockchain, and quantum computing will have an enormous impact in the next several years. Economists are certainly aware of these innovations, but economic research in ICT is limited and scattered. This course will survey what economics has to say about ICT and try to outline what still needs to be done. Students should gain an understanding of how these technologies came into being, how they fit together, and where they might lead us in the future. Class participation will be emphasized.

Mechanics

I will expect you to do background reading on your own before class. ICT is an enormous and rapidly evolving topic. I also encourage you do to dives into topic that interest you using Wikipedia, search, YouTube videos, even books. Getting up to speed on a topic and then keeping up takes work. This is an important habit to get into, The only way to stay on top of technolgical change for either personal or professional reasons is to become an autodidact.

Exam and Due Date Schedule

Project:	Monday, March 18, 2024, in class
Midterm:	Wednesday, February 28, 2024, in class
Final:	Thursday, May 2, 2024, 9:00 – 11:00am, in class

Grading Plan

25% Assignments: I will generate five two-page assignments over the course of the semester. These will ask you to dive into some topic and learn as much as you can. The two-pager is to be a clear, succinct summary of your findings or understanding along with relevant (mostly web-based) references. Part of the exercise is to reduce a complex idea to its essentials and explain it clearly. If you can do this, you probably understand it yourself and can convey it to others. Assignments will be graded on a 100 point scale. The TA will base this on his subjective ranking of the assignments relative to one another.

5% Attendance: This is a capstone course that makes use of many of the tools and approaches you have learned in more foundational courses. We will be connecting to the technologies and institutions related to ICT. Most of this material will be new to you, and some of it is complex. Attendance is important both because it is difficult to master and contextualize these topics, and because discussion and questions central to the learning process. Since taking attendance every day is costs class time, I will randomly ask you to sign-in one time in six, as determined by a die. (Welcome to mechanism design.) If there is a valid reason that you cannot attend, please send me an email before class.

20% Projects: A hands-on project to learn the technology and economics of the ICT we use every day. Choose one, and actually complete the assignment in real life. That is, you must get the systems you find up and running. The point of this exercise to gain a better understanding of how technologies, platforms, or ecosystems both enable and constrain us. We will schedule some out-of-class time for students who are working on the same project to show their results as a group to the TA. Details to be determined. In addition, a three-page paper outlining what you did, how you did it, and what you learned is required. Grading is based on how complete and elegant your solutions are, how little they cost, and the quality of your paper.

- <u>Get Ecosystem free</u> – Find a way to get email, a calendar, a task list, web storage space and document sharing, search, maps, and other major cloud services you use without using the any Google, Microsoft, or Apple services. This means no Gmail, Google Docs, Microsoft 365 or anything in the Apple cloud. You may outline how you put together relatively new platforms such as Telegram, Discord, WhatsApp, and others to get the collection communication, collaboration and organizing services that suit your needs, The services you find should be either free or low cost and minimally invade your privacy.

- <u>Jailbreak an Android, Apple, or Chrome OS device</u> – These devices are all set up to keep you within the ecosystem that they establish. You are directed to the preferred providers of services and are prevented from completely controlling the hardware that you own. More recently, platforms have actually started to prevent the placement of applications they find distasteful for various reasons in their official stores. Jailbreaking means establishing root control so that you can install any applications you want and are not trapped within the ecosystem.

- <u>Anonymize yourself</u> – Establish an anonymous web identity. Participate in Facebook and in at least one other social network, get an email address that cannot be traced to you, be able

to search and browse without leaving a trail to follow, and make a physical purchase on the web without it being connected to you any way.

- Install Linux – Install a version of Linux on a laptop, tablet, or desktop. You can either over-write your existing OS or make a dual-boot machine, **but do not simply use a Virtual Machine for this project**. Ubuntu, Mint, and Debian are examples of distributions that are easy to work with. Install drivers for all the hardware (printers, scanners, webcams, etc.) you used before and get them working. Find and install free and open source programs that allow you to do all the things you did with your original OS (word processing, email, cloud storage, watch or listen to media, play games, messaging, etc.) What is easier and what is more diffi-cult? What things can't you do, and what things can you now that you could not with your original OS?

  - Micro-kernels and embedded systems – Get a Raspberry Pi, Arduino, or similar open source hardware platform up and running. Find a creative application. and get it running our your device.

  - Hold cryptocurrency – Get an account on a centralized crypto exchange such as Coinbase. What sorts of KYC-AML did you go through, and how much personal information did you have to give up? Now buy some amount of a cryptocurrency of your choice. What were the transactions costs of acquiring your crypto-assets? Suppose you wanted to hold your assets using your own private key instead of letting the exchange keep them in a custodial account. How would you go about this? Finally, find a way to use your assets to buy something, or to provide some useful service. What did you do?

  - Evaluate a crypto project – Choose a crypto/blockchain project (Cosmos, EOS, Stellar, an NFT or gaming project that uses Blockchain, for example). Give a critique of the game theo-retic and economic aspects. Do they make sense? Are they sustainable? Is it a Ponzi Scheme? What is the use case? What do you need to do to buy the project token? What regulations are being enforced? Is it legal to do so?

25% Midterm: There will be one in class midterm. The point of this will be to test your under-standing of the basic technologies, economics, and ideas covered in the class up to that point. Keeping up with the assigned readings, the lecture notes and the discussion in class is all that is needed.

25% Final: The final is based on the same principles as the midterm and will be comprehensive.

Policies

<u>Neither make-up exams nor alternate final exams will be offered</u> It is simply impossible to produce two exams of equal difficulty, and it is therefore not a fair procedure. If you find that you will not be able to be present on any one of the three exam dates above, please drop the class now and choose an alternative. In the event of a verified emergency as defined by the University rules, I will adjust the weights give above to compensate for the missing work to determine a final grade. Grading will be done on a curve rather than an absolute scale.

<u>The TA will be in charge of grading the assignments and exams</u>: If you have any questions regarding how a problem set or exam was scored, please start by talking to the TA. If you feel he is not being reasonable, come to me next. On the other hand, I will be grading the projects, so I should be your first stop for this.

<u>Ask me anything</u>: You are more than welcome to ask me anything. I encourage questions, and will answer them if I can. I don't know everything, however. I would also like to learn what you know, and what your perspectives are on the subjects and sectors we cover. I probably will choose at few people at random to <u>Tell Me Something</u> related to the topics and readings if things get too quiet.

<u>Questions about the material, homework, or exams will not be answered via email</u>: If you have a question, please ask it in class or in office hours. I have instructed the TA not to respond to emails asking questions that fall into this category. I have instructed myself to do likewise. On the other hand, if you have other questions or issues that relate personally to you, feel free to send an email or talk to me after class.

<u>Final Grades</u>: Final grades are based on the weighted sum of the scores from assignments, attendance, projects, and exams. <u>Grading is on a curve</u> rather than an absolute scale. This means that a final score of 80% might give you a B+ and a 90% might give you a B-. Your grade depends on your ordinal rank compared to the rest of the class. I will ask the TA to report average scores and distributions, so you will know your relative standing.

<u>Grading Rubric:</u> The assignments, project, and many of the questions on the tests, tend to be more qualitative rather than quantitative. Good responses should be:
- Correct
- Clearly expressed
- Concise
- Reasonably complete
- Well-argued
- Insightful

and should not:

- Make incorrect or internally inconsistent statements
- Omit elements thar are key to the question or problem

This creates an unavoidable subjective element to grading. **My instructions to the TA are that each such assignment and question starts with a score of 80%.** Points are added for elements that are better than the norm, and deducted for elements that are worse (or for omitted elements). The TA will only be able to determine what the norm is after reading what is turned in. I will also instruct the TA to establish a consistent approach, uniformly applied, once this norm is determined.

Office Hours:

Yuhan Chen (yuhan.chen.2@Vanderbilt.edu) will be our TA.
Office hours: 1pm – 3 pm at Stevenson 1115.

John Conley: I will generally be available after class. If you wish to see me, please send an email or catch after class. My office is 414 Calhoun Hall.

Textbook

I have been writing a textbook entitled "The Economics of Information and Communications Technology". The focus is to point the reader to the basic tools from different areas of economics that directly relate to the policy and social questions raised by specific aspects of ICT. It does not, however, attempt to give detailed economic analyses since this would essentially require us to explain the whole corpus of the field, including especially game theory, micro, macro, behavioral, network, and computational economics, industrial organization, finance, public economics, law and economics, business economics and even economic history, Instead, the objective is to provide a high level view of what economics has to say about ICT, and offer readers a structure to think about the issues and challenges that these transformative technologies pose for our society.

Below is a list of additional reading. You will find these, as well as the textbook at:

https://johnpconley.com/about/ict/

Reading list:

Chapter 1: Introduction
Nothing

Chapter 2: The History and Future of ICT

Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia (2010) "**A View of Cloud Computing**", Communications of the ACM, Vol. 53, pp. 50-58

Ergin Bayrak, John P. Conley and Simon Wilkie (2011) "**The Economics of Cloud Computing**" *Korean Economic Review*, Vol. 27, pp. 203-230

Jason Dedrick, Vijay Gurbaxani, and Kenneth L. Kraemer (2003) "**Information Technology and Economic Performance: A Critical Review of the Empirical Evidence**" *ACM Computing Surveys*, Vol. 35, No. 1, pp. 1–28

Avi Goldfarb and Catherine Tucker (2019) "**Digital Economics**" *Journal of Economic Literature* Vol.57 pp. 3–43

Hal Varian (2003) "**Economics of Information Technology**", Working paper

Simon Wilkie (2016) "**Economic Perspectives on the Digital Transformation**" Power Point Deck

Chapter 3: Information Creation, Marketing, and Protection

John P. Conley and Fan-chin Kung (2010) "**Private Benefits, Warm Glow and Reputation in the Free and Open Source Software Production Mode**l" *Journal of Public Economic The-*

ory, (Special issue edited by Ted Bergstrom, Parkash Chander and Lise Vesterlund), Vol. 12, No. 4, pp. 665-689

Georg von Krogh and Eric von Hippel (2003) "**Special issue on open source software development**" Research Policy, Vol. 32 pp. 1149–1157

Josh Lerner and Jean Tirole (2005) "**The Economics of Technology Sharing: Open Source and Beyond**", Journal of Economic Perspectives, Vol. 19, pp. 99-120

Eric Raymond (2000) "**Homesteading the Noosphere**", Working paper

Eric Raymond (2000) "**The Cathedral and the Bazaar**", Working paper

Eric Raymond (2000), "**Revenge of the Hackers**", Working paper

Hal Varian (2005) "**Copying and Copyright**", Working paper

Chapter 4: Computers and Hardware

Rajeev Alur, Emery Berger, Ann W. Drobnis, Limor Fix, Kevin Fu, Gregory D. Hager, Daniel Lopresti, Klara Nahrstedt, Elizabeth Mynatt, Shwetak Patel, Jennifer Rexford, John A. Stankovic, and Benjamin Zorn (2016) "**Systems Computing Challenges in the Internet of Thing**s" https://arxiv.org/abs/1604

Mary Meeker (2017) "**Internet Trends 2017 – Code Conference**" Slide Deck, kpcb.com/InternetTrends

Joseph Y. Halpern and Rafael Pass (2015) "**Algorithmic Rationality: Game Theory with Costly Computation**" *Journal of Economic Theory* Vol 156, pp. 246-268

Jeffrey MacKie-Mason and Hal Varian (2006) "**Some Economics of the Internet**", Working paper

Chapter 5: Networks and Infrastructure and Architecture

Mary Meeker (2017) "**Internet Trends 2017 – Code Conference**" Slide Deck, kpcb.com/InternetTrends

Picornell, Miguel, Tomás Ruiz, Maxime Lenormand, Jose Javier Ramasco, Thibaut Dubernet, and Enrique Frias-Martinez (2015) "**Exploring the potential of phone call data to characterize the relationship between social network and travel behavior**" Transportation Vol. 42, 42.10.1007/s11116-015-9594-1

Chapter 6: Wireless, Wired and Spectrum Basics

Badr Benmammar and Francine Krief (2014) "**Game theory applications in wireless networks: A survey**" In *Proceedings of the 13th International Conference on Software Engineering, Parallel and Distributed Systems* (SEPADS'14), Gdansk, Poland, 15–17 May 2014; pp. 15–17

John P. Conley, (2019) "**Economic Implications of New Technologies for Licensed and Unlicensed Spectrum**", *Vanderbilt University Department of Economics Working Papers*, VUE-CON-19-00011

Ericsson Mobility Report (2020) https://www.ericsson.com/4adc87/assets/local/mobility-report/documents/2020/november-2020-ericsson-mobility-report.pdf

Paul Milgrom, Jonathan Levin and Assaf Eilat (2011) "The Case for Unlicensed Spectrum" Discussion papers, Stanford Institute for Economic Policy Research

Richard Thanki (2009) "The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum" Perspective Associates, http://apps.fcc.gov/ecfs/document/view?id=7020039036

Chapter 7: Systems Software

Nothing

Chapter 8: Encoding, Encrypting, Hashing, and Security Protocols

John P. Conley, (2019) "Encryption, Hashing, PPK, and Blockchain: A Simple Introduction", *Vanderbilt University Department of Economics Working Papers*, VUECON-19-00013

Chapter 9: Authentication

Christian Rathgeb and Andreas Uhl (2011) "A Survey on Biometric Cryptosystems and Cancelable Biometrics" *EURASIP Journal on Information Security*, Vol 2011, Article number: 3

Chapter 10: Banking and Credit

Nothing

Chapter 11: Blockchain Basics

John P. Conley (2019) "Proof of Honesty: Coalition-Proof Blockchain Validation without Proof of Work or Stake"

Yossi Gilad, Rotem Hemo, Silvio Micali, Georgios Vlachos, Nickolai Zeldovich (2017) "Algorand: Scaling byzantine agreements for cryptocurrencies" in Proc. 26th ACM Symp. Operating Syst. Principles, pp. 51–68

D. Mazières (2016) "The Stellar Consensus Protocol: A Federated Model for Internet-level Consensus" White Paper, https://www.stellar.org/papers/stellar-consensus-protocol.pdf

Chapter 12: Blockchain, Game Theory, and Incentives

Joseph Abadi and Markus Brunnermeier (2018) "Blockchain Economics" Working paper

Primavera De Filippi and Benjamin Loveluck, B. (2016) "The invisible politics of Bitcoin: governance crisis of a decentralised infrastructure" Internet Policy Review, 5(3). DOI: 10.14763/2016.3.427

Ittay Eyal and Emin Gün Sirer (2014) "**Majority is not enough: Bitcoin mining is vulnerable**" Financial Cryptography and Data Security 18th International Conference, FC 2014, pp. 436–454

Houy, Nicolas (2014) "**It will cost you nothing to "kill" a proof-of-stake crypto-currency**" Economics Bulletin, Vol. 34, pp. 1038-1044

Aggelos Kiayias, Elias Koutsoupias, Maria Kyropoulou, and Yiannis Tselekounis (2016) "**Blockchain Mining Games**" eprint arXiv:1607.02420

Yuan Liu and and Chunyan Miao (2016) "**A Survey of Incentives and Mechanism Design for Human Computation Systems**" eprint arXiv:1602.03277

Chapter 13: Cryptocurrency and Monetary Theory

John P. Conley, (2017) "**Blockchain and the Economics of Crypto-tokens and Initial Coin Offerings**", *Vanderbilt University Department of Economics Working Papers*, VUECON-17-00008

John P. Conley, (2019) "**Blockchain as a Decentralized Mechanism for Financial Inclusion and Economic Mobility**", *Vanderbilt University Department of Economics Working Papers*, VUECON-19-00012

Chapter 14: Security and Privacy

Nothing

Monday, January 8, 2024