CSci651 Syllabus—FA2016, Tuesday-Thursday 7-8:50pm Section

Ethan Katz-Bassett

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Class meets Tuesday-Thursday, 7-8:50pm, beginning August 23 and ending December 1. Thanksgiving break (for my class) is November 24. The date and time of the final is **TBD**. We will use Piazza to host course materials and discussions. As soon as possible, please go to piazza.com and join the course page.

Changes: This syllabus may be updated over the semester. The most recent version can always be found on the class's Piazza page.

2014-08-20: no changes yet.

Obtaining these papers: The papers are available from the class website (on Piazza) in PDF format. Because they are copyrighted they are available only for classroom use.

The *primary* source of content for the class is these papers, so you will want to download and read them. Downloaded they take up about 95MB storage.

A good option for handling the paper is to get some kind of an e-reader. Several class members and the professor did that last year. You need something that can display 8.5x11 inch PDF files comfortably. Android tables work well and several PDF annotators are available (John Heidemann use RepliGo PDF Reader, which is a nice annotator as well). An iPad works well, and several PDF readers and note-taking programs are available. I use an iPad Mini Retina with iAnnotate. John has used a small Kindle, which worked adequately if you can tolerate only seeing half a page at a time. The large Kindle (DX) is good for reading, but John's experience was that its software doesn't support note taking over PDF at all. Please let me know if you have any other suggestions.

Printing out the papers is also tried and true, and note taking with pencils works well. If you print the papers out, I *strongly* encouraged you to use a double-sided printer. You will need a 3-inch binder if you keep them that way. (If you have to pay for printing, you may find it cheaper to get together with other students to print one copy and photocopy additional ones.)

Some of the papers were scanned. These tend to have large (2–5MB) PDF files, and may look slightly fuzzy when printed. Some of the papers may not display well in Acrobat on the screen, but they all should look reasonable when printed.

In SP2005 we tried making hardcopies of the papers available to students. Unfortunately, USC requires that we charge for these (to recover the duplication costs), and the copyright owners (ACM, IEEE, etc.) insist that if there is *any* charge, then they must get a copyright fee. The total fee for the entire paper set was well over $250, and it was still more than $100 even if the optional papers were eliminated. For this reason I do not plan to make hardcopies available.

In this syllabus, I indicate "new" by papers relative to my section from 2014. (There will be other variations between my section and sections taught by other professors.)

Class Pace: We will usually go over two or three papers per week, although sometimes more. The syllabus is designed to be slightly front-loaded, with the intent that we will run a paper or two (or sometimes a full class) behind for part of the semester.

Primary and Supplemental Papers: There are two groups of papers. We will discuss *primary* papers in class. The concepts and details from primary papers are fair game in exams. You are encouraged to read the supplemental papers if you're interested in an area. Additionally, each of you will be required to read and present a few supplemental papers each as part of your coursework. Outside of these student presentations (and any questions you may ask), we will not discuss *supplemental* papers in class, and you are only required to know the details of supplemental papers that you yourself presented in class.

I am happy to take questions about either primary or supplemental papers in class or office hours.

Other class activities: This syllabus lists exams and papers. You should also expect a class project, typically in three parts (A, B and C). For homework, you will have to write about some of the papers we read. You will also have to read some of the responses of your classmates and participate in class discussions about the papers. Please note that the class dates are when you are expected to have read the papers. At times during the semester we will probably be behind a couple of papers, but you are encouraged to stay with this syllabus for reading.

1 Reference and background

Supplemental:

All of the textbooks are *optional*. Peterson and Davies and Keshav provide an overview of some of the topics we talk about. They provide helpful background and are generally broader and more consistent in their coverage of networking, but less deep on the subjects we cover in class.

General background about networking: [Peterson00a]

[Peterson00a] Larry L. Peterson and Bruce S. Davie. *Computer Networks: A Systems Approach*. Morgan Kaufmann Publishers, 2000.

Sockets programming (useful for the project): [Stevens03a]

[Stevens03a] W. Richard Stevens, Bill Fenner, and Andrew M. Rudoff. *Unix Network Programming: Volume 1: Networking APIs, Sockets*. Prentice-Hall, third edition edition, 2003.

(The Stevens *TCP/IP Illustrated* books are also excellent references relating the RFCs to the BSD code, but are less useful for class.)

Class 1 (Aug. 23):

Course structure and outline.

No paper, but we will review and discuss: General networking, network addressing.

Class 2 (Aug. 25):

Primary:

Tips for reading papers: [Hanson99a]

P1. **[Hanson99a]** Michael J. Hanson. Efficient reading of papers in science. Brochure of unknown origin, revised 1999 by Dylan J. McNamee, 1989.

Another viewpoint of paper reading [Jamin03a]

P2. **[Jamin03a]** Sugih Jamin. Paper reading and writing check lists. web page `http://irl.eecs.umich.edu/jamin/courses/eecs589/papers/checklist.html`, November 2003.

What to look for in systems papers: [Levin83a]

P3. **[Levin83a]** Roy Levin and David D. Redell. An evaluation of the ninth SOSP submissions, or how (and how not) to write a good systems paper. *ACM Operating Systems Review*, 17(3):35–40, July 1983.

Finding and judging new ideas: [Heilmeier92a]

P4. **[Heilmeier92a]** George H. Heilmeier. Some reflections on innovation and invention. *The Bridge*, 22:12–16, Winter 1992.

2 Design principles

Class 3 (Aug. 30):

Primary:

The Internet architecture: [Clark88a]

P5. **[Clark88a]** David D. Clark. The design philosophy of the DARPA internet protocols. In *Proceedings of the 1988 Symposium on Communications Architectures and Protocols*, pages 106–114. ACM, August 1988.

Class 4 (Sept. 1):

Primary:

The end-to-end argument: [Saltzer81a]

P6. **[Saltzer81a]** J. H. Saltzer, D. P. Reed, and D. D. Clark. End-to-end arguments in system design. *Proceedings of the 2nd International Conference on Distributed Computing Systems*, pages 509–512, April 1981.

Naming: [Saltzer82a]

P7. **[Saltzer82a]** Jermome H. Saltzer. On the naming and binding of network destinations. In *International Symposium on Local Computer Networks*, pages 311–317, April 1982.

No paper, but we will review and discuss: data marshaling, packet formats and encoding, SOAP and REST at some point in the first several classes.

Supplemental:
How "tussles" affect network architecture: [Clark02a]

P8. **[Clark02a]** David D. Clark, John Wroclawski, Karen Sollins, and Robert Braden. Tussle in cyberspace: Defining tomorrow's internet. In *Proceedings of the ACM SIGCOMM Conference*, pages 347–356, Pittsburgh, PA, USA, August 2002. ACM.

3 Unicast Routing

Class 5 (Sept. 6):

Primary:

Review of unicast and distance vector routing. (Will use class notes, plus please review your EE450 work.)

BGP introduction: [Caesar05a]

P9. **[Caesar05a]** Matthew Caesar and Jennifer Rexford. BGP routing policies in ISP networks. *IEEE Network Magazine*, 19(6):5–11, November 2005. **NOT ELIGIBLE FOR SHORT OR LONG SUMMARY**

Primary:

Routing stability and oscillation (plus a taste of queueing theory): [Shaikh00a]

P10. **[Shaikh00a]** Aman Shaikh, Lampros Kalampoukas, Rohit Dube, and Anujan Varma. Routing stability in congested networks: Experimentation and analysis. In *Proceedings of the ACM SIGCOMM Conference*, pages 163–174, Stockholm, Sweeden, August 2000. ACM.

Supplemental:
Synchronization problems in routing (but also applies much wider): [Floyd94b]

[Floyd94b] S. Floyd and V. Jacobson. The synchronization of periodic routing messages. *ACM/IEEE Transactions on Networking*, 2(2):122–136, April 1994.

Class 6 (Sept. 8): Primary:

Routing outages, results, and causes: [Wang06b]

P11. **[Wang06b]** Feng Wang, Zhuoqing Morley Mao, Jia Wang, Lixin Gao, and Randy Bush. A measurement study on the impact of routing events on end-to-end Internet path performance. In *Proceedings of the ACM SIGCOMM Conference*, pages 375–386, Pisa, Italy, August 2006. ACM.

Supplemental:
Synchronization problems in routing (but also applies much wider): [Floyd94b]

[Floyd94b] S. Floyd and V. Jacobson. The synchronization of periodic routing messages. *ACM/IEEE Transactions on Networking*, 2(2):122–136, April 1994.

Classic cases where policy choices in peerings result in oscillations: [Griffin99a]

[Griffin99a] Timothy G. Griffin and Gordon Wilfong. An analysis of BGP convergence properties. In *Proceedings of the ACM SIGCOMM Conference*, pages 277–288, Cambridge, MA, USA, September 1999. ACM.

Path inflation: [Spring03a]

P12. **[Spring03a]** Neil Spring, Ratul Mahajan, and Thomas Anderson. Quantifying the causes of path inflation. In *Proceedings of the ACM SIGCOMM Conference*, pages 113–124, Karlsruhe, Germany, August 2003. ACM.

Supplemental:
Classic cases where policy choices in peerings result in oscillations: [Griffin99a]

[**Griffin99a**] Timothy G. Griffin and Gordon Wilfong. An analysis of BGP convergence properties. In *Proceedings of the ACM SIGCOMM Conference*, pages 277–288, Cambridge, MA, USA, September 1999. ACM.

Delay-tolerant networking: [Fall08a]

[**Fall08a**] Kevin Fall and Stephen Farrell. DTN: An architectural retrospective. *IEEE Journal of Selected Areas in Communication*, 26(5):828–837, June 2008.

Class 7 (Sept. 13):

Primary:

Routing security: [Goldberg14a]

P13. [**Goldberg14a**] Sharon Goldberg. Why is it taking so long to secure Internet routing? Communications of the ACM, 57(10):5663, October 2014.

Supplemental: [Heilman14a]

[**Heilman14a**] Ethan Heilman, Danny Cooper, Leonid Reyzin, and Sharon Goldberg. From the consent of the routed: Improving the transparency of the RPKI. In *Proceedings of the ACM SIGCOMM Conference*, pages 51–62, Chicago, Illinois, USA, August 2014. ACM.

4 Business Concerns Shape the Internet: Topology, Traffic, and Content Delivery

Class 8 (Sept. 15):

Network topology: [Oliveira08a]

P14. [**Oliveira08a**] Ricardo V. Oliveira, Dan Pei, Walter Willinger, Beichuan Zhang, and Lixia Zhang. In search of the elusive ground truth: the Internet's AS-level connectivity structure. In *Proceedings of the ACM SIGMETRICS*, pages 217–228. ACM, June 2008.

Primary:

Changes to the network traffic mix: [Labovitz10c]

P15. [**Labovitz10c**] Craig Labovitz, Scott Iekel-Johnson, Danny McPherson, Jon Oberheide, and Farnam Jahanian. Internet inter-domain traffic. In *Proceedings of the ACM SIGCOMM Conference*, pages 75–86, New Delhi, India, August 2010. ACM.

Deferred: We are deferring papers on modeling and self-similarity of networking traffic. We will try to find time for them later in the semester but will probably skip them. No need to read them at this time.

Self-similarity in LAN traffic: [Leland94a]

[**Leland94a**] W.E. Leland, M.S. Taqqu, W. Willinger, and D.V. Wilson. On the self-similar nature of Ethernet traffic (extended version). *ACM/IEEE Transactions on Networking*, 2(1):1–15, February 1994.

And in WAN and web traffic: [Crovella97a]

[**Crovella97a**] Mark E. Crovella and Azer Bestavros. Self-similarity in world wide web traffic: evidence and possible causes. *ACM/IEEE Transactions on Networking*, 5(6):835–846, December 1997.

Supplemental:
Routing hierarchy and policy: [Gao01b]

[**Gao01b**] Lixin Gao. On inferring autonomous system relationships in the Internet. *ACM/IEEE Transactions on Networking*, 9(6):733–745, December 2001.

Packet-level network dynamics: [Paxson99b]

[**Paxson99b**] Vern Paxson. End-to-end Internet packet dynamics. *ACM/IEEE Transactions on Networking*, 7(3):277–292, June 1999.

Class 9 (Sept. 20):

Primary:

Growth of content-delivery networks: [Calder13a]

P16. [**Calder13a**] Matt Calder, Xun Fan, Zi Hu, Ethan Katz-Bassett, John Heidemann, and Ramesh Govindan. Mapping the expansion of Google's serving infrastructure. In *Proceedings of the ACM Internet Measurement Conference*, page to appear, Barcelona, Spain, October 2013. ACM.

Supplemental:
Adapting TCP to CDN architectures: [Flach13a]

[**Flach13a**] Tobias Flach, Nandita Dukkipati, Andreas Terzis, Barath Raghavan, Neal Cardwell, Yuchung Cheng, Ankur Jain, Shuai Hao, Ethan Katz-Bassett, and Ramesh Govindan. Reducing web latency: the virtue of gentle aggression. In *Proceedings of the ACM SIGCOMM Conference*, page to appear, Hong Kong, China, August 2013. ACM.

5 Transport protocols, Congestion Control, and Queue Management

Class 10 (Sept. 22):

Primary: TCP and congestion control: [Jacobson88a]

P17. [**Jacobson88a**] Van Jacobson. Congestion avoidance and control. In *Proceedings of the ACM SIGCOMM Conference*, pages 314–329, Stanford, California, USA, August 1988. ACM.

Congestion control from first principles: [Ramakrishnan90a]

P18. [**Ramakrishnan90a**] K. K. Ramakrishnan and Raj Jain. A binary feedback scheme for congestion avoidance in computer networks. *ACM Transactions on Computer Systems*, 8(2):158–181, May 1990.

Supplemental:
An early academic paper on TCP, prompting the 2004 Turning Award to its authors: [Cerf74a]

[**Cerf74a**] Vint Cerf and Robert Kahn. A protocol for packet network interconnection. *IEEE Transactions on Communications*, COM-22(5):637–648, May 1974.

Class 11 (Sept. 27):

Primary:

Modeling TCP: [Padhye98a]

P19. **[Padhye98a]** J. Padhye, V. Firoiu, D. Towsley, and J. Kurose. Modelling TCP throughput: A simple model and its empirical validation. In *Proceedings of the ACM SIGCOMM Conference*, pages 303–314, Vancouver, Canada, September 1998. ACM.

Class 12 (Sept. 29): TCP follow-up:

Primary: Active queue management, such as fair queueing: [Demers89a]

P20. **[Demers89a]** Alan Demers, Srinivasan Keshav, and Scott Shenker. Analysis and simulation of a fair queueing algorithm. In *Proceedings of the ACM SIGCOMM Conference*, pages 1–12, Austin, Texas, September 1989. ACM.

Supplemental:
Congestion control by exhaustive computer search: [Winstein13a]

[Winstein13a] Keith Winstein and Hari Balakrishnan. TCP ex machina: Computer-generated congestion control. In *Proceedings of the ACM SIGCOMM Conference*, pages 123–134, Hong Kong, China, August 2013. ACM.

Primary: Queue management. Early drop with CoDel: [Nichols12a]

P21. **[Nichols12a]** Kathleen Nichols and Van Jacobson. Controlling queue delay. *Communications of the ACM*, 55(7):42–50, July 2012.

Supplemental:
Random early detection: [Floyd93a]

[Floyd93a] Sally Floyd and Van Jacobson. Random early detection gateways for congestion avoidance. *ACM/IEEE Transactions on Networking*, 1(4):397–413, August 1993.

Class 13 (Oct. 4):

Primary: XCP and non-TCP congestion control: [Katabi02a]

P22. **[Katabi02a]** Dina Katabi, Mark Handley, and Charlie Rohrs. Congestion control for high bandwidth-delay product networks. In *Proceedings of the ACM SIGCOMM Conference*, pages 89–102, Pittsburgh, PA, USA, August 2002. ACM.

Supplemental:
TCP extensions for a datacenter: [Alizadeh10a]

[Alizadeh10a] Mohammad Alizadeh, Albert Greenberg, David A. Maltz, Jitendra Padhye, Parveen Patel, Balaji Prabhakar, Sudipta Sengupta, and Murari Sridharan. Data center TCP (DCTCP). In *Proceedings of the ACM SIGCOMM Conference*, New Delhi, India, August 2010. ACM.

6 Catchup

Class 14 (Oct. 6): We will spend this day catching up on earlier topics.

Class 15 (Oct. 11): We will spend this day catching up on earlier topics.

7 Data Centers, Software Defined Networking, and the Cloud

Class 16 (Oct. 13):

Primary:

How should we structure large-scale web services and the data center networks that deliver them?

Building large-scale services [Fox97a]

P23. **[Fox97a]** Armando Fox, Steven D. Gribble, Yatin Chawathe, Eric A. Brewer, and Paul Gauthier. Cluster-based scalable network services. In *Proceedings of the 16th Symposium on Operating Systems Principles*, pages 78–91, St. Malo, France, October 1997. ACM.

Optimizing a datacenter network: [Greenberg09a]

P24. **[Greenberg09a]** Albert Greenberg, James R. Hamilton, Navendu Jain, Srikanth Kandula, Changhoon Kim, Parantap Lahiri, David A. Maltz, and Parveen Pat. VL2: A scalable and flexible data center network. In *Proceedings of the ACM SIGCOMM Conference*, pages 51–62, Barcelona, Spain, August 2009. ACM.

Supplemental:
On to the cloud, with infrastructure/platform as a service (IaaS, PaaS), and hybrids: [He13a]

[He13a] K. He, A. Fisher, L. Wang, A. Gember, A. Akella and T. Ristenpart Next Stop, the Cloud: Understanding Modern Web Service Deployment in EC2 and Azure In *Proceedings of the Internet Measurement Conference*, Barcelona, Spain, October 2013. ACM.

Data-center electrical usage: [Qureshi09a]

[Qureshi09a] Asfandyar Qureshi, Rick Weber, Hari Balakrishnan, John Guttag, and Bruce Maggs. Cutting the electric bill for Internet-scale systems. In *Proceedings of the ACM SIGCOMM Conference*, pages 123–135, Barcelona, Spain, August 2009. ACM.

An alternative datacenter topology, randomness: [Singla12a]

[Singla12a] Ankit Singla, Chi-Yao Hong, Lucian Popa, and P. Brighten Godfrey. Jellyfish: Networking data centers randomly. In *Proceedings of the USENIX Symposium on Network Systems Design and Implementation*, San Jose, CA, USA, April 2012. USENIX.

Data center topology/routing co-design: [Liu13b]

[Liu13b] Vincent Liu, Daniel Halperin, Arvind Krishnamurthy, and Thomas Anderson. F10: A fault-tolerant engineered network. In *Proceedings of the USENIX Symposium on Network Systems Design and Implementation*, pages 399–412, 2013.

Class 17 (Oct. 18):

Primary:

Running an enterprise network (Ethane, a parent of OpenFlow): [Casado09a]

P25. **[Casado09a]** Martin Casado, Michael J. Freedman, Justin Pettit, Jianying Luo, Natasha Gude, Nick McKeown, and Scott Shenker. Rethinking enterprise network control. *ACM/IEEE Transactions on Networking*, 17(4):1270–1283, August 2009.

Supplemental:
Programming SDNs: [Foster13a]

[Foster13a] Nate Foster, Michael J. Freedman, Arjun Guha, Rob Harrison, Naga Praveen Katta, Christopher Monsanto, Joshua Reich, Mark Reitblatt, Jennifer Rexford, Cole Schlesinger, Alec Story, and David Walker. Languages for software-defined networks. *IEEE Communications Magazine*, 51(2):128–134, February 2013.

Class 18 (Oct. 20):

Primary:

Nicira/VMWare's approach in multi-tenant datacenters: [Koponen14a]

P26. **[Koponen14a]** Teemu Koponen, Keith Amidon, Peter Balland, Martn Casado, Anupam Chanda, Bryan Fulton, Igor Ganichev, Jesse Gross, Natasha Gude, Paul Ingram, Ethan Jackson, Andrew Lambeth, Romain Lenglet, Shih-Hao Li, Amar Padmanabhan, Justin Pettit, Ben Pfaff, Rajiv Ramanathan, Scott Shenker, Alan Shieh, Jeremy Stribling, Pankaj Thakkar, Dan Wendlandt, Alexander Yip, and Ronghua Zhang Network Virtualization in Multi-tenant Datacenters In *Proceedings of the 11th USENIX Symposium on Network Systems Design and Implementation (NSDI)*, Seattle, WA, USA, April 2014. USENIX.

Class 19 (Oct. 25):

Primary:

Detecting problems centrally (header-space analysis, SDNs): [Kazemian12a]

P27. **[Kazemian12a]** Peyman Kazemian, George Varghese, and Nick McKeown. Header space analysis: Static checking for networks. In *Proceedings of the 9th USENIX Symposium on Network Systems Design and Implementation*, San Jose, CA, USA, April 2012. USENIX.

8 Other Ways to Deliver Content: Overlays, Spam, and Peer-to-Peer

Class 20 (Oct. 27):

Primary:

Efficient peer-to-peer storage: [Stoica00a]

P28. **[Stoica00a]** Ion Stoica, Robert Morris, David Karger, M. Frans Kaashoek, and Hari Balakrishnan. Chord: A scalable peer-to-peer lookup service for Internet applications. In *Proceedings of the ACM SIGCOMM Conference*, pages 149–160, Stockholm, Sweden, September 2000. ACM.

Onion routing (TOR): [Dingledine04a]

P29. **[Dingledine04a]** Roger Dingledine, Nick Mathewson, and Paul Syverson. Tor: The second-generation onion router. In *Proceedings of the 13th USENIX Security Symposium*, pages 303–320, San Diego, CA, USA, August 2004. USENIX.

Supplemental:
Freenet and anonymous peer-to-peer file sharing: [Clarke02a]

[Clarke02a] Ian Clarke, Theodore W. Hong, Scott G. Miller, Oskar Sandberg, and Brandon Wiley. Protecting free expression online with Freenet. *IEEE Internet Computing*, 6(1):40–49, February 2002.

Novel routing with DHTs: [Caesar06a]

[Caesar06a] Matthew Caesar, Tyson Condie, Jayanthkumar Kannan, Karthik Lakshminarayanan, Ion Stoica, and Scott Shenker. ROFL: Routing on flat labels. In *Proceedings of the ACM SIGCOMM Conference*, pages 363–374, Pisa, Italy, September 2006. ACM.

(This paper should be with routing, but we'll talk about it here because it assumes background about Chord.)
End-to-end encryption: [Popa14a]

[Popa14a] Raluca Ada Popa, Emily Stark, Jonas Helfer, Steven Valdez, Nickolai Zeldovich, M. Frans Kaashoek, and Hari Balakrishnan. Building web applications on top of encrypted data using Mylar. In *Proceedings of the 11th USENIX Symposium on Network Systems Design and Implementation (NSDI)*, pages 157–172, Seattle, WA, USA, April 2014. USENIX.

Class 21 (Nov. 1):

Spam and anti-spam: [Levchenko11a]

P30. [Levchenko11a] Kirill Levchenko, Andreas Pitsillidis, Neha Chachra, Brandon Enright, Márk Félegyházi, Chris Grier, Tristan Halvorson, Chris Kanich, Christian Kreibich, He Liu, Damon McCoy, Nicholas Weaver, Vern Paxson, Geoffrey M. Voelker, and Stefan Savage. Click trajectories: End-to-end analysis of the spam value chain. In *Proceedings of the IEEE Symposium on Security and Privacy*, pages 431–446, Oakland, CA, USA, May 2011. IEEE.

Supplemental:
Denial of service attacks: [Hussain03b]

[Hussain03b] Alefiya Hussain, John Heidemann, and Christos Papadopoulos. A framework for classifying denial of service attacks. In *Proceedings of the ACM SIGCOMM Conference*, pages 99–110, Karlsruhe, Germany, August 2003. ACM.

Worm propagation: [Staniford02a]

[Staniford02a] Stuart Staniford, Vern Paxson, and Nicholas Weaver. How to 0wn the Internet in your spare time. *Proceedings of the 11th USENIX Security Symposium*, pages 149–167, August 2002.

(Note that, in this class, we intentionally do not do the cryptographic side of network security. There is coverage of that material in CSci555, Graduate Operating Systems, and most of CSci530, Security Systems, is about that.)
Unfortunately there is not time to talk about security and network protocols in this course. CSci555 provides a good coverage of security from an operating systems perspective; see the papers by Voydock and Kent and Needham and Schroder there.

Class 22 (Nov. 3):

Primary:

Can BitTorrent and ISPs get along?

Yes! [Choffnes08a]

P31. **[Choffnes08a]** David Choffnes and Fabian E. Bustamante. Taming the torrent: A practical approach to reducing cross-ISP traffic in peer-to-peer systems. In *SIGCOMM*, 2008.

No! [Piatek09a]

P32. **[Piatek09a]** Michael Piatek, Harsha V. Madhyastha, John P. John, Arvind Krishnamurthy, and Thomas Anderson. Pitfalls for isp-friendly p2p design. In *HotNets*, 2009.

Supplemental:
Privacy built over BitTorrent in OneSwarm: [Isdal10a]

[Isdal10a] Tomas Isdal, Michael Piatek, Arvind Krishnamurthy, and Thomas Anderson. Privacy-preserving P2P data sharing with OneSwarm. In *Proceedings of the ACM SIGCOMM Conference*, pages 111–122, New Delhi, India, August 2010. ACM.

Does BitTorrent provide the right incentives to users to contribute, or can they manipulate the protocol to obtain better performance at lower cost? [Piatek07a]

[Piatek07a] Michael Piatek, Tomas Isdal, Thomas Anderson, Arvind Krishnamurthy, and Arun Venkataramani. Do incentives build robustness in BitTorrent? In *Proceedings of the 4th USENIX Symposium on Network Systems Design and Implementation*, pages 1–14. USENIX, April 2007.

9 Network Architecture Past, Present, and Future

Class 23 (Nov. 8):

Primary:

Quality of service and admission control: [Shenker95a]

P33. **[Shenker95a]** Scott Shenker. Fundamental design issues for the future Internet. *IEEE Journal of Selected Areas in Communication*, 13(7):1176–1188, September 1995.

Google's use of Software Defined Networking for traffic engineering: [Jain13a]

P34. **[Jain13a]** Sushant Jain, Alok Kumar, Joon Ong Subhasree Mandal, Leon Poutievski, Arjun Singh, Subbaiah Venkata, Jim Wanderer, Junlan Zhou, Jonathan Zolla Min Zhu, Urs Hölzle, Stephen Stuart, and Amin Vahdat. B4: Experience with a globally-deployed software defined WAN. In *Proceedings of the ACM SIGCOMM Conference*, page to appear, Hong Kong, China, August 2013. ACM.

Supplemental:
Lighter-weight QoS: [Stoica03a]

[Stoica03a] Ion Stoica, Scott Shenker, and Hui Zhang. Core-stateless fair queueing: a scalable architecture to approximate fair bandwidth allocations in high-speed networks. *ACM/IEEE Transactions on Networking*, 11(1):33–46, February 2003.

Class 24 (Nov. 10):

Primary:

Information-centric networking: [Jacobson12a]

P35. **[Jacobson12a]** Van Jacobson, Diana K. Smetters, James D. Thornton, Michael Plass, Nick Briggs, and Rebecca Braynard. Networking named content. *Communications of the ACM*, 55(1):117–124, January 2012.

Supplemental:
How do we evaluate and compare different proposed network architectures that deal with mobility in different ways? [Gao14a]

[Gao14a] Zhaoyu Gao, Arun Venkataramani, James Kurose, and Simon Heimlicher
Towards a Quantitative Comparison of Location-Independent Network Architectures In *Proceedings of the ACM SIGCOMM Conference*, Chicago, SIGCOMM, August 2014. ACM.

Incrementally deployable information-centric networking: [Fayazbakhsh13a]

[Fayazbakhsh13a] Seyed Kaveh Fayazbakhsh, Yin Lin, Amin Tootoonchian, Ali Ghodsi, Teemu Koponen, Bruce Maggs, K. C. Ng, Vyas Sekar, and Scott Shenker. Less Pain, Most of the Gain: Incrementally Deployable ICN. In *Proceedings of the 11th USENIX Symposium on Network Systems Design and Implementation*, Seattle, WA, USA, April 2014.

Use of QoS and differentiated services: [Davie03a]

[Davie03a] Bruce Davie. Deployment experience with differentiated services. In *Proceedings of the ACM Workshop on Revisiting IP QoS*, pages 131–136, Karlsruhe, Germany, August 2003. ACM.

10 Wireless and Mobile Networking

Class 25 (Nov. 15):

Primary: MAC protocols: [Bharghavan94a]

P36. **[Bharghavan94a]** Vaduvur Bharghavan, Alan Demers, Scott Shenker, and Lixia Zhang. MACAW: A media access protocol for wireless LANs. In *Proceedings of the ACM SIGCOMM Conference*, pages 212–225, London, UK, September 1994. ACM.

Non-IP routing in sensor networks: [Intanagonwiwat00a]

P37. **[Intanagonwiwat00a]** Chalermek Intanagonwiwat, Ramesh Govindan, and Deborah Estrin. Directed diffusion: A scalable and robust communication paradigm for sensor networks. In *Proceedings of the ACM International Conference on Mobile Computing and Networking*, pages 56–67, Boston, MA, USA, August 2000. ACM.

Supplemental:
Wireless propagation characteristics: [Aguayo04a]

[Aguayo04a] Daniel Aguayo, John Bicket, Sanjit Biswas, Glenn Judd, and Robert Morris. Link-level measurements from an 802.11b mesh network. In *Proceedings of the ACM SIGCOMM Conference*, pages 121–132, Portland, Oregon, USA, August 2004. ACM.

Wireless security: [Borisov01a]

[Borisov01a] Nikita Borisov, Ian Goldberg, and David Wagner. Intercepting mobile communications: The insecurity of 802.11. In *Proceedings of the ACM International Conference on Mobile Computing and Networking*, pages 180–189, Rome, Italy, July 2001. ACM.

Wireless software radios: [Bahl09a]

[**Bahl09a**] Paramvir Bahl, Ranveer Chandra, Thomas Moscibroda, Rohan Murty, and Matt Welsh. White space networking with Wi-Fi like connectivity. In *Proceedings of the ACM SIGCOMM Conference*, pages 27–39, Barcelona, Spain, August 2009. ACM.

Class 26 (Nov. 17):

Primary:

Mobile (cellular) networks: [Huang13a]

P38. [**Huang13a**] Junxian Huang, Feng Qian, Yihua Guo, Yuanyuan Zhou, Qiang Xu, and Z. Morley Mao. An in-depth study of LTE: Effect of network protocol and application behavior on performance. In *Proceedings of the ACM SIGCOMM Conference*, pages 363–374, Hong Kong, China, Aug 2013. ACM.

Supplemental:
Looking across layers (very impactful project): [Qian11a]

[**Qian11a**] Feng Qian, Zhaoguang Wang, Alexandre Gerber, Z. Morley Mao, Subhabrata Sen, and Oliver Spatscheck. Profiling Resource Usage for Mobile Applications: A Cross-layer Approach In *Proceedings of the ACM MobiSys Conference*, Bethesda, Maryland, USA, July, 2011. ACM.

Class 27 (Nov. 22):

Thursday is **Thanksgiving break**, so no class.

11 Privacy and Ethics

Class 28 (Nov. 29):

Primary:

Network data collection and differential privacy: [Dittrich11a]

P39. [**Dittrich11a**] David Dittrich and Erin Kenneally (editors). The Menlo report: Ethical principles guiding information and communication technology research. Technical report, United States Department of Homeland Security, September 2011. **NOT ELIGIBLE FOR SHORT OR LONG SUMMARY**

Class 29 (Dec. 1):

Primary:

Network data collection and differential privacy: [McSherry10a]

P40. [**McSherry10a**] Frank McSherry and Ratul Mahajan. Differentially-private network trace analysis. In *Proceedings of the ACM SIGCOMM Conference*, pages 123–134, New Delhi, India, August 2010. ACM. **NOT ELIGIBLE FOR SHORT OR LONG SUMMARY**

12 Multicast Routing, Transport, and Applications

Multicast was a major push in networking in the 1990s, and it is standardized, deployed, and used in some niches. However a glut of bandwidth and technical challenges dealing with state (most protocols required

per-multicast-group state in routers) means that wide-area IP mutlicast does not seem to have prospered. The techniques developed in multicast are interesting, worth understanding, and used by some. But as of FA2014, they are all supplemental.

Supplemental:

Multicast routing (flood-and-prune, rendezvous): (*for [Deering88b], please read only sections 1–4, pages 85–103*): [Deering88b]

[Deering88b] Stephen E. Deering. Multicast routing in internetworks and extended LANs. In *Proceedings of the ACM SIGCOMM Conference*, pages 55–64, Stanford, CA, August 1988. ACM.

Reliable multicast and SRM: (*for [Floyd97c], please read only through section 7.1, page 15)*) [Floyd97c]

[Floyd97c] Sally Floyd, Van Jacobson, Ching-Gung Liu, Steven McCanne, and Lixia Zhang. A reliable multicast framework for light-weight sessions and application level framing. *ACM/IEEE Transactions on Networking*, 5(6):784–803, December 1997.

File distribution and coding: [Byers98a]

[Byers98a] John W. Byers, Michael Luby, Michael Mitzenmacher, and Ashutosh Rege. A digital fountain approach to reliable distribution of bulk data. In *Proceedings of the ACM SIGCOMM Conference*, pages 56–67, Vancouver, Canada, September 1998. ACM.

Multimedia: [Bolot94a]

[Bolot94a] Jean-Chrysostome Bolot, Thierry Turlettil, and Ian Wakeman. Scalable feedback control for multicast video distribution in the Internet. In *Proceedings of the ACM SIGCOMM Conference*, pages 58–67, London, United Kingdom, September 1994. ACM.

13 Other Topics: Hardware and Software in Routers and Devices

These are topics we cannot cover but that are considered in some similar network courses. All these materials are supplemental.

Supplemental:

Router design: [Partridge98a]

[Partridge98a] Craig Partridge, Steve Kohalmi, Tracy Ma, John Mcallen, Trevor Mendez, Walter C. Milliken, Ronald Pettyjohn, John Rokosz, Joshua Seeger, Michael Sollins, Steve Storch, Philip P. Carvey, Benjamin Tober, Gregory D. Troxel, Ed Burgess, Isidro Castineyra, Tom Clarke, Lise Graham, Michael Hathaway, Phil Herman, and Allen King. A fifty gagabit per second IP router. *ACM/IEEE Transactions on Networking*, 6(3):237–248, June 1998.

Router software (Click): [Kohler00a]

[Kohler00a] Eddie Kohler, Robert Morris, Benjie Chen, John Jannotti, and M. Frans Kaashoek. The Click modular router. *ACM Transactions on Computer Systems*, 18(3):263–297, August 2000.

Optical networking: [Mukherjee00a]

[Mukherjee00a] Biswanath Mukherjee. WDM optical communication networks: Progress and challenges. *IEEE Journal of Selected Areas in Communication*, 18(10):1810–1824, October 2000.

RFID-inspired energy harvesting networks: [Liu13a]

[Liu13a] Vincent Liu, Aaron Parks, Vamsi Talla, Shyamnath Gollakota, David Wetherall, and Joshua R. Smith. Ambient backscatter: Wireless communication out of thin air. In *Proceedings of the ACM SIGCOMM Conference*, pages 39–50, Hong Kong, China, August 2013. ACM.

14 Final Exam

The final exam is **TBD**.