

CSci652 Syllabus—FA2023, Monday/Wednesday Section

John Heidemann

August 20, 2023

Class meets Monday and Wednesday, noon to 1:50pm, beginning August 21 and ending November 29 (with a final exam on December 4). There will be no class on September 4 (Labor day) nor on November 22 (Thanksgiving recess). There will be no class September 27, when I have to travel for a PhD defense. We will have **two short midterms** at noon Sept. 20 and noon October 25. The date and time of the final is ~~Monday, 2022-12-11, 8am-10am~~ Friday, 2022-12-08, 11am-1pm (the mandatory university time for our class).

All students are expected to confirm they can make the midterms and final exams—we do not offer alternative dates.

All classes will be hybrid in-person and online via DEN's web videoconferencing. I have an interactive lecture style and will do my best to adapt it to online class—I *strongly encourage* students to attend class synchronously and be prepared to comment during class to get the most out of class.

Changes: This syllabus may be updated over the semester. The most recent version can always be found at the class Moodle site.

2023-08-18: No changes yet.

2023-08-19: The same papers, but shuffled slightly so each day has only one group of primary papers, and correct time of midterms.

2023-08-20: Correct time of final exam.

Obtaining class papers: All class papers are available from the CSci652 Moodle site (described below) in PDF format. Because they are copyrighted they are available only for classroom use. The Moodle site is only available to students with class-specific accounts.

To get a Moodle account, go to <http://www.isi.edu/~johnh/cs652.html> and follow the instructions, or e-mail the professor or TA.

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

Class Pace: We will usually go over three or four papers or so per week, and occasionally 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.

Other class activities: This syllabus lists exams and papers. You should also expect a class project, typically in three parts (A, B and C), and several homework assignments (often 4, but at least 3 and no more than 6). Dates for these will be given as the semester progresses.

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

Class Week 1 (Aug. 21 and Aug. 23):

Project A assigned August 25, due September 10.

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.

Finding and judging new ideas: [Heilmeier92a]

- P2. [Heilmeier92a]** George H. Heilmeier. Some reflections on innovation and invention. *The Bridge*, 22:12–16, Winter 1992.

What to measure? Reverse engineering the Internet: [Spring03b]

- P3. [Spring03b]** Neil Spring, David Wetherall, and Thomas Anderson. Reverse engineering the internet. In *Proceedings of the ACM Workshop on Hot Topics in Networks*, pages 3–8, Boston, Mass., USA, November 2003. ACM, <https://doi.org/10.1145/972374.972376>.

No paper, but we will review and discuss: NABC talk presentation.

2 Design principles

Class Week 2 (Aug. 28 and Aug. 30):

The challenge of measuring (and simulating) the Internet:

[Floyd01a]

- P4. [Floyd01a]** Sally Floyd and Vern Paxson. Difficulties in simulating the Internet. *ACM/IEEE Transactions on Networking*, 9(4):392–403, August 2001, <http://dx.doi.org/10.1109/90.944338>.

Sound internet measurement: [Paxson04a]

- P5. [Paxson04a]** Vern Paxson. Strategies for sound Internet measurement. In *Proceedings of the ACM Internet Measurement Conference*, pages 263–271, Taormina, Sicily, Italy, October 2004. ACM, <http://dx.doi.org/10.1145/1028788.1028824>.

Ethics and network research: [Dittrich11a]

- P6. [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.

3 On-Path Estimation: RTT and Available Bitrate

Class Week 3 (Sep. 4—Labor Day holiday and Sep. 6—back to class):

No class Sept. 4 due to Labor Day, a USC holiday.

Estimating RTT in TCP: [Jacobson88a]

- P7. [Jacobson88a]** Van Jacobson. Congestion avoidance and control. In *Proceedings of the ACM SIGCOMM Conference*, pages 314–329, Stanford, California, USA, August 1988. ACM, <http://dx.doi.org/10.1145/52325.52356>.

Estimating available bandwidth in BBR [Cardwell17a]

- P8. [Cardwell17a]** Neal Cardwell, Yuchung Cheng, C. Stephen Gunn, Soheil Hassas Yeganeh, and Van Jacobson. BBR: Congestion-based congestion control. *Communications of the ACM*, 60(2):58–66, February 2017, [10.1145/3009824](https://doi.org/10.1145/3009824).

Packet pair: [Paxson97d]

- P9. [Paxson97d]** Vern Paxson. End-to-end Internet packet dynamics. In *Proceedings of the ACM SIGCOMM Conference*, pages 139–152, Cannes, France, October 1997. ACM, <https://doi.org/10.1145/263105.263155>.

Estimating packet loss: [Sommers05a]

- P10. [Sommers05a]** Joel Sommers, Paul Barford, Nick Duffield, and Amos Ron. Improving accuracy in end-to-end packet loss measurement. In *Proceedings of the ACM SIGCOMM Conference*, pages 157–168, Philadelphia, PA, USA, August 2005. ACM, <https://doi.org/10.1145/1080091.1080111>.

Project B assigned Sep. 8, due October 15.

4 Topology

Class Week 4 (Sep. 11 and Sep. 13):

(Paris) Traceroute: [Augustin07a]

- P11. [Augustin07a]** Brice Augustin, Timur Friedman, and Renata Teixeira. Measuring load-balanced paths in the Internet. In *Proceedings of the ACM Internet Measurement Conference*, pages 149–160, San Diego, CA, USA, October 2007. ACM, <https://doi.org/10.1145/1298306.1298329>.

Building topologies: [Govindan00a]

- P12. [Govindan00a]** Ramesh Govindan and Hongsuda Tangmunarunkit. Heuristics for Internet map discovery. In *Proceedings of the IEEE Infocom*, pages 1371–1380, Tel Aviv, Israel, March 2000. IEEE, [10.1109/INFCOM.2000.832534](https://doi.org/10.1109/INFCOM.2000.832534).

IP Geolocation and CBG: [Gueye06a]

- P13. [Gueye06a]** Bamba Gueye, Artur Ziviani Mark Crovella, and Serge Fdida. Constraint-based geolocation of Internet hosts. *ACM/IEEE Transactions on Networking*, 14(6):1219–1232, December 2006, [10.1109/TNET.2006.886332](https://doi.org/10.1109/TNET.2006.886332).

The physical topology: [Durairajan15a]

- P14.** [Durairajan15a] Ramakrishnan Durairajan, Paul Barford, Joel Sommers, and Walter Willinger. InterTubes: A study of the US long-haul fiber-optic infrastructure. In *Proceedings of the ACM SIGCOMM Conference*, pages 565–578, London, United Kingdom, August 2015. ACM, <http://dx.doi.org/10.1145/2785956.2787499>.

Supplemental: Geolocation validation applied to VPNs: [Weinberg18a]

- S1.** [Weinberg18a] Zachary Weinberg, Shinyoung Cho, Nicolas Christin, Vyas Sekar, and Phillipa Gill. How to catch when proxies lie: Verifying the physical locations of network proxies with active geolocation. In *Proceedings of the ACM Internet Measurement Conference*, Boston, Massachusetts, USA, October 2018. ACM, <https://doi.org/10.1145/3278532.3278551>.

Router geolocation and hostname hints: [Luckie21a]

- S2.** [Luckie21a] Matthew Luckie, Bradley Huffaker, Alexander Marder, Zachary Bischof, Marianne Fletcher, and k. claffy. Learning to extract geographic information from internet router hostnames. In *Proceedings of the ACM Conference on Emerging Networking Experiments and Technologies*, pages 440–453, Virtual Location, December 2021. ACM, <https://doi.org/10.1145/3485983.3494869>.

Submarine cables: [Liu20a]

- S3.** [Liu20a] Shucheng Liu, Zachary S. Bischof, Ishaan Madan, Peter K. Chan, and Fabián E. Bustamante. Out of sight, not out of mind: A user-view on the criticality of the submarine cable network. In *Proceedings of the ACM Internet Measurement Conference*, Pittsburgh, PA, USA, October 2020. ACM, <https://doi.org/10.1145/3419394.3423633>.

5 Routing and Autonomous Systems (ASes)

Class Week 5 (Sep. 18 and Sep. 20):

Short Midterm 1 will be the first 35 minutes of September 20.

WAN routing: [Paxson97f]

- P15.** [Paxson97f] Vern Paxson. End-to-end routing behavior in the Internet. *ACM/IEEE Transactions on Networking*, 5(5):601–615, October 1997, [10.5555/268715.268716](https://doi.org/10.5555/268715.268716).

BGP background: [Caesar05a]

- P16.** [Caesar05a] Matthew Caesar and Jennifer Rexford. BGP routing policies in ISP networks. *IEEE Network Magazine*, 19(6):5–11, November 2005, <http://dx.doi.org/10.1109/MNET.2005.1541715>.

AS relationships: [Gao01b]

- P17.** [Gao01b] Lixin Gao. On inferring autonomous system relationships in the Internet. *ACM/IEEE Transactions on Networking*, 9(6):733–745, December 2001, <http://dx.doi.org/10.1109/90.974527>.

Supplemental: AS relationships, 15 years later: [Anwar15a]

- S4.** [Anwar15a] Ruwaifa Anwar, Haseeb Niaz, David Choffnes, Ítalo Cunha, Phillipa Gill, and Ethan Katz-Bassett. Investigating interdomain routing policies in the wild. In *Proceedings of the ACM Internet Measurement Conference*, pages 71–77, Tokyo, Japan, October 2015. ACM, <http://dx.doi.org/10.1145/2815675.2815712>.

BGPStream: processing BGP: [Orsini16a]

- S5.** [Orsini16a] Chiara Orsini, Alistair King, Danilo Giordano, Vasileios Giotsas, and Alberto Dainotti. BGPStream: A software framework for live and historical BGP data analysis. In *Proceedings of the ACM Internet Measurement Conference*, Santa Monica, CA, USA, November 2016. ACM, <https://doi.org/10.1145/2987443.2987482>.

Class Week 6 (Sep. 25 and Sep. 27):

No class Sept. 27: the professor has to travel to attend a PhD defense.

Ground truth AS relationships: [Oliveira08a]

- P18.** [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, <http://doi.acm.org/10.1145/1384529.1375482>.

IXPs: [Ager12a]

- P19.** [Ager12a] Bernhard Ager, Nikolaos Chatzis, Anja Feldmann, Nadi Sarrar, Steve Uhlig, and Walter Willinger. Anatomy of a large European IXP. In *Proceedings of the ACM SIGCOMM Conference*, pages 163–174, Helsinki, Finland, August 2012. ACM, <https://doi.org/10.1145/2342356.2342393>.

Supplemental: AS-to-organizations: [Cai10c]

- S6.** [Cai10c] Xue Cai, John Heidemann, Balachander Krishnamurthy, and Walter Willinger. Towards an AS-to-Organization map. In *Proceedings of the ACM Internet Measurement Conference*, pages 199–205, Melbourne, Australia, November 2010. ACM, <http://dx.doi.org/10.1145/1879141.1879166>.

Class Week 7 (Oct. 2 and Oct. 4): More routing.

Anycast: [Vries17b]

- P20.** [Vries17b] Wouter B. de Vries, Ricardo de O. Schmidt, Wes Hardaker, John Heidemann, Pieter-Tjerk de Boer, and Aiko Pras. Verploeter: Broad and load-aware anycast mapping. In *Proceedings of the ACM Internet Measurement Conference*, London, UK, 2017. <https://doi.org/10.1145/3131365.3131371>.

CDNs: [Calder15a]

- P21.** [Calder15a] Matt Calder, Ashley Flavel, Ethan Katz-Bassett, Ratul Mahajan, and Jitendra Padhye. Analyzing the performance of an anycast CDN. In *Proceedings of the ACM Internet Measurement Conference*, pages 531–537, Tokyo, Japan, October 2015. ACM, <http://dx.doi.org/10.1145/2815675.2815717>.

6 Trends in Routing and Peering

Class Week 8 (Oct. 9 and Oct. 11):

Project C assigned Oct. 13, due Nov. 18.

Hypergiants: [Labovitz10c]

- P22. [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, <http://doi.acm.org/10.1145/1851182.1851194>.

Flattening of the Internet: [Chiu15a]

- P23. [Chiu15a]** Yi-Ching Chiu, Brandon Schlinker, Abhishek Balaji Radhakrishnan, Ethan Katz-Bassett, and Ramesh Govindan. Are we one hop away from a better Internet? In *Proceedings of the ACM Internet Measurement Conference*, pages 523–529, Tokyo, Japan, October 2015. ACM, <http://dx.doi.org/10.1145/2815675.2815719>.

Supplemental: IXPs revisited: [Lutu21a]

- S7. [Lutu21a]** Andra Lutu, Diego Perino, Marcelo Bagnulo, and Fabián E. Bustamante. Insights from operating an IP exchange provider. In *Proceedings of the ACM SIGCOMM Conference*, pages 718–730, Virtual, August 2021. ACM, <https://doi.org/10.1145/3452296.3472930>.

7 Reliability

Class Week 9 (Oct. 16 and Oct. 18):

Primary:

Internet outages: [Quan13c]

- P24. [Quan13c]** Lin Quan, John Heidemann, and Yuri Pradkin. Trinocular: Understanding Internet reliability through adaptive probing. In *Proceedings of the ACM SIGCOMM Conference*, pages 255–266, Hong Kong, China, August 2013. ACM, <http://doi.acm.org/10.1145/2486001.2486017>.

CDNs and outages: [Richter18a]

- P25. [Richter18a]** Philipp Richter, Ramakrishna Padmanabhan, Neil Spring, Arthur Berger, and David Clark. Advancing the art of Internet edge outage detection. In *Proceedings of the ACM Internet Measurement Conference*, pages 350–363, Boston, Massachusetts, USA, October 2018. ACM, <https://doi.org/10.1145/3278532.3278563>.

Partial reachability: [Baltra23a]

- P26. [Baltra23a]** Guillermo Baltra and John Heidemann. What is the Internet? partial connectivity of the Internet core. Technical Report arXiv:2107.11439v3, USC/Information Sciences Institute, March 2023, <https://doi.org/10.48550/2107.11439v3>.

Supplemental: Passive outages from darknets: [Guillot19a]

- S8. [Guillot19a]** Andreas Guillot, Romain Fontugne, Philipp Winter, Pascal Merindol, Alistair King, Alberto Dainotti, and Cristel Pelsser. Chocolatine: Outage detection for Internet background radiation. In *Proceedings of the IFIP International Workshop on Traffic Monitoring and Analysis*, Paris, France, June 2019. IFIP, <https://doi.org/10.23919/TMA.2019.8784607>.

8 Censorship

Class Week 10 (Oct. 23 and Oct. 25):

Short Midterm 2 will be the first 35 minutes of Oct. 25.

The great firewall and DNS: [Anonymous14a]

P27. [Anonymous14a] Anonymous. Towards a comprehensive picture of the Great Firewall’s DNS censorship. In *Proceedings of the USENIX Workshop on Free and Open Communications on the Internet*, San Diego, CA, USA, August 2014. USENIX.

HTTPS in Kazhakstan: [Raman20a]

P28. [Raman20a] Ram Sundara Raman, Leonid Evdokimov, Eric Wurstrow, J. Alex Halderman, and Roya Ensafi. Investigating large scale HTTPS interception in Kazakhstan. In *Proceedings of the ACM Internet Measurement Conference*, pages 125–132, Pittsburgh, PA, USA, October 2020. ACM, <https://doi.org/10.1145/3419394.3423665>.

Application-level interference and ICLab: [Naiki20a]

P29. [Naiki20a] Arian Akhavan Niaki, Shinyoung Cho, Zachary Weinberg, Nguyen Phong Hoang, Abbas Razaghpanah, Nicolas Christin, and Phillipa Gill. ICLab: A global and longitudinal Internet censorship measurement platform. In *Proceedings of the IEEE Symposium on Security and Privacy*, pages 135–151, San Francisco, CA, USA, May 2020. IEEE, [10.1109/SP40000.2020.00014](https://doi.org/10.1109/SP40000.2020.00014).

Supplemental: Uneven distribution of Internet access: [Weidmann16a]

S9. [Weidmann16a] Nils B. Weidmann, Suso Benitez-Baleato, Philipp Hunziker, Eduard Glatz, and Xenofontas Dimitropoulos. Digital discrimination: Political bias in Internet service provision across ethnic groups. *Science*, 353(6304):1151–1155, 9 September 2016, <https://doi.org/10.1126/science.aaf5062>.

9 Security

Class Week 11 (Oct. 30 and Nov. 1)

Spam: [Levchenko11a]

P30. [Levchenko11a] Kirill Levchenko, Andreas Pitsillidis, Neha Chachra, Brandon Enright, Márk Félégyházi, 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, <https://doi.org/10.1109/SP.2011.24>.

DDoS: [Moore01a]

P31. [Moore01a] David Moore, Geoffrey Voelker, and Stefan Savage. Inferring Internet denial of service activity. In *Proceedings of the USENIX Security Symposium*, Washington, DC, USA, August 2001. USENIX.

Scanners: [Richter19a]

- P32.** [Richter19a] Philipp Richter and Arthur Berger. Scanning the scanners: Sensing the internet from a massively distributed network telescope. In *Proceedings of the ACM Internet Measurement Conference*, pages 144–157, Amsterdam, the Netherlands, October 2019. ACM, <https://doi.org/10.1145/3355369.3355595>.

TLS from passive data: [Kotzias18a]

- P33.** [Kotzias18a] Platon Kotzias, Abbas Razaghpanah, Johanna Amann, Kenneth G. Paterson, Narseo Vallina-Rodriguez, and Juan Caballero. Coming of age: A longitudinal study of TLS deployment. In *Proceedings of the ACM Internet Measurement Conference*, pages 415–428, Boston, Mass., USA, October 2018. ACM, <https://doi.org/10.1145/3278532.3278568>.

Supplemental: Booters (DDoS-as-a-Service): [Santanna15a]

- S10.** [Santanna15a] José Jair Santanna, Roland van Rijswijk-Deij, Rick Hofstede, Anna Sperotto, Mark Wierbosch, Lisandro Zambenedetti Granville, and Aiko Pras. Booters—an analysis of DDoS-as-a-Service attacks. In *Proceedings of the 14th IFIP/IEEE International Symposium on Integrated Network Management*, Ottawa, Canada, May 2015. IFIP, <https://doi.org/10.1109/INM.2015.7140298>.

DDoS from BGP: [Giotsas17b]

- S11.** [Giotsas17b] Vasileios Giotsas, Georgios Smaragdakis, Christoph Dietzel, Philipp Richter, Anja Feldmann, and Arthur Berger. Inferring BGP blackholing activity in the Internet. In *Proceedings of the ACM Internet Measurement Conference*, London, UK, November 2017. ACM, <https://doi.org/10.1145/3131365.3131379>.

TLS Certificates: [Durumeric13b]

- S12.** [Durumeric13b] Zakir Durumeric, James Kasten, Michael Bailey, and J. Alex Halderman. Analysis of the HTTPS certificate ecosystem. In *Proceedings of the ACM Internet Measurement Conference*, page to appear, Barcelona, Spain, October 2013. ACM, <https://doi.org/10.1145/2504730.2504755>.

Malware: [Alrawi21a]

- S13.** [Alrawi21a] Omar Alrawi, Charles Lever, Kevin Valakuzhy, Ryan Court, Kevin Snow, Fabian Monrose, and Manos Antonakakis. The circle of life: A large-scale study of the iot malware lifecycle. In *Proceedings of the 30th USENIX Security Symposium*, pages 3505–3522, Virtual Location, August 2021. USENIX.

10 DNS and Services

Class Week 12 (Nov. 6 and Nov. 8):

Traffic at the root: [Castro08a]

- P34.** [Castro08a] Sebastian Castro, Duane Wessels, Marina Fomenkov, and Kimberly Claffy. A day at the root of the Internet. *ACM Computer Communication Review*, 38(5):41–46, October 2008, <http://dx.doi.org/10.1145/1452335.1452341>.

DNS under DDoS: [Moura16b]

- P35. [Moura16b]** Giovane C. M. Moura, Ricardo de O. Schmidt, John Heidemann, Wouter B. de Vries, Moritz Müller, Lan Wei, and Christian Hesselman. Anycast vs. DDoS: Evaluating the November 2015 root DNS event. In *Proceedings of the ACM Internet Measurement Conference*, pages 255–270, Santa Monica, California, USA, November 2016. ACM, <http://dx.doi.org/10.1145/2987443.2987446>.

Anycast in DNS and CDNs: [Koch21a]

- P36. [Koch21a]** Thomas Koch, Ke Li, Calvin Ardi, Ethan Katz-Bassett, Matt Calder, and John Heidemann. Anycast in context: A tale of two systems. In *Proceedings of the ACM SIGCOMM Conference*, Virtual, August 2021. ACM, <https://doi.org/10.1145/3452296.3472891>.

Service discover: [Durumeric15b]

- P37. [Durumeric15b]** Zakir Durumeric, David Adrian, Ariana Mirian, Michael Bailey, and J. Alex Halderman. A search engine backed by internet-wide scanning. In *Proceedings of the ACM Conference on Computer and Communications Security*, pages 542–553, Denver, CO, USA, October 2015. ACM, <https://doi.org/10.1145/2810103.2813703>.

Supplemental: Defending DDoS with Anycast: [Rizvi22a]

- S14. [Rizvi22a]** A S M Rizvi, Leandro Bertholdo, João Ceron, and John Heidemann. Anycast agility: Network playbooks to fight DDoS. In *Proceedings of the 31st USENIX Security Symposium*, pages 4201–4218. USENIX, August 2022.

Passive DNS databases: [Bilge14a]

- S15. [Bilge14a]** Leyla Bilge, Sevil Sen, Davide Balzarotti, Engin Kirda, and Christopher Kruegel. Exposure: A passive DNS analysis service to detect and report malicious domains. *Proceedings of the ACM Transactions on Information and System Security*, 16(4):1–28, April 2014, <https://doi.org/10.1145/2584679>.

Reverse DNS, passive and active: [Fiebig18a]

- S16. [Fiebig18a]** Tobias Fiebig, Kevin Borgolte, Shuang Hao, Christopher Kruegel, Giovanni Vigna, and Anja Feldmann. In rDNS we trust: Revisiting a common data-source’s reliability. In *Proceedings of the Passive and Active Measurement Conference*, pages 131–145, Berlin, Germany, March 2018. Springer, https://doi.org/10.1007/978-3-319-76481-8_10.

11 Traffic in the Aggregate

Class Week 13 (Nov. 13 and Nov. 15):

Self-Similarity: [Leland94a] and why [?]

- P38. [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, <https://doi.org/10.1109/90.282603>.

Persistent congestion: [Dhamdhere18a]

- P39. [Dhamdhere18a]** Amogh Dhamdhere, David D. Clark, Alexander Gamero-Garrido, Matthew Luckie, Ricky K. P. Mok, Gautam Akiwate, Kabir Gogia, Vaibhav Bajpai, Alex C. Snoeren, and kc claffy. Inferring persistent interdomain congestion. In *Proceedings of the ACM SIGCOMM Conference*, pages 1–15, Budapest, Hungary, August 2018. ACM, <https://doi.org/10.1145/3230543.3230549>.

Effects of Covid on Facebook: [Boettger20a]

- P40.** [Boettger20a] Timm Böttger, Ghida Ibrahim, and Ben Vallis. How the internet reacted to Covid-19—a perspective from Facebook’s edge network. In *Proceedings of the ACM Internet Measurement Conference*, pages 34–41, Pittsburgh, PA, USA, October 2020. ACM, <https://dl.acm.org/doi/10.1145/3419394.3423621>.

12 Mobile and Wireless

Class Week 14 (Nov. 20 and Nov. 22): **No Class Nov. 22 due to the Thanksgiving Holiday.**

Wifi wireless networks: [Aguayo04a]

- P41.** [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, <https://doi.org/10.1145/1015467.1015482>.

5G: [Narayanan21a]

- P42.** [Narayanan21a] Arvind Narayanan, Xumiao Zhang, Ruiyang Zhu, Ahmad Hassan, Shuwei Jin, Xiao Zhu, Xiaoxuan Zhang, Denis Rybkin, Zhengxuan Yang, Z. Morley Mao, Feng Qian, and Zhi-Li Zhang. A variegated look at 5G in the wild: Performance, power, and QoE implications. In *Proceedings of the ACM SIGCOMM Conference*, pages 610–626, Virtual, August 2021. ACM, <https://doi.org/10.1145/3452296.3472923>.

Covid: [Lutu20a]

- P43.** [Lutu20a] Andra Lutu, Diego Perino, Marcelo Bagnulo, Enrique Frias-Martinez, and Javad Khangosstar. A characterization of the COVID-19 pandemic impact on a mobile network operator traffic. In *Proceedings of the ACM Internet Measurement Conference*, pages 19–33, Pittsburgh, PA, USA, October 2020. ACM, <https://doi.org/10.1145/3419394.3423655>.

What’s inside your mobile provider? Regional access topologies: [Zhang21b]

- P44.** [Zhang21b] Zesen Zhang, Alexander Marder, Ricky Mok, Bradley Huffaker, Matthew Luckie, K C Claffy, and Aaron Schulman. Inferring regional access network topologies: methods and applications. In *Proceedings of the ACM Internet Measurement Conference*, Virtual Event, November 2021. ACM, <https://doi.org/10.1145/3487552.3487812>.

13 Catch up and Hitlists

Class Week 15 (Nov. 27) and (Nov. 27)

We will have this week to catch up on any pending papers.

If we have time, we will cover these two papers:

IPv4 hitlists: [Fan10a]

- P45.** [Fan10a] Xun Fan and John Heidemann. Selecting representative IP addresses for Internet topology studies. In *Proceedings of the ACM Internet Measurement Conference*, pages 411–423, Melbourne, Australia, November 2010. ACM, <http://dx.doi.org/10.1145/1879141.1879195>.

IPv6 hitlists: [Gasser18a]

- P46.** [Gasser18a] Oliver Gasser, Quirin Scheitle, Pawel Foremski, Qasim Lone, Maciej Korczynski, Stephen D. Strowes, Luuk Hendriks, and Georg Carle. Clusters in the expanse: Understanding and unbiassing IPv6 hitlists. In *Proceedings of the ACM Internet Measurement Conference*, page to appear, Boston, Mass., USA, October 2018. ACM, <https://doi.org/10.1145/3278532.3278564>.

Supplemental: IP address assignment policies: [Padmanabhan20a]

- S17.** [Padmanabhan20a] Ramakrishna Padmanabhan, John P. Rula, Philipp Richter, Stephen D. Strowes, and Alberto Dainotti. DynamIPs: Analyzing address assignment practices in IPv4 and IPv6. In *Proceedings of the ACM Conference on Emerging Networking Experiments and Technologies*, pages 55–70, Barcelona, Spain, December 2020. ACM, <https://doi.org/10.1145/3386367.3431314>.

Poster Session: we will have a poster session research projects on Nov. 29.

14 Final Exam

The final exam is ~~Monday, December 11, 8am–10am~~ **Friday, December 8, 11am-1pm.**