CS551 Syllabus—Spring 2003, Friday Section

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January 16, 2003

Class meets Friday, 9am to 11:15am, beginning January 17 and ending May 2. Spring break is March 21 and the the stop period does not intersect classroom days. The date and time of the final is Friday, May 9, at 8-10am.

Changes: This syllabus may be updated over the semester. The most recent version can always be found at `http://www.isi.edu/~johnh/WORK/CS551/SP2003/SYLLABUS` (html) and `http://www.isi.edu/~johnh/WORK/CS551/SP2003/SYLLABUS/paper.pdf` (pdf).

16-Jan-03: year in title corrected (oops :-).

Obtaining these papers: All of these papers are available from the CSci551 web syllabus (see URL above) in PDF format. Because they are copyrighted they are available only for classroom use. The papers on the web site are password protected to enforce this; the password will be given to you on the first day of class, or e-mail the TA to ask about it.

You are encouraged to download and print the papers. Downloaded they take up about 95MB storage. Because there are many papers and many, many pages, you are *strongly* encouraged 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 paper do not display well in Acrobat on the screen, but they all should look reasonable when printed.

1 Reference and background

Supplementary:

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. The Stevens book is a very good for socket programming and may be useful for the projects. (The Stevens *TCP/IP Illustrated* books are also excellent references relating the RFCs to the BSD code, but are less useful for class.)

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

[2. Stevens97b] W. Richard Stevens. *Unix Network Programming: Volume 1: Networking APIs, Sockets*. Prentice-Hall, 1997.

Class 1 (Jan. 17): intro and background.

Papers: [Hanson99a, Jamin97b, Levin83a]

[3. Hanson99a] Michael J. Hanson. Efficient reading of papers in science. Brochure of unknown origin, revised 1999 by Dylan J. McNamee, 1989. [class PDF copy]

[4. Jamin97b] Sugih Jamin. Paper reading check list. web page `http://irl.eecs.umich.edu/jamin/courses/eecs589/papers/checklist.html`, 1997. [class PDF copy]

[5. 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. [class PDF copy]

2 Design principles

Class 2 (Jan. 24): network design principles. The end-to-end argument. Caching. Addressing.

Papers. Primary: [Clark88a, Deering98a, Saltzer81a, Saltzer82a]

[6. 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 PDF copy]

[7. Deering98a] Steve Deering. Watching the waist of the protocol hourglass. Keynote address at ICNP '98, October 1998. [class PDF copy]

[8. 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. [class PDF copy]

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

Supplementary: [Lampson83a, Tichy98a]

[10. Lampson83a] Butler Lampson. Hints for computer system design. In *Proceedings of the 9th Symposium on Operating Systems Principles*, pages 33–48, Bretton Woods, New Hampshire, October 1983. ACM. [class PDF copy]

[11. Tichy98a] Walter F. Tichy. Should computer scientists experiment more? *IEEE Computer*, 31(5):32–40, May 1998. [class PDF copy]

3 Unicast Routing

Class 3 (Jan. 31): Unicast routing principles. Link-state and distance verctor routing. The importance of hierarchy.

primary: [Papadopoulos00a, Tsuchiya88a, Labovitz00a]

[12. Papadopoulos00a] Christos Papadopoulos and Ramesh Govindan. Intra-domain routing. (Slides for USC CSci551), 2000. [class PDF copy]

[13. Tsuchiya88a] Paul F. Tsuchiya. The landmark hierarchy: A new hierarchy for routing in very large networks. In *Proceedings of the ACM SIGCOMM Conference*, pages 128–134, Stanford, CA, USA, August 1988. ACM. [class PDF copy]

[14. Labovitz00a] Craig Labovitz, Abha Ahuja, Abhijit Abose, and Farnam Jahanian. Delayed Internet routing convergence. In *Proceedings of the ACM SIGCOMM Conference*, pages 175–187, Stockholm, Sweeden, August 2000. ACM. [class PDF copy]

Supplementary: [Rekhter95a, Floyd94b, Stewart99a]

[15. Rekhter95a] Y. Rekhter and T. Li. A border gateway protocol 4 (BGP-4). RFC 1771, Internet Request For Comments, March 1995. [class PDF copy]

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

[17. Stewart99a] John W. Stewart. *BGP4 Inter-Domain Routing in the Internet*. Addison-Wesley, 1999.

Other references: `http://www.academ.com/nanog/feb1997/BGPTutorial/` and `http://www.ittc.ku.edu/EECS/EECS_800.ira/bgp_tutorial/`

Class 4 (Feb. 7): Routing convergence and osciallation. Policy routing.

primary: [Gao00b, Shaikh00a, Gao02a]

[18. Gao00b] Lixin Gao and Jennifer Rexford. Stable Internet routing without global coordination. In *Proceedings of the ACM SIGMETRICS*, pages 307–317, Santa Clara, CA, USA, June 2000. ACM. [class PDF copy]

[19. 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. [class PDF copy]

[20. Gao02a] Lixin Gao. On inferring automonous system relationships in the internet. *ACM/IEEE Transactions on Networking*, 9(6):733–745, December 2001. [class PDF copy]

Supplementary: [Tangmunarunkit01a]

[21. Tangmunarunkit01a] Hongsuda Tangmunarunkit, Ramesh Govindan, and Scott Shenker. Internet path inflation due to policy routing. In *Proceedings of the SPIE ITCom*, pages 188–195, Denver, CO, USA, August 2001. SPIE. [class PDF copy]

4 TCP, Congestion Control, and Queue Management

Class 5 (Feb. 14):TCP, congestion control, TCP variants including SACK and ECN.

primary: [Jacobson88a, Padhye98a, Fall96a, Ramakrishnan90a, Floyd99b]

[22. Jacobson88a] Van Jacobson. Congestion avoidance and control. In *Proceedings of the SIGCOMM '88*, pages 314–329, Stanford, California, August 1988. ACM. [class PDF copy]

[23. Padhye98a] J. Padhye, V. Firoiu, D. Towsley, and J. Kurose. Modeling 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 PDF copy]

[24. Fall96a] K. Fall and Sally Floyd. Simulation-based comparisons of Tahoe, Reno, and SACK TCP. *ACM Computer Communication Review*, 26(3):5–21, July 1996. [class PDF copy]

[25. 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. [class PDF copy]

[26. Floyd99b] Sally Floyd and Kevin Fall. Promoting the use of end-to-end congestion control in the Internet. *ACM/IEEE Transactions on Networking*, 7(4):458–473, August 1999. [class PDF copy]

Supplementary: [Postel81b, Allman99c, Floyd99a, Ramakrishnan99a]

[27. Postel81b] Jon Postel. Transmission control protocol. RFC 793, Internet Request For Comments, September 1981. [class PDF copy]

[28. Allman99c] M. Allman, V. Paxson, and W. Stevens. TCP congestion control. RFC 2581, Internet Request For Comments, April 1999. [class PDF copy]

[29. Floyd99a] S. Floyd and T. Henderson. The NewReno modification to TCP's fast recovery algorithm. RFC 2582, Internet Request For Comments, April 1999. [class PDF copy]

[30. Ramakrishnan99a] K. Ramakrishnan and S. Floyd. A proposal to add explicit congestion notification (ECN) to IP. RFC 2481, Internet Request For Comments, January 1999. [class PDF copy]

Class 6 (Feb. 21): TCP follow-up and queue management. Fair queueing.

primary: [Demers89a, Floyd93a]

[31. Demers89a] Alan Demers, Srinivasan Keshav, and Scott Shenker. Analsysis and simulation of a fair queueing algorithm. In *Proceedings of the ACM SIGCOMM Conference '89*, pages 1–12, Austin, Texas, September 1989. ACM. [class PDF copy]

[32. 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 PDF copy]

5 Differentiated and Integrated Services

Class 7 (Feb. 28): QoS. Admission control. Multimedia.

primary: [Clark92a, Shenker95a, Clark98a, Nichols99a]

[33. Clark92a] D. D. Clark, S. Shenker, and L. Zhang. Supporting real-time applications in an integrated services packet network: Architecture and mechanism. In *Proceedings of the ACM SIGCOMM Conference*, pages 14–26, Baltimore, MD, October 1992. ACM. [class PDF copy]

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

[35. Clark98a] David D. Clark and Wenjia Fang. Explicit allocation of best-effort packet delivery service. *ACM/IEEE Transactions on Networking*, 6(4):362–373, August 1998. [class PDF copy]

[36. Nichols99a] K. Nichols, V. Jacobson, and L. Zhang. A two-bit differentiated services architecture for the Internet. RFC 2638, Internet Request For Comments, July 1999. [class PDF copy]

Supplementary: [Hardman98a, Blake98a, Zhang93a]

[37. Hardman98a] Vicky Hardman, Martina Angela Sasse, and Isidor Kouvelas. Successful multiparty audio communication over the Internet. *Communications of the ACM*, 41(5):74–80, May 1998. [class PDF copy]

[38. Blake98a] S. Blake, D. Black, M. Carlson, E. Davies, and W. Weiss Z. Wang. An architecture for differentiated service. RFC 2475, Internet Request For Comments, December 1998. [class PDF copy]

[39. Zhang93a] L. Zhang, S. Deering, D. Estrin, and D. Zappala. RSVP: A new resource ReSerVation Protocol. *IEEE Network Magazine*, pages 8–18, September 1993. [class PDF copy]

6 Network Performance Modeling

Class 8 (Mar. 7): Self-similarity. Route stability. Topology.

Primary: [Leland94a, Paxson99b, Crovella97a]

[40. 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. [class PDF copy]

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

[42. 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. [class PDF copy]

Supplementary: [Willinger98a, Faloutsos99a, Balachandran02b]

[43. Willinger98a] W. Willinger and V. Paxson. Where mathematics meets the Internet. *Notices of the American Mathematical Society*, 45(8):961–970, August 1998. [class PDF copy]

[44. Faloutsos99a] Michalis Faloutsos, Petros Faloutsos, and Christos Faloutsos. On power-law relationships of the internet topology. In *Proceedings of the ACM SIGCOMM Conference*, pages 251–262, Cambridge, MA, USA, September 1999. ACM. [class PDF copy]

[45. Balachandran02b] Anand Balachandran, Goeffrey M. Voelker, Paramvir Bahl, and Venkat Rangan. Characterizing user behavior and network performance in a public wireless LAN. In *Proceedings of the ACM SIGMETRICS*, pages 195–205, Marina del Rey, CA, USA, June 2002. ACM. [class PDF copy]

7 Midterm

Class 9 (Mar. 14): **midterm exam**

8 Wireless and Mobile Networking

Class 10 (Mar. 28): Basestations. Mobile IP. Ad hoc routing. Performance optimizations: TCP packet replay and connection splicing.

[Bharghavan94a, Johnson96b, Johnson96c, Balakrishnan95b]

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

[47. Johnson96b] David B. Johnson. *Scalable Support for Transparent Mobile Host Internetworking, in Mobile Computing*, chapter 3, pages 103–128. Kluwer Academic Publishers, 1996. in Mobile Computing, edited by Tomasz Imielinski and Hank Korth. [class PDF copy]

[48. Johnson96c] David B. Johnson and David A. Maltz. *Dynamic Source Routing in Ad Hoc Wireless Networks*, chapter 5, pages 153–181. Kluwer Academic Publishers, 1996. in Mobile Computing, edited by Tomasz Imielinski and Hank Korth. [class PDF copy]

[49. Balakrishnan95b] H. Balakrishnan, S. Seshan, and R. Katz. Improving reliable transport and handoff performance over wireless networks. *Wireless Networks Journal*, 1(4):469–481, December 1995. [class PDF copy]

9 Peer-to-peer Communication

Class 11 (Mar. 29): Peer-to-peer storage and search. Stealing content.

[Clarke00a, Stoica00a, Ratnasamy02b]

[50. Clarke00a] Ian Clarke, Oskar Sandberg, Brandon Wiley, and Theodore W. Hong. Freenet: A distributed anonymous information storage retrieval system. In *Proceedings of the ICSI Workshop on Design Issues in Anonymity and Unobservability*, Berkeley, CA, USA, July 2000. [class PDF copy]

[51. 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*, Stockholm, Sweden, September 2000. ACM. [class PDF copy]

[52. Ratnasamy02b] Sylvia Ratnasamy, Brad Karp, Li Yin, Fang Yu, Deborah Estrin, Ramesh Govindan, and Scott Shenker. GHT: A geographic hash table for data-centric storage. In *Proceedings of the ACM Workshop on Sensor Networks and Applications*, pages 78–87, Atlanta, Georgia, USA, September 2002. ACM. [class PDF copy]

10 Web Protocols and Caching

Class 12 (Apr. 4): HTTP/1.0 and HTTP/1.1. Caching and cache consistency. Service location.

[Padmanabhan95a, Wolman99a]

[53. Padmanabhan95a] Venkata N. Padmanabhan and Jeffrey C. Mogul. Improving HTTP latency. In *Proceedings of the Second International World Wide Web Conference*, October 1994. [class PDF copy]

[54. Wolman99a] Alec Wolman, Geoffrey M. Voelker, Nitin Sharma, Neal Cardwell, Anna Karlin, and Henry M. Levy. On the scale and performance of cooperative web proxy caching. In *Proceedings of the 17th Symposium on Operating Systems Principles*, pages 16–31, Kiawah Island, SC, USA, December 1999. ACM. [class PDF copy]

Supplementary: [Fan98a, Freier96a]

[55. Fan98a] Li Fan, Pei Cao, Jussara Almeida, and Andrei Broder. Summary cache: A scalable wide-area web cache sharing protocol. In *Proceedings of the ACM SIGCOMM Conference*, pages 254–265, Vancouver, Canada, September 1998. ACM. [class PDF copy]

[56. Freier96a] Alan O. Freier, Philip Karlton, and Paul C. Kocher. The SSL protocol version 3.0. Work in progress (Internet draft draft-freier-ssl-version3-02.txt), November 1996. [class PDF copy]

11 Multicast Routing

Class 13 (Apr. 11): Multicast routing: flood-and-prune, rendezvous, source-specific.

primary: [Deering88b, Deering96a, Holbrook99a]

[57. 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. [class PDF copy]

[58. Deering96a] Stephen Deering, Deborah L. Estrin, Dino Farinacci, Van Jacobson, Ching-Gung Liu, and Liming Wei. The PIM architecture for wide-area multicast routing. *ACM/IEEE Transactions on Networking*, 4(2):153–162, April 1996. [class PDF copy]

[59. Holbrook99a] Hugh W. Holbrook and David R. Cheriton. IP multicast channels: EXPRESS support for large-scale single-source applications. In *Proceedings of the ACM SIGCOMM Conference*, pages 65–78, Cambridge, MA, USA, September 1999. ACM. [class PDF copy]

Supplementary: [Deering89a, Fenner97a, Estrin98c]

[60. Deering89a] S. Deering. Host extensions for IP multicasting. RFC 1112, Internet Request For Comments, August 1989. [class PDF copy]

[61. Fenner97a] W. Fenner. Internet group management protocol, version 2. RFC 2236, Internet Request For Comments, November 1997. [class PDF copy]

[62. Estrin98c] D. Estrin, D. Farinacci, A. Helmy, D. Thaler, S. Deering, M. Handley, V. Jacobson, C. Liu, P. Sharma, and L. Wei. Protocol independent multicast-sparse mode (pim-sm): Protocol specification. RFC 2362, Internet Request For Comments, June 1998. [class PDF copy]

March 15: Spring break, no class.

12 Multicast Transport and Applications

Class 14 (Apr. 18): Reliable multicast (SRM, bulk file transfer). Multicast video/audio and real-time multimedia.

[Floyd97c, McCanne96a]

[63. 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. [class PDF copy]

[64. McCanne96a] S. McCanne, V. Jacobson, and M. Vetterli. Receiver-driven layered multicast. In *Proceedings of the ACM SIGCOMM Conference '96*, pages 117–130, Stanford, CA, August 1996. ACM. [class PDF copy]

Supplementary: [Bolot98a, Schulzrinne96a]

[65. Bolot98a] 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 58–68, Vancouver, Canada, September 1998. ACM. [class PDF copy]

[66. Schulzrinne96a] H. Schulzrinne. RTP profile for audio and video conferences with minimal control. RFC 1890, Internet Request For Comments, April 1996. [class PDF copy]

13 Current topics

Class 15 (Apr. 25): Active networking. Sensor networking. Ubiqutious computing.

[Calvert98a, Intanagonwiwat00a, Waldo99a]

[67. Calvert98a] Kenneth L. Calvert, Samrat Bhattacharjee, Ellen Zegura, and James Sterbenz. Directions in active networks. *IEEE Communications Magazine*, 36(10):72–78, October 1998. [class PDF copy]

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

[69. Waldo99a] Jim Waldo. The Jini architecture for network-centric computing. *Communications of the ACM*, 42(10):76–82, October 1999. [class PDF copy]

Class 16 (May 2): Distributed denial-of-service. Overlay networks. Content-addressable networking.

[Savage00a, Andersen01a]

[70. Savage00a] Stefan Savage, David Wetherall, Anna Karlin, and Tom Anderson. Practical network support for IP traceback. In *Proceedings of the ACM SIGCOMM Conference*, pages 295–306, Stockholm, Sweeden, August 2000. ACM. [class PDF copy]

[71. Andersen01a] David G. Andersen, Hari Balakrishnan, M. Frans Kaashoek, and Robert Morris. Resilient overlay networks. In *Proceedings of the Symposium on Operating Systems Principles*, pages 131–145, Chateau Lake Louise, Alberta, Canada, October 2001. ACM. [class PDF copy]

14 Security (supplementary)

Supplementary: Unfortunately there is not time to talk about security and network protocols in CSci551. CSci555 provides a good coverage of security from an operating systems perspective. Students not taking that course may be interested in these supplementary papers and topics:

Threat models and encryption. SSL and IPsec. Key exchange. Firewalls.

Supplementary: [Voydock83a, Needham78a, Freier96a]

[72. Voydock83a] V. L. Voydock and S. T. Kent. Security mechanisms in high-level network protocols. *ACM Computing Surveys*, 15(2):135–171, June 1983. [class PDF copy]

[73. Needham78a] Roger M. Needham and Michael D. Schroeder. Using encryption for authentication in large networks of computers. *Communications of the ACM*, 21(12):993–999, December 1978. [class PDF copy]

[Freier96a] see above.

(Please note: some of Voydock is too detailed and out of date. I suggest you omit or skim sections 3.4, 4, and 6.2.*.)