CS551 Syllabus—Spring 2006, Thursday Section

John Heidemann

December 1, 2006

Class meets Thursday, 9am to 11:50am, beginning January 12 and ending April 27 Spring break is March 16 and the the stop period does not intersect classroom days. The date and time of the final is Tuesday, May 9, 8–10am.

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

8-Dec-05: no changes yet

18-Jan-06: fix date of class spring break.

Obtaining these papers: All of these papers are available from the CSci551 wiki site (see URL above) in PDF format. Because they are copyrighted they are available only for classroom use. The wiki sites is only available to students with wiki-specific accounts to enforce this; to get an account, go to `http://www.isi.edu/~johnh/cs551.html` and follow the instructions, or contact the professor or TA.

You are encouraged to download and print the papers. Downloaded they take up about 95MB storage. You're encouraged to print them out and make notes on them as you go. 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 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 costs of reproduction), 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 comparing what's different relative to the last section of CSci551 I taught.

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.

General background about networking: [Peterson00a]

[S1. Peterson00a] Larry L. Peterson and Bruce S. Davie. *Computer Networks: A Systems Approach*. Morgan Kaufmann Publishers, 2000.

[S2. Stevens97b] W. Richard Stevens. *Unix Network Programming: Volume 1: Networking APIs, Sockets*. Prentice-Hall, 1997.

(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 (Jan. 12):

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 [Jamin97b]

[P2. Jamin97b] Sugih Jamin. Paper reading check list. web page `http://irl.eecs.umich.edu/jamin/courses/eecs589` 1997.

What to look for in a paper: [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.

2 Design principles

Class 2 (Jan. 19):

Primary: The Internet architecture: [Clark88a]

[P4. 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.

The Internet architecture, 10 years later: [Deering98a]

[P5. Deering98a] Steve Deering. Watching the waist of the protocol hourglass. Keynote address at ICNP '98, October 1998.

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.

Supplementary: More about the end-to-end argument: [Blumenthal01a]

[S3. Blumenthal01a] Marjory S. Blumenthal and David D. Clark. Rethinking the design of the Internet: the end-to-end arguments vs. the brave new world. *ACM Transactions on Internet Technology*, 1(1):70–109, August 2001.

How "tussles" affect network architecture: [Clark02a]

[S4. 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 3 (Jan. 26):

Primary:

Review of unicast and distance vector routing: [Papadopoulos00a]

[P8. Papadopoulos00a] Christos Papadopoulos and Ramesh Govindan. Intra-domain routing. (Slides for USC CSci551), 2000.

Stranger kinds of routing: [Tsuchiya88a]

[P9. 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.

Potential routing problems: [Labovitz00a]

[P10. 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.

Supplementary: Supplement with detailed BGP information: [Stewart99a]

[S5. Stewart99a] John W. Stewart. *BGP4 Inter-Domain Routing in the Internet*. Addison-Wesley, 1999.

Synchronization as a pervasive problem, demonstrated here in routing: [Floyd94b]

[S6. Floyd94b] S. Floyd and V. Jacobson. The synchronization of periodic routing messages. *ACM/IEEE Transactions on Networking*, 2(2):122–136, April 1994.

NEW: Historical perspective on Internet routing: [Narten89a]

[S7. Narten89a] Thomas Narten. Internet routing. In *Proceedings of the ACM SIGCOMM Conference*, pages 271–282, Austin, Texas, USA, September 1989. ACM.

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

Class 4 (Feb. 2):

Primary:

Routing stability and oscialliation: [Shaikh00a]

[P11. 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.

Routng hierarchicy and policy: [Gao02a]

[P12. Gao02a] Lixin Gao. On inferring automonous system relationships in the internet. *ACM/IEEE Transactions on Networking*, 9(6):733–745, December 2001.

Supplementary: Consider the impacts of policy on routing: [Tangmunarunkit01a]

[S8. 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.

Classic cases where peerings result in oscillations: [Griffin99a]

[S9. 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.

4 Transport protocols, Congestion Control, and Queue Management

Class 5 (Feb. 9):

Primary: Congestion control from first principles: [Ramakrishnan90a]

[P13. 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.

TCP and congestion control: [Jacobson88a]

[P14. Jacobson88a] Van Jacobson. Congestion avoidance and control. In *Proceedings of the ACM SIGCOMM Conference*, pages 314–329, Stanford, California, USA, August 1988. ACM.

Modeling TCP: [Padhye98a]

[P15. 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.

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

[S10. Cerf74a] Vint Cerf and Robert Kahn. A protocol for packet network interconnection. *IEEE Transactions on Communications*, COM-22(5):637–648, May 1974.

Explicit congestion notification (a version of adding DECbit to the Internet): [Ramakrishnan99a]

[S11. Ramakrishnan99a] K. Ramakrishnan and S. Floyd. A proposal to add explicit congestion notification (ECN) to IP. RFC 2481, Internet Request For Comments, January 1999.

NEW: A recent look at a two-bit feedback from routers: [Xia05a]

[S12. Xia05a] Yong Xia, Lakshminarayanan Subramanian, Ion Stoica, and Shivkumar Kalyanaraman. One more bit is enough. In *Proceedings of the ACM SIGCOMM Conference*, pages 37–48, Philadelphia, PA, USA, August 2005. ACM.

An alternative, delay-based approach to detect congestion (current research uses the similar "FAST TCP"): [Brakmo94a]

[S13. Brakmo94a] L. S. Brakmo, S. W. O'Malley, and L. L. Peterson. TCP Vegas: New techniques for congestion detection and avoidance. In *Proceedings of the ACM SIGCOMM Conference*, pages 24–35. ACM, September 1994.

Class 6 (Feb. 16): TCP follow-up. XCP and other transport protocols. Queue management. Fair queueing.

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

[P16. Demers89a] Alan Demers, Srinivasan Keshav, and Scott Shenker. Analysis and simulation of a fair queueing algorithm. In *Proceedings of the ACM SIGCOMM Conference '89*, pages 1–12, Austin, Texas, September 1989. ACM.

Random early detection: [Floyd93a]

[P17. Floyd93a] Sally Floyd and Van Jacobson. Random early detection gateways for congestion avoidance. *ACM/IEEE Transactions on Networking*, 1(4):397–413, August 1993.

XCP and non-TCP congeston control: [Katabi02a]

[P18. 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.

What characeristic should we have in a network? [Floyd99b]

[P19. 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.

5 Differentiated and Integrated Services

Class 7 (Feb. 23):

Primary: Quality of service and admission control: [Shenker95a]

[P20. Shenker95a] Scott Shenker. Fundamental design issues for the future internet. *IEEE Journal of Selected Areas in Communication*, 13(7):1176–1188, September 1995.

Lighter-weight QoS: [Stoica03a]

[P21. 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.

Supplementary: Resource reservation and RSVP: [Zhang93a]

[S14. Zhang93a] L. Zhang, S. Deering, D. Estrin, and D. Zappala. RSVP: A new resource ReSerVation Protocol. *IEEE Network Magazine*, pages 8–18, September 1993.

6 Wireless and Mobile Networking

Class 8 (Mar. 2):

Primary:

Ad hoc routing: [Johnson96c]

[P22. 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.

Non-IP routing in sensor networks: [Intanagonwiwat00a]

[P23. 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.

MAC protocols: [Bharghavan94a]

[P24. 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.

Wireless propgation characteristics: [Aguayo04a]

[P25. 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.

Supplementary: NEW TCP interactions with wireless: [Balakrishnan97c]

[S15. Balakrishnan97c] Hari Balakrishnan, Venkata N. Padmanabhan, and Randy H. Katz. The effects of asymmetry on TCP performance. In *Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking*, pages 77–89, Budapest, Hungary, September 1997. ACM.

Resource discovery: [Waldo99a]

[S16. Waldo99a] Jim Waldo. The Jini architecture for network-centric computing. *Communications of the ACM*, 42(10):76–82, October 1999.

A survey of sensor net research: [Heidemann04a]

[S17. Heidemann04a] John Heidemann and Ramesh Govindan. An overview of embedded sensor networks. Technical Report ISI-TR-2004-594, USC/Information Sciences Institute, November 2004. book chapter to appear in *Handbook of Networked and Embedded Control Systems*, D. Hristu-Varsakelis and W.S. Levine, editors, Springer-Verlag, 2004.

7 Midterm and Spring Break

Class 9 (Mar. 9): **midterm exam** The midterm exam will be half of the class period, with lecture the other half.

Spring break: March 16, no class.

8 Modeling Network Traffic

Class 10 (Mar. 23):

Primary:

Self-similarity in LAN traffic: [Leland94a]

[P26. 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]

[P27. 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.

Packet-level network dynamics: [Paxson99b]

[P28. Paxson99b] Vern Paxson. End-to-end Internet packet dynamics. *ACM/IEEE Transactions on Networking*, 7(3):277–292, June 1999.

Internet topology: [Li04a]

[P29. Li04a] Lun Li, David Alderson, Walter Willinger, and John Doyle. A first-principles approach to understanding the Internet's router-level topology. In *Proceedings of the ACM SIGCOMM Conference*, pages 3–14, Portland, Oregon, USA, August 2004. ACM.

Supplementary: More information about potential causes of self-similarity: [Feldmann99a]

[S18. Feldmann99a] Anja Feldmann, Anna C. Gilbert, Polly Huang, and Walter Willinger. Dynamics of IP traffic: A study of the role of variability and the impact of control. In *Proceedings of the ACM SIGCOMM Conference*, pages 301–313, Cambridge, MA, USA, August 1999. ACM.

9 Web Protocols and Caching

Class 11 (Mar. 30):

Primary: HTTP and TCP: [Padmanabhan95a]

[P30. Padmanabhan95a] Venkata N. Padmanabhan and Jeffrey C. Mogul. Improving HTTP latency. In *Proceedings of the Second International World Wide Web Conference*, October 1994.

Web cachng and cache consistency: [Wolman99a]

[P31. 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.

Supplementary: Transport Layer Security (used in https): [Dierks99a]

[S19. Dierks99a] T. Dierks and C. Allen. The TLS protocol, version 1.0. RFC 2246, Internet Request For Comments, January 1999. (Transport Layer Security).

10 Multicast Routing, Transport, and Applications

Class 12 (Apr. 6):

Primary:

Multicast routing: flood-and-prune, rendezvous: [Deering88b]

[P32. 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.

An alternate take at multicast: [Holbrook99a]

[P33. 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.

Multicast video/audio and real-time multimedia.

Primary:

Reliable multicast and SRM: [Floyd97c]

[P34. 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]

[P35. 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.

Supplementary: Multicast at the application layer: [Chu02b]

[S20. Chu02b] Yang hua Chu, Sanjay G. Rao, Srinivasan Seshan, and Hui Zhang. A case for end system multicast. *IEEE Journal of Selected Areas in Communication*, 20(8):1456–1471, October 2002.

Multicast and congestion control via layering: [McCanne96a]

[S21. 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.

Multimedia: [Bolot98a]

[S22. 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.

11 Security

Class 13 (Apr. 13):

Primary: Denial of service attacks: [Hussain03b]

[P36. 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.

Worms and viruses: [Moore03a]

[P37. Moore03a] David Moore, Colleen Shannon, Geoffrey M. Voelker, and Stefan Savage. Internet quarantine: Requirements for containing self-propagating code. In *Proceedings of the IEEE Infocom*, pages 1901–1910, San Francisco, CA, USA, March 2003. IEEE.

Supplementary: IP traceback: [Snoeren01b]

[S23. Snoeren01b] Alex C. Snoeren, Craig Partridge, luis A. Sanchez, Christine E. Jones, Fabrice Tchakountio, Stephen T. Kent, and W. Timothy Strayer. Hash-based IP traceback. In *Proceedings of the ACM SIGCOMM Conference*, pages 3–14, San Diego, California, USA, August 2001. ACM.

Worm propagation: [Staniford02a]

[S24. Staniford02a] Stuart Staniford, Vern Paxson, and Nicholas Weaver. How to own the internet in your spare time. *Proceedings of the 11th USENIX Security Symposium*, pages 149–167, August 2002.

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; see the papers by Voydock and Kent and Needham and Schroder there.

12 Peer-to-peer storage

Class 14 (Apr. 20):

Primary:

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

[P38. 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.

Efficient peer-to-peer storage: [Stoica00a]

[P39. 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.

Geographical peer-to-peer storage: [Ratnasamy02b]

[P40. 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.

13 Current topics

Class 15 (Apr. 27):

Primary:

Peer-to-peer traffic loads and self-similarity: [Gummadi03a]

[P41. Gummadi03a] Krishna P. Gummadi, Richard J. Dunn, Stefan Saroiu, Steven D. Gribble, Henry M. Levy, and John Zahorjan. Measurement, modelling, and analysis of a peer-to-peer file-sharing workload. In *Proceedings of the 19th Symposium on Operating Systems Principles*, pages 314–329, Bolton Landing, NY, USA, October 2003. ACM.

NEW traffic engineering: [Kandula05a]

[P42. Kandula05a] Srikanth Kandula, Dina Katabi, Bruce Davie, and Anna Charny. Walking the tightrope: Responsive yet stable traffic engineering. In *Proceedings of the ACM SIGCOMM Conference*, pages 253–264, Philadelphia, PA, USA, August 2005. ACM.

A crazy idea, or a busness model? [Wang04b]

[P43. Wang04b] Randolph Y. Wang, Sumeet Sobti, Nitin Garg, Elisha Ziskind, Junwen Lai, and Arvind Krishnamurthy. Turning the postal system into a generic digital communication mechanism. In *Proceedings of the ACM SIGCOMM Conference*, pages 159–166, Portland, Oregon, USA, August 2004. ACM.

Knowledge plane: [Clark03a]

[P44. Clark03a] David D. Clark, Craig Partridge, J. Christopher Ramming, and John T. Wroclawski. A knowledge plane for the Internet. In *Proceedings of the ACM SIGCOMM Conference*, pages 3–10, Karlsruhe, Germany, August 2003. ACM.

Supplementary: Overlay networks: [Andersen01a]

[S25. 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.

Traffic engineering: [Feldmann00a]

[S26. Feldmann00a] Anja Feldmann, Albert Greenberg, Carsten Lund, Nick Reingold, and Fred True Jennifer Rexford. Deriving traffic demands for operational IP networks: Methodology and experience. In *Proceedings of the ACM SIGCOMM Conference*, pages 257–270, Stockholm, Sweeden, August 2000. ACM.

Revisiting statistical multiplexing: [BenFredj01a]

[S27. BenFredj01a] S. Ben Fredj, T. Bonald, A. Proutiere, G. Régnié, and J. W. Roberts. Statistical bandwidth sharing: A study of congestion at flow level. In *Proceedings of the ACM SIGCOMM Conference*, pages 111–122, San Diego, CA, USA, August 2001. ACM.

14 Other Topics

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

Supplementary: Router design: [Partridge98a]

[S28. 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.

Optical networking: [Mukherjee00a]

[S29. Mukherjee00a] Biswanath Mukherjee. WDM optical communication networks: Progress and challenges. *IEEE Journal of Selected Areas in Communication*, 18(10):1810–1824, October 2000.