Srinivasan Keshav

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EDUCATION

Ph.D. in Computer Science, University of California at Berkeley *August 1991*
Thesis: *Congestion Control in Computer Networks*
Awarded the Sakrison Prize for the best dissertation in the EECS department

M.S. in Computer Science, University of California at Berkeley *August 1988*
Thesis: *Distributed Simulation Using REAL*

B.Tech. in Computer Science, Indian Institute of Technology, Delhi *May 1986*
Awarded the Director's Gold Medal for best allround performance

EMPLOYMENT RECORD

University of Waterloo, ***Professor*** *July 2008-*
University of Waterloo, ***Associate Professor*** *August 2003-June 2008*

My research goal is to exploit sound theoretical foundations to build robust systems for tetherless computing, a research area that spans smart mobile devices, wireless networks, and data-center –scale server clusters. My current interests are in the use of tetherless computing for rural development, and for gaining efficiency in energy generation, transmission, and consumption.

Over the past six years, I have built up strong and well-funded research program from scratch, helping to make Waterloo internationally known for its work in opportunistic communication, delay- and disconnection-tolerant networking, and the use of Information and Communications Technology for development.

Astilbe Networks Corp. *Co-founder and Director* *June 2007 -*

Astilbe commercializes work by my students and myself on opportunistic communication by mobile devices.

Ensim Corp. *Co-founder, CTO, General Manager, and Director* *June 1998 - July 2003*

Ensim's Operations Support System (OSS) software allows Internet service providers to host applications, primarily websites, scalably and profitably on behalf of small-to-midsize enterprises. Ensim raised over $85 million in venture funding from venture capital firms such as New Enterprise Associates and Worldview Ventures. From a handful of employees and a tiny office in Ithaca, NY Ensim has grown to 150 employees in the US and India. Ensim software today hosts over 1.5 million websites and 5 million mailboxes.

As co-founder I was involved with every aspect of Ensim's operations and at every stage in its development. My technical role was to provide architectural guidance to all of Ensim's products. I helped to architect a world class product line supported by 13 patents, of which I

am an inventor or co-inventor on eight. In addition, my non-technical roles included Business Unit Manager with profit and loss responsibility, Product Line Manager, Sales Engineer, Test Automation Engineer, Director of Quality Assurance, and Director of Information Technology.

GreenBorder Technologies Inc. *Co-Founder* *October 2000 - March 2007*

GreenBorder's software uses virtualization technology to proactively defend enterprise desktops from malware. I originated the idea that led to the formation of the company and helped raise its first round of funding of $2.4 million (the company subsequently raised $12 million in August 2002). I also contributed to the design of the company's product, its market positioning, and its patent strategy. GreenBorder was acquired by Google Inc. in March 2007.

Cornell University *Associate Professor* *August 1996 – June 1999*

I was instrumental in initiating a research and teaching program in computer networking at Cornell. In 1996, I created a graduate course on networking based on my textbook and taught the course in 1997 and 1998, each time to over 80 students. As part of the course, I led student teams in designing and implementing large-scale research projects. I also taught a graduate course on systems, and introductory courses on computer architecture and logic design. In recognition of my work, I was awarded the Fiona Ip Li '78 and Donald Li '75 Excellence in Teaching Award in 1998.

I founded and led the C/NRG (Cornell Network Research) group, working in the areas of Network Performance Management, Internet topology discovery, and Computer Telephony Integration. In Spring 1999, C/NRG consisted of seven Ph.D. students, one staff programmer, six masters students, and four undergraduates and had nearly $1,000,00 in research funding.

AT&T Bell Laboratories, *Member of Technical Staff* *August 1991 August 1996*

I was one of the 60 Members of Technical Staff at Center 1127. Over a period of five years, I participated in the design, implementation, testing, and performance tuning of Xunet II, a widearea highspeed ATM network testbed, and IDLInet, a PersonalComputer based ATM LAN that provided nativemode ATM connections. As part of this effort, I investigated several areas in traffic management and feedback congestion control. I ran some of the earliest (1993) and largest (twelve simultaneous video feeds) videoconferences over an IP network. I added Quality of Service (QoS) support to signaling, and helped design a scheduling architecture to allow per-virtual circuit QoS for Constant Bit Rate, Variable Bit Rate, and Available Bit Rate virtual circuits. Finally, I did some work in telepresence and low-bitrate video encoding.

In addition to research, I wrote a graduate-level textbook on an engineering approach to computer networking. Published by AddisonWesley Longman in May 1997, it has sold over 30,000 copies and is used at many leading universities around the world.

Columbia University, *Visiting Faculty* *September December 1995*

I taught a graduate course in computer networking in the Department of Electrical Engineering.

Indian Institute of Technology, Delhi, *Visiting Faculty*. *January May 1993*

I developed and taught a graduate course on computer networking and telephony. The

course is still taught more than fifteen years later.

UC Berkeley, *Graduate Research Associate* *August 1986 - August 1991*

I was a founding member of the TENET group led by Prof. Domenico Ferrari. I developed flow and congestion control policies for data traffic in high-speed networks (Advisor: Prof. D. Ferrari).

AT&T Bell Laboratories, Murray Hill, *Intern* *Summer 1989, Winter 1989, Summer 1990*

I was a consultant on network control for XUNET II and co-invented the Hierarchical Round Robin service discipline, for which U.S. patent 5,272,897 was awarded in December 1993.

Xerox PARC, *Intern* *Summer 1988 - Summer 1989*

I designed and built a packet-level network simulator, REAL, to realistically simulate large computer networks. I contributed to the design, analysis, and simulation of the Fair Queueing service discipline (with S. Shenker and A. Demers).

AWARDS AND HONORS

- Best Paper Award at the ACM MOBICOM 2009 Conference.
- NSERC Discovery Accelerator Supplement Award of $120,000, 2007-2010. Only 50 such awards were granted across all scientific disciplines in Canada.
- Awarded Test-of-time awards for **two** of my early papers by ACM SIGCOMM, 2006.
- Tier II Canada Research Chair in Tetherless Computing, 2004-2009. Only 1000 such chairs were awarded across all disciplines in Canada.
- Fiona Ip Li '78 and Donald Li '75 Excellence in Teaching Award, Cornell University, 1998.
- Alfred P. Sloan Fellow in Computer Science, 1997-1999. A total of 112 fellowships are awarded annually in seven fields: chemistry, computational and evolutionary molecular biology, computer science, economics, mathematics, neuroscience, and physics.
- ACM SIGCOMM selected two of my papers as among the ``... most important papers that have appeared in *Computer Communication Review* over the past 25 years,'' January 1995.
- Recipient of the Sakrison Prize, awarded annually for the best Ph.D. dissertation in the EECS department at UC Berkeley, 1992.
- Best Student Paper Award at the ACM SIGCOMM 1991 Conference.
- Director's Gold Medal for best allround performance in the graduating class, Indian Institute of Technology, Delhi, May 1986.
- Awarded the National Talent Scholarship by the Government of India, 1980-86. This is awarded annually to about 100 students selected from over 100,000 applicants.

AREAS OF RESEARCH INTEREST

Tetherless computing is a style of computing where smart mobile devices opportunistically communicate with centralized servers over heterogeneously administered wireless networks. It enables numerous applications that cheaply connect people to information sources and to each other. For example, it allows villagers in remote communities to gain Internet access by opportunistically using cars, buses, and trains that pass through. As another example, it allows users of 'smart phones' to receive email through cellular modems, but bulky email attachments opportunistically from nearby wireless access points.

The component elements of tetherless computing--broadband wireless networks, server clusters, and increasingly powerful mobile computing devices--are already in place or are rapidly becoming available. Yet many critical problems remain. Broadly speaking, computing systems built using these elements lack properties such as seamless connectivity, disconnection-tolerance, ability to use multiple network interfaces, ease of programming, and security. Indeed, what is missing is an infrastructure that is cost-effective, robust and efficient; an infrastructure that people can afford, yet trust with their data, their computing needs, and in some cases, their lives.

My research addresses the practical and theoretical problems involved in establishing the foundations of an affordable, efficient, secure and robust infrastructure for tetherless computing. I am also interested in applying my research to create novel applications, especially those that benefit rural communities in developing countries.

Within this context, my work spans the following research areas:

Opportunistic Communication

Opportunistic communication allows a mobile device to exploit a transient wireless connection to exchange data. My research group has studied the implications of opportunistic communication at every layer of the protocol stack, from the physical layer to the application layer. One focus of our work has been access to a roadside wireless Access Point from a moving vehicle. Another focus is the design and implementation of an architecture (the Opportunistic Communication Management Protocol layered over the Tetherless Communication Architecture) that allows a mobile device to opportunistically communicate with legacy servers in the Internet. Using OCMP, we support disconnected web browsing, disconnection-tolerant email, and opportunistic upload of blogs and images to blogger.com and flickr.com respectively. We are now working on location-aware applications. These applications are typically deployed on J2ME-based multi-NIC, smart, mobile devices.

Bus-and-Kiosk Networks (VLink)

Opportunistic communication enables kiosks in rural areas of developing countries to reliably and cheaply access the Internet using mechanical backhaul. We have built VLink that uses our system for opportunistic communication to deliver email to villagers using USB Keys and SMS. VLink is Free Open Source Software that can be downloaded from the Internet and works on both Windows and Linux.

Cellular Networks

Cellular networks and mobile phones will dominate the future Internet. My group has studied some implications of this fact in our work, and also some problems that arise when carrying data in cellular networks.

Wireless LANs

We have developed SMARTA, a centralized algorithm for wireless access point deployment and management that take both irregular coverage and dynamic changes in coverage area into account. We have also worked on automatic fault detection in such networks. Finally, we are looking into the effect of Software Defined Radio on future WLANs.

Networking Foundations

My work in non-traditional networks has led me to re-examine networking foundations and fundamentals and the development of an axiomatic basis for communication. With Martin Karsten, I am working on a meta-language that embodies these axioms, and can therefore be formally proved to be correct, yet can be compiled into efficient forwarding engines.

PUBLICATIONS

Note on author order**: Student co-authors appear first unless they are marginal contributors; peer co-authors are in order of relative contribution. * marks graduate students, ** PDFs, *** undergraduates, and * staff programmers.*

Refereed Journals

1. M.A. Zaharia*** and S. Keshav, Gossip-Based Algorithms for Efficient Search Selection, *Journal of Concurrency and Computation: Practice and Experience*, 2008 (14 pages)

2. L. Qiu, Y. Zhang, and S. Keshav, Understanding the Performance of Many TCP Flows. *Computer Networks*, 37(3-4):277-306, November 2001. (29 pages)

3. M. Grossglauser*, S. Keshav, and D. Tse, RCBR: A Simple and Efficient Service for Multiple TimeScale Traffic, *IEEE/ACM Transactions on Networking,* 5(6):741-755, December 1997. (15 pages)

4. A.E. Kaplan, S. Keshav, N.L. Schryer, and J.H. Venutolo, An Internet-accessible Telepresence, *ACM Multimedia Systems Journal*, 5(3):140-144, Summer 1997. (5 pages)

5. C.R. Kalmanek, S. Keshav, W.T. Marshall, S.P. Morgan, and R.C. Restrick, Xunet 2: Lessons from an Early WideArea ATM Testbed, *IEEE/ACM Transactions on Networking,* 5(1):40-55 April 1997. (16 pages)

6. R. Ahuja***, S. Keshav, and H. Saran, Design, Implementation, and Performance of a Native-Mode ATM Transport Protocol, *IEEE/ACM Transactions on Networking*, 4(4): 502-515, August 1996. (14 pages)

7. S. Keshav, C. Lund, S. Phillips, N. Reingold, and H. Saran, An Empirical Evaluation of Virtual Circuit Holding Time Policies in IPoverATM Networks, *IEEE Journal on Selected Areas in Communication,* 13(8):1371-1382 October 1995. (12 pages)

8. H. Saran, S. Keshav, and C.R. Kalmanek, A Scheduling Discipline and Admission Control Policy for Xunet 2, *ACM Multimedia Systems Journa*l, 2(3):89-101, September 1994. (13 pages)

9. *S. Keshav, On the Efficient Implementation of Fair Queueing, *Journal of Internetworking: Research and Experience*, 2(3):157-173, September 1991. (17 pages)

10. A. Demers, *S. Keshav and S. Shenker, Analysis and Simulation of a Fair Queueing Algorithm, *Journal of Internetworking Research and Experience*, 1(1):3-26, September 1990. (24 pages)

Magazine Articles

11. S. Keshav, "The Riches of White Space," Editorial in *The Mark News (online newspaper)*, October 2009 (2 pages).

12. S. Keshav, "The SIGCOMM Community," Editorial in *ACM SIGCOMM Computer Communication Review*, October 2009 (2 pages).

13. S. Keshav, "Statistics," Editorial in *ACM SIGCOMM Computer Communication Review*, July 2009 (2 pages).

14. S. Keshav, "Bubbles," Editorial in *ACM SIGCOMM Computer Communication Review*, April 2009 (2 pages).

15. J. Crowcroft, S. Keshav, and N. McKeown, Scaling the Academic Publication Process to Internet Scale, *Communications of the ACM*, January 2009 (3 pages).

16. S. Guo*, M.H. Falaki*, E.A. Oliver*, S. Ur Rahman*, A. Seth*, M.A. Zaharia**, and S. Keshav, Very Low-Cost Internet Access Using KioskNet, *ACM SIGCOMM Computer Communication Review*, 37(5):95-100, October 2007. (6 pages)

17. S. Keshav, How to Read a Paper, *ACM SIGCOMM Computer Communication Review*, 37 (3):83-84, July 2007. (2 pages)

18. S. Keshav, Efficient and Decentralized Computation of Approximate Global State, *ACM SIGCOMM Computer Communication Review*, 36(1):69-74, Jan. 2006. (6 pages)

19. S. Keshav, Why Cell Phones Will Dominate the Future Internet, *ACM SIGCOMM Computer Communication Review*, 35(2):83-86, April 2005. (4 pages)

20. S. Keshav, Blueprints for Web Hosting, *Web Hosting Magazine*, April 2001. (8 pages)

21. D. Bergmark**** and S. Keshav, Building Blocks for Internet Telephony, *IEEE Communications Magazine*, 37(4)4: 88-94, April 2000. (7 pages)

22. S. Keshav and *R. Sharma, Issues and Trends in Router Design, *IEEE Communications Magazine*, 36(5):144-151, May 1998. (8 pages)

23. S. Keshav, A Control-Theoretic Approach to Flow Control, *ACM SIGCOMM Computer Communication Review,* January 1995. **Appeared in the 25th Anniversary Special Issue on the "most important papers that have appeared in *Computer Communication Review* over the past 25 years."** (12 pages)

24. A. Demers, S. Keshav* and S. Shenker, Analysis and Simulation of a Fair Queueing Algorithm, *ACM SIGCOMM Computer Communication Review,* January 1995. **Appeared in the 25th Anniversary Special Issue on the "most important papers that have appeared in *Computer Communication Review* over the past 25 years."** (12 pages)

25. A. Berenbaum, M.J. Dixon**, A. Iyengar***, and S. Keshav, A Flexible ATM Host-Interface for Xunet 2, *IEEE Network Magazine*, 7(4):18-23, July 1993. (6 pages)

26. S. Keshav, Report on Workshop on Quality of Service Issues in High Speed Networks, *ACM SIGCOMM Computer Communication Review*, 22(5):74-85 October 1992. (10 pages)

Refereed Conferences and Workshops

27. V. Shrivastava*, N. Ahmed*, S. Rayanchu*, S. Banerjee, S. Keshav, K. Papagiannaki, A. Mishra. CENTAUR: Realizing the Full Potential of Centralized WLANs using a Hybrid Data Path. (**Best paper award winner**) , *ACM MobiCom*, Beijing, September 2009 (14 pages).

28. N. Ahmed*, U. Ismail*, S. Keshav, and K. Papagiannaki, Online Estimation of RF Interference, *Proc. ACM Conext,* Madrid, December 2008. (12 pages)

29. E. Oliver* and S. Keshav, Design Principles for Opportunistic Communication in Constrained Computing Environments, *Proc. MobiCom Workshop on Wireless Networks and Systems for Developing Regions (WiNS-DR*), San Francisco, September 2008. (6 pages)

30. S. Ur Rahman*, U. Hengartner, U. Ismail* and S. Keshav, Practical Security for Rural Internet, *Proc. of ACM SIGCOMM Workshop on Networked Systems for Developing Regions (NSDR 2008),* Seattle WA, August 2008. (6 pages)

31. J. Crowcroft, S. Keshav, and N. McKeown, Scaling Internet Research Publication Processes to Internet Scale, *Proc. Workshop on Organizing Workshops, Conferences, and Symposia in Computer Systems*, April 2008. (6 pages).

32. S. Guo* and S. Keshav, Fair and Efficient Scheduling in Data Ferrying Networks, *Proc. ACM CoNEXT 2007,* December 2007. (10 pages)

33. S. Guo*, M.H. Falaki*, E.A. Oliver*, S. Ur Rahman*, A. Seth*, M.A. Zaharia**, U. Ismail**, and S. Keshav Design and Implementation of the KioskNet System, *Proc. International Conference on Information Technologies and Development*, December 2007. (12 pages)

34. N. Ahmed*, V. Shrivastava*, A. Mishra***, S. Banerjee, S. Keshav, K. Papagiannaki, Interference Mitigation in Enterprise WLANs through Speculative Scheduling (Extended Abstract), *Proc. ACM Mobicom 2007*, September 2007. (6 pages)

35. M. Karsten, S. Keshav, S. Prasad, and O. Beg*, An Axiomatic Basis for Communication, *Proc. ACM SIGCOMM*, August 2007. (12 pages)

36. D. Hadaller*, S. Keshav, T. Brecht, S. Agarwal***, Vehicular Opportunistic Communication Under the Microscope, *Proc. ACM Mobisys*, June 2007. (14 pages)

37. M. Zaharia***, A. Chandel*, S. Saroiu, and S. Keshav, Finding Content in File-Sharing Networks When You Can't Even Spell, *Proc. ACM International Peer-to-Peer Symposium 2007*, Feb 2007. (8 pages)

38. M. Thomas*, A. Gupta, and S. Keshav, Group Based Routing in Disconnected Ad Hoc Networks, *Proc. 13th Annual IEEE International Conference on High Performance Computing*, December 2006. (12 pages)

39. N. Ahmed* and S. Keshav, SMARTA: Self-Management Architecture for Thin Access Points, *Proc. ACM CoNEXT,* December 2006. (12 pages)

40. M. Karsten, S. Keshav, and S. Prasad, An Axiomatic Basis for Communication, *Proc. ACM HOTNETS V,* November 2006. (6 pages)

41. N. Ahmed*, D. Hadaller*, and S. Keshav, GUESS: Gossiping Updates for Efficient Spectrum Sensing, *Proc. ACM MobiShare- 1st International Workshop on Decentralized Resource Sharing in Mobile Computing and Networking*, September 2006. (6 pages)

42. D. Hadaller*, S. Keshav, and T. Brecht, MV-MAX: Improving Wireless Infrastructure Access for Multi-Vehicular Communication, *Proc. SIGCOMM 2006 Workshop on Challenged Networks,* September 2006. (8 pages)

43. A. Seth*, D. Kroeker****, M. Zaharia***, S. Guo*, S. Keshav, Low-cost Communication for Rural Internet Kiosks Using Mechanical Backhaul, *Proc. ACM MOBICOM 2006*, September 2006. (12 pages)

44. S. Guo*, M. Ghaderi*, A. Seth*, S. Keshav, Opportunistic Scheduling in Ferry-Based Networks, *Proc. IEEE Workshop on Network Protocols for Transportation* 2006, August 2006. (6 pages)

45. N. Ahmed* and S. Keshav, A Successive Refinement Approach to Wireless Infrastructure Network Deployment, *Proc. IEEE Wireless Communication and Networking Conference*, April 2006. (9 pages)

46. H.J. Pan*** and S. Keshav, Detection and Repair of Faulty Access Points, *Proc. IEEE Wireless Communication and Networking Conference*, April 2006. (8 pages)

47. M.A. Zaharia*** and S. Keshav, Gossip-Based Algorithms for Efficient Search Selection, *Proc. ACM International Peer-to-Peer Symposium 2006*, Feb 2006. (8 pages)

48. A. Seth* and S. Keshav, Practical Security for Disconnected Nodes, *Proc. First Workshop on Secure Network Protocols (NPSEC)*, November 2005. (6 pages)

49. M. Ghaderi* and S. Keshav, Multimedia Messaging Service: System Description and Performance Analysis*, Proc. Wireless Internet Conference*, July 2005. (8 pages)

50. J. Wang*, Y. Zhang*, and S. Keshav, Understanding End-to-End Performance: Testbed and Preliminary Results, *Proc. of IEEE Global Internet Symposium,* November 2001. (5 pages)

51. Y. Zhang*, L. Qiu*, and S. Keshav, Speeding Up Short Data Transfers: Theory, Architectural Support, and Simulation Results, *Proc. NOSSDAV'2000*, Chapel Hill, NC, June 2000. (11 pages)

52. S. Keshav and S. Paul, Centralized Multicast, *Proc. International Conference on Network Protocols '99,* October 1999. (10 pages)

53. L. Qiu*, Y. Zhang*, and S. Keshav, On the Performance of Individual and Aggregated TCP Connections, *Proc. International Conference on Network Protocols '99*, October 1999. (10 pages)

54. J. Wang* and S. Keshav, Efficient and Accurate Ethernet Simulation, *Proc. Local Computer Networks '99,* October 1999. (10 pages)

55. X.W.Huang*, R. Sharma*, and S. Keshav, The Entrapid Protocol Development Environment, *Proc. INFOCOM '99*, March 1999. (9 pages)

56. S. Keshav and R. Sharma*, Achieving Quality of Service through Network Performance Management, *Proc. NOSSDAV '98*, July 1998. (8 pages)

57. R. Sharma*, S. Keshav, M. Wu*, and L. Wu*, Environments for Active Networks, *Proc. NOSSDAV '97*, May 1997. (8 pages)

58. S. Keshav and S.P. Morgan, SMART: Retransmission: Performance with Random Losses and Overload, *Proc. INFOCOM '97*, April 1997. (9 pages)

59. A. Jain*** and S. Keshav, Native-mode ATM in FreeBSD: Experience and Performance, *Proc. NOSSDAV '96,* April 1996. (8 pages)

60. R. Ahuja***, S. Keshav, and H. Saran, Design, Implementation, and Performance of a Native-Mode ATM Transport Protocol, *Proc. INFOCOM'96*, March 1996. **Selected as one of the top ten papers of the approximately 500 submitted to the conference.** (12 pages)

61. M. Grossglauser* and S. Keshav, On CBR Service, *Proc. INFOCOM'96*, March 1996. (8 pages)

62. M. Grossglauser*, S. Keshav, and D. Tse, RCBR: A Simple and Efficient Service for Multiple TimeScale Traffic, *Proc. ACM SIGCOMM'95*, August 1995. (12 pages)

63. M. Grossglauser*, S. Keshav , D. Tse, The Case Against VBR, *Proc. NOSSDAV '95* , April 1995. (4 pages)

64. R. Sharma* and S. Keshav, Signaling and Operating System Support for Native-Mode ATM Applications, *Proc. ACM SIGCOMM'94*, September 1994. (12 pages)

65. H. Saran and S. Keshav, An Empirical Evaluation of Virtual Circuit Holding Times in IP-over-ATM Networks, *Proc. INFOCOM '94*, June 1994. (8 pages)

66. S. Keshav, Experience with Large Videoconferences in Xunet 2, *Proc. INET'94,* June1994. (5 pages)

67. H. Saran, S. Keshav, and C.R. Kalmanek, A Scheduling Discipline and Admission Control Policy for Xunet 2, *Proc. NOSSDAV '93*, November 1993. (8 pages)

68. A. Banerjea* and S. Keshav, Queueing Delays in Rate-Controlled Networks, *Proc. INFOCOM '93*, March 1993. (8 pages)

69. S. Keshav, Flow Control in High-Speed Networks with Long Delays, *Proceedings of INET '92*, Kobe, Japan, June 1992. (8 pages)

70. P.S. Khedkar* and S. Keshav*, Fuzzy Prediction of Timeseries, *Proc. IEEE Conference on Fuzzy Systems, FUZZ-IEEE*, March 1992. (8 pages)

71. S. Keshav*, A Control-theoretic Approach to Flow Control, *Proc. ACM SIGCOMM '91*, September 1991. **Winner of the Best Student Paper Award.** (12 pages)

72. H. Zhang* and S. Keshav*, Comparison of Rate-Based Service Disciplines, *Proc. ACM SIGCOMM '91,* September 1991. (12 pages)

73. C.R. Kalmanek, H. Kanakia, and S. Keshav*, Rate-Controlled Servers for Very High-Speed Networks, *Proc. GLOBECOM '90*, San Diego, December 1990. (9 pages)

74. A. Demers, S. Keshav* and S. Shenker, Analysis and Simulation of a Fair Queueing Algorithm, *Proc. ACM SIGCOMM '89*, September 1989. (12 pages)

75. S. Keshav* and D.P. Anderson, A Workload Model for Large Distributed File Systems, *Proc. 19th Annual Pittsburgh Conference on Simulation and Modeling*, May 1988. (8 pages)

Book chapters

76. S. Keshav*, A. Agrawala and S. Singh, Design and Analysis of a Flow Control Algorithm for a Network of Rate Allocating Servers, *Protocols for High Speed Networks II*, published by IFIP Press, April 1991. (14 pages)

Books

77. S. Keshav, An Engineering Approach to Computer Networking, *AddisonWesley*, May 1997. (660 pages)

Technical Reports

78. S. Guo*, M.H. Falaki*, U. Ismail***, E.A. Oliver*, S. Ur Rahman*, A. Seth*, M.A. Zaharia**, and S. Keshav Design and Implementation of the KioskNet System (Extended Version), *University of Waterloo Technical Report No. CS-2007-40*, November 2007.

79. S. Ur Rahman*, U. Hengartner, U. Ismail**, and S. Keshav, Securing KioskNet: A Systems Approach, *University of Waterloo Technical Report No. CS-2007-43*, November 2007.

80. M.A. Zaharia**, and S. Keshav Fast and Optimal Scheduling Over Multiple Network Interfaces, *University of Waterloo Technical Report CS-2007-36*, October 2007.

81. A. Allavena** and S. Keshav, LOT: Fast, Efficient and Robust In-Network Computation, *UW Technical Report CS-2006-22*, July 2006.

82. A. Allavena**, Q. Wang*, I. Ilyas, and S. Keshav, LOT: A Robust Overlay for Distributed Range Query Processing, *UW Technical Report CS-2006-21*, July 2006.

83. S.P. Morgan and S. Keshav, Packet-Pair Rate Control - Buffer Requirements and Overload Performance, *Technical Memorandum, AT&T Bell Laboratories*, October 1994.

84. H. Kanakia, S. Keshav and P. Mishra*, A Benchmark Suite for Comparing Congestion Control Schemes, *Technical Memorandum, AT&T Bell Laboratories*, July 1992.

85. C. Parris*, S. Keshav and D. Ferrari, A Framework for the Study of Pricing in Integrated Networks, *ICSI Technical Report TR-92-016 and AT&T Bell Labs Technical Memorandum TM-920105-03*, January 1992.

86. S. Keshav*, Congestion Control in Computer Networks, *UC Berkeley CS Technical Report 91/654*, September 1991.

87. S. Singh, A. Agrawala and S. Keshav*, Deterministic Analysis of Flow and Congestion Control Policies in Virtual Circuits, *University of Maryland Tech Report TR 2490,* June 1990.

88. R. Govindan*, S. Keshav*, and D.C Verma*, A Survey of Optical Fibers in Communication, *International Computer Science Institute Technical Report TR-89-034*, Berkeley, May 1989.

89. S. Keshav*, REAL : A Network Simulator, *UC Berkeley CS Tech Report 88/472,* December 1988.

90. S. Gozani*, M. Gray*, S. Keshav*, V. Madisetti*, E. Munson*, M. Rosenblum*, S. Schoettler*, M. Sullivan*, and D. Terry, GAFFES: The Design of a Globally Distributed File System, *UC Berkeley CS Tech Report 87/361*, June 1987.

Software

REAL: An early packet level public-domain network simulator that provided extensive support for research in flow and congestion control. First released as v2.0 in 1989; v 5.0 released in 1997. Installed at over 1500 sites in over 50 countries. I was solely responsible for design, implementation, packaging, release, maintenance, and documentation. The REAL simulator later became the basis for the very widely used ns-2 simulator.

XUNET II: The first wide area ATM network. Responsible for design, implementation, testing, and performance tuning of host adaptor firmware, device driver, signaling extensions and master source tree maintenance. The source code was available for research use, at no charge, at all Xunet II university sites.

IDLInet: The first Personal-Computer based ATM LAN. The software was implemented in DOS, Brazil, FreeBSD, and Linux kernels with Fore and Zeitnet hardware. Responsible for top-level design, architecture, kernel-level debugging, and coordination of implementation between IIT Delhi and AT&T Bell Laboratories. This source code was licensed at no charge to academia.

ITX: A Java-based computer telephony platform. The software was first built as part of a course on computer networking, then refined by a team of six students in Spring 1999. This platform implements the basic building blocks for computer telephony: voice-over-IP, signaling, dynamic directory resolution, and CTI gateway management. The source code is freely available and has been used by researchers at Columbia University, AT&T Labs, and U. Kentucky.

TCA: Our implementation of the Tetherless Communication Architecture (2005) is part of the open source Delay Tolerant Networking Reference Implementation distributed by the IRTF DTNRG research group.

OCMP: My group developed the Opportunistic Communication Management Protocol during 2005-2006. We publicly released the software, and distributed to an NGO partner, eGovServices, in May 2006.

KioskNet/VLink: KioskNet and VLink are comprehensive systems for low-cost internet access from rural kiosks using mechanical backhaul. They also includes software to allow recycled PCs to be used as terminals in these kiosks. We first released the KioskNet system software in July 2007. Since then, we made the deployment process simpler, re-written big portions of the underlying system to make it more robust, and added comprehensive support for end-to-end security using public-key encryption. The VLink version adds support for USB-key based

communication and SMS.

I did the entire overall design and software architecture of the KioskNet and VLink systems, which includes about fifteen sub-systems. I also did all the quality assurance, spending nearly four months in the lab testing every aspect of the system on a testbed before the KioskNet software was released in August 2008 and the VLink software was released in June 2009.

US Patents

I hold 19 US patents on a wide variety of systems issues, ranging from cryptography to cluster computing, and from server virtualization to telecommunications services. Several of these have had real-world impact.

1. 7,219,354: *Virtualizing super-user privileges for multiple virtual processes* (with Xun Wilson Huang and Cristian Estan), May 15, 2007. Describes a technique to give a virtualized process Unix 'root' privileges for certain selected actions.

2. 7,143,024: *Associating identifiers with virtual processes* (with Pawan Goyal, Snorri Gylfason, Xun Wilson Huang, and Rosen Sharma), November 28, 2006. Describes a technique to allocate immutable identifiers to virtualized processes despite process forking and termination – an essential step for lightweight virtualization.

3. 6,985,937: *Dynamically modifying the resources of a virtual server* (with Shaw Chuang and Rosen Sharma), January 10, 2006. Shows how to modify the resources granted to a virtual server dynamically in response to changes in workload.

4. 6,976,258: *Providing quality of service guarantees to virtual hosts* (with Pawan Goyal, Xun Wilson Huang, and Rosen Sharma), December 13, 2005. Describes a technique to give quality of service guarantees to Apache virtual web sites.

5. 6,909,691: *Fairly partitioning resources while limiting the maximum fair share* (with Pawan Goyal), June 21, 2005. Describes a technique to provide fair share of a resource, but still not allowing a user to get more than a pre-defined maximum share. This is needed to ensure that users do not get used to higher performance on an idle machine.

6. 6,907,421: *Regulating file access rates according to file type* (with Rosen Sharma), June 14, 2005. Describes a technique to regulate access to I/O devices that are accessed by means of a Unix device file. This allows certain devices to be hidden from users in a virtualized system.

7. 6,754,716: *Restricting communication between network devices on a common network* (with Rosen Sharma), June 22, 2004. Describes a technique to limit the set of network interface cards on a subnet that are allowed to communicate with each other. This allows a single Ethernet segment to be partitioned into a number of virtual private subnets that are totally isolated, without the need for any additional Virtual Private Networking technology.

8. 6,732,211: *Intercepting I/O multiplexing operations involving cross-domain file descriptor sets* (with Pawan Goyal, Snorri Gylfason, Wilson Huang and Rosen Sharma), May 4, 2004. Allows select() calls involving both file and socket fd's to work properly within a virtual server.

9. 6,393,581: *Reliable time delay-constrained cluster computing* (with Roy Friedman, Ken Birman, and Werner Vogels), May 21, 2002. Describes a technique to transparently handoff live TCP connections from a failed server to a backup server. This is an essential step in building reliable clusters.

10. 6,363,483 : *Methods and systems for performing article authentication,* March 26, 2002. This allows any unique object (paintings, sculptures, artwork etc.) to be authenticated by creating a cheap, easily checked and unforgeable certificate. Essentially, the certificate is made as hard to forge as a currency bill, thus leveraging the entire Department of Treasury to enforce unforgeability.

11. 5,864,605: *Voice menu optimization method and system* , Jan 26, 1999. This allows an automatic voice response system to dynamically rearrange its menu options to minimize the number of steps taken by an average caller to complete a transaction.

12. 5,835,595: *Method and apparatus for cryptographically protecting data*, (with Alexander Fraser and Andrew Odlyzsko), Nov. 10, 1998. This describes a digital rights management system based on a hardware 'dongle'.

13. 5,793,768 : *Method and apparatus for collapsing TCP ACKs on asymmetrical connections,* Aug. 11, 1998. This presents a technique for enhancing the performance of asymmetric cable modems by an order of magnitude.

14. 5,761,289 : *800 number callback*, June 2 , 1998. This describes a service where, on calling a toll free number, if the call center attendant is busy, the caller is called back when the attendant is freed up.

15. 5,627,970 **:** *Methods and apparatus for achieving and maintaining optimum transmission rates and preventing data loss in a processing system network*, May 6 , 1997. This patent covers several novel techniques for flow control that I invented as part of my work on packet-pair flow control.

16. 5,623,605 : *Methods and systems for inter-process communication and inter-network data transfer* (with Rosen Sharma), Apr. 22, 1997. This describes a way to interconnect two networks by using a layer-3 tunnel.

17. 5,604,731 : *Renegotiated bit-rate service system and method***,** (with Matthias Grossglauser, David Tse), Feb. 18, 1997. This protects several innovations arising from my work on Renegotiated Constant Bit Rate Service.

18. 5,559,798 : *Data segmentation within a renegotiated bit-rate service transmission system* (with Ken Clarkson, Matthias Grossglauser, David Tse), Sep. 24, 1996. This patent is an adjunct to the previous patent.

19. 5,272,697 : *Apparatus and method for time multiplexing a resource among a plurality of entities* (with Alexander Fraser and Charles Kalmanek), Dec. 21, 1993. This patent covers innovations in my work on Hierarchical Round Robin Service.

Press (2007-2009)

[9/10/09] My Senate testimony was mentioned in Time magazine and The Hindu.

[6/18/09] I was on CBC Radio's 'The Current' with Anna Maria Tremonti.

[6/17/09] Press reports on my testimony before the US Senate appeared in the Wall Street Journal and the National Post. The National Post article was syndicated to several papers in Canada.

[2/20/09] I did an email interview with the Italian online newspaper Il Salvagente on SMS pricing.

[12/27/08] I was quoted on the cost of SMS in the New York Times. This was referred to in an editorial in The Ottawa Citizen, which also appeared in the Windsor Star and the Regina Leader-Post. Several magazines picked this up, including Computerworld). My work was also featured in three Italian publications: Agenda Communicazione, i-dome, and Il Secolo XIX.

[11/6/08] I did an interview on Radio Canada International about KioskNet.

[10/26/08] The Times of India ran an article describing the use of KioskNet at a village in South India.

[4/8/08] The Economic Times in India mentioned work by Rajat Sethi, who interned with me at Waterloo, and who is using KioskNet technology for villages in Eastern India.

[3/3/08] The local Waterloo area newspaper--the Record ran a full-page article on KioskNet.

[11/27/07] I was quoted in an article in Liberation.fr a French online magazine, on cellphone usage in the South.

[8/1/07] My research group's work on smartphones was mentioned in the New Scientist.

[5/4/07] CBC News quoted me on security risks on the iPhone.

[4/30/07] CBC News carried my view on the inevitable centralization of computing.

Invited Addresses and Panels (2006-2009)

1. "An Infrastructure for Rural Networking," Invited presentation, Microsoft Research, Bangalore, January 2, 2006.
2. "Delay Tolerant Networking: Concepts and Extensions," Invited presentation, Infosys Research, Bangalore, January 3, 2006.
3. "Delay Tolerant Networking: Concepts and Extensions," Invited presentation, Intel Research, Bangalore, January 4, 2006.
4. "A perspective on sensor network research," Invited panel presentation, COMSWARE 2006, January 8th, 2006.
5. "Opportunistic Connection Management Protocol," Invited presentation, Airtel Inc., New Delhi, January 11th 2006.
6. "Gossip-Based Algorithms for Efficient Search Selection," Presentation at IPTPS 2006, February 2006.
7. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at Sprint Advanced Technology Lab, March 15th, 2006.
8. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at Intel , Beaverton, OR, March 20th, 2006.

9. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at Intel Research, Berkeley, March 21st, 2006.
10. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at Google, March 22nd, 2006.
11. "Low-cost Internet Access," Work in Progress Session, ACM Mobisys 2006, Uppsala, Sweden, June 2006.
12. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at Microsoft Research, Cambridge, UK, July 4, 2006.
13. "Using Mechanical Backhaul for Low-Cost Internet Access," Invited Presentation at University College London, UK, July 5, 2006.
14. "Intelligent Configuration of Wireless LANs'', Nortel Networks Institute talk, UW, July 10, 2006.
15. "Mesh networking," Panel presentation at Microsoft Faculty Research Summit, Redmond, WA, July 18th, 2006.
16. "Very Low Cost Networking," Invited presentation, Cheriton Research Symposium, University of Waterloo, September 8, 2006.
17. "An Axiomatic Basis for Communication," Invited Presentation at the Network and Distributed Systems Seminar, UW, October 2006.
18. "Industry vs. Academia," Panel in Prof. Robin Cohen's graduate research seminar, November 27, 2006.
19. Organized a panel at CoNEXT' 06 on "Who will Win the Content War," Lisbon, Portugal, December 2006.
20. "Naming, Addressing, and Routing for Delay Tolerant Networks," Invited Presentation at Future Networks Workshop, Lisbon, December 2006.
21. "SMARTA: A Self-Management Architecture for Thin Access Points," Invited Presentation at ACM CoNEXT conference, Lisbon, December 2006.
22. "Very Low Cost Networking," Invited presentation, Canadian Undergraduate Technology Conference, Toronto, January 12 2007.
23. "Tetherless computing: Vision and status," Invited presentation, LOSER Workshop, May 19th 2007.
24. "Flexibility vs. Modularity: An Axiomatic Basis", Invited presentation at PRESTO workshop, Princeton, May 30 2007.
25. Participated in a panel on "Opportunistic communication: directions for future work," ACM MOBIOPP workshop (co-located with Mobisys), June 11 2007.
26. Conducted a panel on "Cell phones as a research platform: Opportunities and Pitfalls", MOBISYS 2007, June 12 2007.
27. "How to do GREAT research," invited keynote at CoNEXT student workshop, December 10th 2007.
28. "Fair and Efficient Scheduling in Data Ferrying Networks," presentation at CoNEXT 2007, December 12th 2007.
29. Conducted a panel on "Clean slate design: why or why not," CoNEXT 2007, December 12th 2007.
30. "The Case for Opportunistic Communication," Invited presentation, Cisco, Jan. 5th, 2008.
31. "The Case for Opportunistic Communication," Invited presentation, Microsoft Research, Jan. 6th, 2008.
32. "The Case for Opportunistic Communication," Network and Distributed Systems Seminar, Waterloo, February 2008.
33. "Overview of the KioskNet System," CITRIS Seminar, UC Berkeley, April 23, 2008.
34. "Overview of the KioskNet System," Cisco, April 25, 2008.
35. "Power to the People," Invited presentation, TTI Vanguard Ventures Conference on "Being Everywhere," Toronto, April 29, 2008.
36. "Practical Security for Internet Kiosks," NSDR workshop, Seattle, August 17th, 2008.

37. "Doing International Research," Panel presentation at a symposium run by the International Research Office, University of Waterloo, November 2008.
38. "Design and Implementation of Internet Protocols," an invited series of four lectures (five hours) at the Tata Excellence in Computer Science Week, Pune, India, Jan 5-9 2009.
39. "Design Principles for Robust Opportunistic Communication," Invited presentation, Google Inc., Bangalore, India, Jan 12, 2009.
40. "Design Principles for Robust Opportunistic Communication," Invited presentation, Microsoft Research, Bangalore, India, Jan 13, 2009.
41. "Design Principles for Robust Opportunistic Communication," Invited presentation, IBM Research., New Delhi, India, Jan 19, 2009.
42. "Design Principles for Robust Opportunistic Communication," Invited presentation, IIT Delhi, New Delhi, India, Jan 20, 2009.
43. "Design Principles for Robust Opportunistic Communication," Invited presentation, Dayalbagh Educational Institute, Agra, India, Jan 21, 2009.
44. "Design Principles for Robust Opportunistic Communication," Invited presentation, IIT Bombay, Mumbai, India, Jan 23, 2009.
45. "How to Give a Research Talk," Presentation at Network and Distributed Systems Seminar, U. Waterloo, February 6, 2009.

Tutorial

I presented a full day tutorial on Traffic Management, ACM SIGCOMM '97, Cannes, August 1997.

TEACHING ACTIVITIES

Courses taught in the last five years

1. CS 456, "Computer Networking," Senior Undergraduate, January-April 2004, 105 students.
2. CS 856 "Advanced Topics in Distributed Systems: Tetherless Computing," Graduate, September -December 2004, 16 students.
3. CS 456, "Computer Networking," Senior Undergraduate, September - December 2005, 54 students.
4. CS 456, "Computer Networking," Senior Undergraduate, January – April 2007, 90 students.
5. CS 497, "Frontiers of Computer Science," Senior Undergraduate, January – April 2007, 45 students (I gave two lectures and guided three projects in this shared course).
6. CS 798, "Mathematical Foundations of Computer Networking," Graduate course, September-December 2008, 42 students.
7. CS 456, "Computer Networking," Senior Undergraduate, May – August 2009, 53 students.

Curriculum development

- During Winter 2004, I developed three new programming assignments for CS 456: (1) to design and implement a 'math server' that receives simple mathematical expressions and evaluates them (2) to design and implement a protocol for reliable transmission of files over a link that can corrupt and drop packets. Students were graded on protocol efficiency (3) implementing a Link State Protocol where routers can fail.

- During Fall 2004, I developed a new graduate course on 'Tetherless Computing' (http://cs856.watsmore.net) Students read 42 papers. They had to enter reviews of each paper in an online conference package (CRP) before class. They also did a course project resulting in a paper. Almost all the project work resulted in publishable-quality papers, and has led to one poster, two workshop papers, two MS theses, and one PhD thesis.

- During 2004, I worked with Prof. Martin Karsten to set up a lab where students could work hands-on with routers and servers in a stand-alone configuration. We received $12,300 funding from MEF to buy equipment for this lab. We purchased equipment in Spring and it was used for a course in Fall 2004. We subsequently expanded this lab and have used it for 456 and related courses in all subsequent terms.

- During Fall 2005, I developed three inter-related programming assignments for my networking course. This led the students to build a complete network simulator in Java that simulates the transport, network, and link layers of a network. The students started the course with just a 'wire' that could send bits from one end to the other. They added framing, network-layer routing, and transport-layer reliability over the course of three assignments. A variant of this assignment continued to be used in three future offerings of the course.

- During Winter 2007, I completely revamped the CS 456 course project – instead of programming assignments, four groups of ~25 students each collaboratively built a

peer-to-peer opportunistic wireless video exchange application. I spent quite a bit of time coming up with the course project, going through two cycles of refinement, and coming up with the initial APIs for each of eight teams that constitute a group. The class responded enthusiastically to the project, and, in the course of twelve weeks, three of four project teams were able to demonstrate a working prototype. Two of my Master's students are using this project as a springboard for their thesis work.

- To help refine the project, and also to provide a forum where students in the class could ask questions from practitioners in the field, I have set up an advisory panel of experts. The experts used an online message board to answer questions. The board included diverse experts, ranging from a former UW student now at Google, to a manager of an outsourcing facility and India, and a venture capitalist in Washington DC. I believe that such an unique learning opportunity has not been provided in any other CS course at Waterloo, or, indeed, anywhere else in the world.

- I taught CS 798 in Fall 2008. The lecture notes were a draft of the second edition of my graduate textbook on computer networking. I wrote five entirely new chapters for the course (about 150 pages of text), covering Optimization, Statistics, Probability, Game Theory, and Queueing Theory.

Students supervised and co-supervised

Post-doctoral:

1. Andre Allavena (Ph.D. from Cornell), September 2005 – August 2006

Ph.D.:

1. *Rosen Sharma*, Thesis title: "Internet TV", (1996-98), currently CEO, SolidCore Inc., Co-Founder and ex-CEO Ensim Corp., Co-Founder GreenBorder Technologies, Co-Founder Stratum8 Inc., Co-Founder Remarkable Hosting, and Co-Founder VxTreme Inc.

2. *Snorri Gylfason* (1997-98), did not graduate, currently Co-Founder and Lead Engineer at Ensim Corp.

3. *Lili Qiu** (1997-99), currently Assistant Professor at UT Austin.

4. *Jia Wang** (1997-99), currently Member of Technical Staff at AT&T Labs.

5. *Yin Zhang** (1997-99), currently Assistant Professor at UT Austin.

6. *Cristian Estan** (1998-1999), currently Assistant Professor at UW Madison.

7. *Suihong Liang*. (2003- 05), did not graduate, currently an engineer at RedKnee networks.

8. *Majid Ghaderi* (2004-06), Thesis title: "Impact of Mobility and Wireless Channel on the Performance of Wireless Networks," co-supervised with R. Boutaba, currently an Assistant Professor at U. Calgary.

9. *Aaditeshwar Seth*, (2004-2008), Thesis title: "Design of a Recommender System for Participatory Media Built on a Tetherless Communication Infrastructure," co-supervised with R. Cohen. Currently a researcher at IBM Research, Delhi.

10. *Nabeel Ahmed*, (2006-)

11. *David Hadaller*, (2006 – 2008), co-supervised with Prof. Tim Brecht.

12. *Earl Oliver* (2007-)

*completed degree under another supervisor due to my departure from Cornell.

Masters of Engineering (Cornell) *:

1997: *D. Balakrishna, K. Chan, B. Nicks, J. Teo, M. Wu, L. Wu, H. Jamjoom*
1998: *K. Lee, R. Schwager, R. Siamwalla*
1999: *Y. Xu, N. Sastry, J. Wann, P. Singh, A. Singh, M. Ranjan, W. Ng, J. Howes*

* Cornell does not require a thesis from Masters of Engineering students.

Masters of Mathematics (Waterloo):

1. *N. Ahmed*, Thesis title: "A Self-Management Approach to Configuring Wireless Infrastructure Networks, " June 2004-December 2005.

2. *S. Guo*, Thesis title: "Algorithms and Design Principles for Rural Kiosk Networks," September 2005 – August 2007.

3. *O. Beg*, Thesis title: "FLECS: A Data-Driven Framework for Rapid Protocol Prototyping," January 2006 – August 2007. (co-supervised with M. Karsten)

4. *E. Oliver*, September 2006 – August 2007 (accepted admission to Ph.D. program)

5. *S. Ur Rahman*, September 2006 –August 2008. (co-supervised with U. Hengartner)

6. *H. Falaki,* September 2006 – August 2008.

Undergraduates

1997: A. Narasimhan
1998: A. Landrum, J. Lin
1999: W. Chang, H. Chan, D. Guitirrez, L. Ku
2003: P. Darragh, S. Fung, M. Tariq

2004: H. Pan, M. Zaharia, P. Darragh, J. Hiliker, G. Salmon, B. Redman, M. Thomas, A. Lifchits, S. Fung, N. Arora

2005: H. Pan (NSERC SURA), M. Zaharia, M. Liang, G. Salmon, S. Fung, Y. Yin, G. Wang, M. Thomas (IIT Kharagpur), G. Singh (IIT Delhi), A. Agarwal (IIT Delhi, R. Garg (IIT Kanpur). R. Jain (IIT Bombay), H. Chopra (IIT Bombay)

2006: H. Pan, M. Zaharia (NSERC SURA), Y. Xu, G. Yang, S. Ur Rahman, Z. Koradia (IIT Kanpur), G. Goyal (IIT Delhi), S. Agrawal (IIIT Ahmedabad), Y. Hu

2007: M. Zaharia, U. Ismail (LUMS), S. Mushtaq (LUMS), S. Dube (IIT Kanpur), R. Sethi (IIT Kharagpur), A. Kumar (IIT Delhi)

2008: C. Tang, L. Bowman, C. Ho, A. Leong, A. Narayan, D. Yim

2009: I. Ko, A. Ganjali.

Thesis reader/examiner

Member of thesis committee

1995: *Klara Nahrstadt*, Ph.D., University of Pennsylvania
1995: *Nikos Aneroussis*, Ph.D., Columbia University
1996: *Dimitrios Pendarakis*, Ph.D., Columbia University
1997: *Zvi Ostfeld*, Ph.D., Tel Aviv University
1997: *Pawan Goyal,* Ph.D., University of Texas, Austin
2008: *Qiang Wang*, Ph.D., University of Waterloo

Reader

2004: *Hao-Hsien Wang*, M.Math, University of Waterloo
2005: *Yunfeng Lin* , M.Math, University of Waterloo
2005: *Amol Pradhan* , M.Math, University of Waterloo
2005: *Dushyant Bansal* , M.Eng., University of Waterloo
2006: *Omar Khan* , M.Math, University of Waterloo
2006: *Evan Jones,* M.Eng., University of Waterloo
2006 *Alex Sung* , M.Math, University of Waterloo
2006: *Mark Grove* , M.Math, University of Waterloo
2008: *Joel Reardon*, M. Math, University of Waterloo

PROFESSIONAL ACTIVITIES

Society memberships

Member of ACM, ACM SIGCOMM, IEEE, and IEEE Communications Society
Member, *ex officio*, ACM SIGCOMM Executive Committee

Editorial positions

1997-1999: Editor, IEEE/ACM Transactions on Networking
1997-1999: Editor, Journal of High Speed Networks
1997-1999: Editor, ACM SIGCOMM Computer Communication Review
2004-2006: Editor, ACM SIGCOMM Computer Communication Review
2008- : Editor-in-chief, ACM SIGCOMM Computer Communication Review

Conference organization

- General Chair and Organizer, Workshop on Quality of Service Issues in High Speed Networks, AT&T Bell Laboratories, April 1992.
- Organizer, XUNET II student meeting, Chicago, 1995
- Publicity Chair, ACM SIGCOMM, 1995
- Organizer, Session on Transport APIs, OPENSIG, 1996
- Program Co-Chair, ACM SIGCOMM Workshop on Future Directions in Network Architecture, 2004
- Member, Steering Committee and Program Committee, Combinatorial and Algorithmic Aspects of Networking and the Internet, 2004
- Program Co-Chair, ACM SIGCOMM Workshop on DTN, 2005
- Member, Steering Committee, Lake Ontario Systems Engineering and Research , 2007
- Track Co-Chair, WWW for Developing Regions, WWW 2008.
- TPC Co-Chair, ACM CoNext 2009
- TPC Co-Chair, ACM Mobisys 2010

Program committee memberships (recent and selected)

- IEEE INFOCOM 2004
- ACM Mobiquitous, 2005
- International Conference on Technology for Development, 2006-2009
- ACM SIGCOMM Challenged Networks Workshop, 2006
- WWW Conference, 2007, 2008
- ACM Mobisys, 2007, 2010
- ACM SIGCOMM Networking Systems for Developing Regions Workshop 2007-2009
- ACM MOBICOM Workshop on Challenged Networks 2007, 2008
- ACM SIGCOMM 2008, 2009, 2010

External reviewer

- Served as an expert external review for the European Union's HAGGLE project, March 2007

- Served as an expert external reviewer for the US NSF FIND program, April 2007