SHIVKUMAR KALYANARAMAN

EDUCATION

B.Tech, **Computer Science**, Indian Institute of Technology (IIT), Madras, INDIA [1989-1993]
{ranked **All India #3** (south zone 1st) in IIT-JEE }

M.S., Computer and Information Sciences (CIS), The Ohio State University, Columbus, OH, USA [1993-1994]

Ph.D., Computer and Information Sciences (CIS), The Ohio State University, Columbus, OH, USA [1994-1997]

Executive M.B.A., Rensselaer Polytechnic Institute (RPI), Troy, NY, USA. (Specialization: *Innovation and Technological Entrepreneurship*) [2003-2005].

CITIZENSHIP: United States of America (USA);
Overseas Citizen of India (OCI Card & permanent Indian visa).

EMPLOYMENT:

January 2013 – ***present***: **Co-Director,** UBD | IBM Centre, Brunei.

August 2011 – ***present***: **Senior Technical Staff Member (STSM),** IBM Research – India, Bangalore

July 2009 – ***present***: **Senior Manager, Next Generation Systems & Smarter Planet Solutions,** IBM Research – India, Bangalore

Jan 2008 – June 2009: **Manager, Next Generation Telecom Research, & Senior Researcher**, IBM Research – India, Bangalore

2006-December 2007: **Full Professor**, Department of Electrical Computer Systems Engineering (ECSE), Rensselaer Polytechnic Institute (RPI), Troy NY, USA. [Served on leave-of-absence till December 2009.]
[*Joint Appointments*: Computer Science Department, School of Information Technology]

2002-December 2007: **Deputy Director:** Center for Pervasive Computing and Networking, RPI.

2001-2006: **Associate Professor (with tenure)**, Department of Electrical Computer Systems Engineering (ECSE), Rensselaer Polytechnic Institute (RPI), Troy NY, USA.
Promoted on *fast-track* to full professor.

1997-2001: **Assistant Professor**, Department of Electrical Computer Systems Engineering (ECSE), Rensselaer Polytechnic Institute (RPI), Troy NY, USA.
Promoted on *fast-track* to associate professor.

1993-1997: **Teaching and Research Associate**, Computer and Information Sciences (CIS), The Ohio State University, Columbus, OH, USA

Research Interests:

At IBM, Shiv established the networking and wireless research team in IBM Research - India in 2008. Shiv has been working on projects at intersection between emerging HPC, wireless technologies, IBM middleware, next generation systems and networking technologies, with applications to large-scale smarter planet problems (energy, weather, hydrology, agriculture). Shiv helped establish & leads a joint research centre for IBM and Universiti of Brunei Darussalam (UBD) in Brunei (UBD | IBM Centre) at the intersection of Smarter Planet modeling and High Performance Computing. Shiv was a principal leader of the 2010 Global technology outlook (GTO) on the Convergence of IT and Wireless Infrastructure, an effort that was instrumental in shaping IBM's R&D investments in smarter wireless technologies

Shiv's core specialization is computer networking around themes of high performance wireless networking and traffic management. In particular, he has worked on topics of congestion control, reliability, multimedia networking (including peer-to-peer multimedia systems), connectionless traffic engineering, quality of service (QoS), last-mile community wireless networks, low-cost free-space-optical networks, automated network management using online simulation, multicast, and performance analysis. His special interest lies in developing the interdisciplinary connections between network architecture and fields like control theory, economics, scalable simulation technologies, databases, machine learning, video compression and optoelectronics.

Professional Activities:

- Principal investigator (or Co-PI) on 15 Federal and industry Grants, for a cumulative budget of over $10 million.
- Industrial R&D funding: AT&T Labs Research, WIMAX Forum, Intel Labs, Nortel Networks, Packeteer, IBM, Qwest, Reuters, Pulsecom.
- Supervised and Graduated **17 Ph.D. students**, **50+ M.S. students**
- Awards:
    - **ACM Recognition of Service Award,** November 2010. For service as General Chair of ACM SIGCOMM 2010.
    - **ACM Distinguished Scientist,** October 2010.
    - **IEEE Fellow**, January 2010.
    - MIT Technology Review inaugural ***TR100***, **100 top young innovators for the new millennium**, 1999.
    - Rensselaer School of Engineering (SoE) Research Award, 2003
    - Rensselaer Faculty Early Career Award, 2001
    - Ameritech Presidential Dissertation Fellowship award, The Ohio State University, 1997
    - Indian Institute of Technology Merit Award, 1989, For being **All India Rank #3**, out of 100,000+ students in the IIT-JEE entrance
- **Invited Seminars (selected from 150+ talks):** MIT, UC Berkeley, Caltech, CMU, U Illinois Urbana Champaign (UIUC), Univ. of Wisconsin, Madison, U. Mass (Amherst), Purdue, Columbia Univ., U. Penn, Ohio State University, INRIA (France), Politecnico Di Torino (Italy), KTH (Sweden), Chinese Univ. of Hong Kong (CUHK), National Univ. of Singapore (NUS), Indian Inst. Of Science (Bangalore, India), I.I.T Mumbai, Tsinghua Univ (Beijing, China).
- **Consulting and training activities (selected):** Cisco, Intel, Packeteer, AT&T, Nortel Networks, Infosys, Tata Elxsi, TCS, HCL, BPL Telecom.
- **Entrepreneurship activities**: co-founder of Premonitia, 2001. Funded by Lazard Freyer Ventures, Castile Ventures, Paul Severino (former CEO, Bay Networks), Marty Schoffstall (former CTO and founder, PSInet).

Publications & Patents**: (over 180 refereed publications in top conferences/journals)**

- 50+ refereed journal articles in top IEEE/ACM/Elselvier journals
- 130+ refereed conference publications (including top networking conferences: SIGCOMM, MOBICOM, INFOCOM, SIGMETRICS, IMC, MOBIHOC, ICNP, IwQoS)
- 7 book chapters
- 6 patents granted, 8 patents pending
- 3600+ citations (Google Scholar: “Shivkumar Kalyanaraman” or “Shiv Kalyanaraman”), h-index 29

Technical direction or management

- Built and led the networking research group at Rensselaer Polytechnic Institute since 1997 (including hiring and mentoring four successful faculty members).
- Invited seminars and talks: 50+ (including top universities: MIT, UC Berkeley, CMU, Caltech, University of Illinois, Urbana Champaign and many more)
- Co-founded the Center for Pervasive Computing and Networking (CPCN),
    - First deputy director (2003-2007)
- $7+ million (direct to RPI) and $10 million+ in cumulative federal and industry research grants (29 grants, 15 federal grants).
    - Sources: DARPA-IPTO, NSF, ARO, AT&T Research, WIMAX Forum, Intel Research, IBM, Nortel Networks, Reuters, Packeteer.

External Service:

- **General Co-Chair, ACM/IEEE COMSNETS 2013,** Bangalore, January 2013
- Area Chair, IEEE INFOCOM 2013, Wireless & Sensor Networks.

- Co-Chair, E6 (Energy in Communication, Information, and Cyber-physical Systems) workshop, IEEE COMSNETS 2012.
- Area Chair, IEEE INFOCOM 2012, Wireless & Sensor Networks.
- Co-Chair, Green Networking & Smarter Systems workshop, ACM SIGCOMM 2011.
- **General Co-Chair, ACM SIGCOMM 2010** (the top ACM conference in networking), New Delhi, India, August-September 2010.
- **Member of Editorial Board,** ***IEEE/ACM Transactions of Networking*** (the topmost networking journal)
- Member of Research Advisory Board, NIIT University, India, 2010-present.
- Guest Editor, Special Issue on "Network Technologies for Emerging Broadband Multimedia Services," Journal of Visual Communication and Image Representation (JVCI), 2008-2009.
- **Technical Program Committee (TPC) Co-Chair**, *The First IEEE International Conference on COMmunication Systems and NETworkS (COMSNETS 2009*), Bangalore, India, January 2009.
- **Technical Program (TPC) Co-Chair, IEEE INFOCOM 2008** (the top IEEE networking conference)
- Technical Program Co-Chair, IFIP Tridentcom 2005
- Area Editor, ACM Computer Communications Review (CCR), 2002-2005
- Editor, ACM/Springer Wireless Networks Journal, 2005-present
- Guest Editor, Journal of Network and System Management, Special Issue on Active Networks, 2005
- Guest Editor, Computer Networks and ISDN Systems, Special Issue on ATM Traffic Management, 1998.
- Technical Program Committee (TPC) member in several IEEE conferences (IEEE INFOCOM, IEEE IwQoS, IEEE ICNP, IEEE Globecom, ACM SIGMETRICS)

Courses Developed & Taught:

- Online Videos of my lectures have been downloaded by hundreds of students & professionals worldwide: http://www.ecse.rpi.edu/Homepages/koushik/shivkuma-teaching/video_index.html
  - ECSE-6961 Fundamentals of Wireless Broadband Networks, 2007
  - ECSE-6600 Internet Protocols, graduate networking course: 1998, 1999, 2000, 2001, 2002, 2004, 2006, 2007.
  - ECSE-4963, Experimental Networking, senior undergraduate lab/studio course: 2002, 2003
  - ECSE-6660: Broadband and Optical Networking: 2003
  - ECSE-4670: Computer Communications Networks, 1999, 2001
  - ECSE-2610: Computer Components and Operations, 2000
  - 35.473: Computer Systems Architecture, 1997, 1998
- Distinguished lecturer (one of 4 worldwide), TECS Week 2011, TRDDC, Wireless Broadband Networks and Cyber-Physical Systems: http://www.tcs-trddc.com/trddc_website/tecsweek/pasttecsweeks/2011/2011-tecsweek.html

Educational Funding and Activities:

- $150,000 funding by CAIDA, Intel for experimental networking class
- Co-PI in $3.86 million NSF IGERT program for graduate fellowships
- Session Co-Organizer, ACM SIGCOMM Education Workshop, 2002, 2003

Other Activities:

- Created a south Indian (carnatic) music audio archive/podcast, including 200+ free downloadable MP3 audio classes (that draws over 500,000 hits/year and > 20K unique users): http://www.shivkumar.org/music/index.html

Papers/Professional details:

http://www.shivkumar.org/ (or Google: Shiv IBM)

Papers/Publications:

Books, Monographs, Book Chapters:
(Give title, co-authors or collaborators, if any, publisher or commissioner, and date.
State if a contributing author to an edited compilation.)

1. Murat Yuksel, Aparna Gupta, Koushik Kar, and Shiv Kalyanaraman, "Contract Switching for Managing Inter-Domain Dynamics," Book Chapter in: *Next-Generation Internet Architectures and Protocols*, Eds. B. Ramamurthy, G. Rouskas, K. Sivalingam, Cambridge University Press, 2010.
2. L. Du, S. Ukkusuri, S. Kalyanaraman, "Integrating Traffic Flow Features to Characterize the Interference in Vehicular Ad Hoc Networks," Book Chapter in: *Automotive Informatics and Communicative Systems: Principles of Vehicular Networks and Data Exchange*, Book Editor: Huaqun Guo, 2009.
3. S.Kalyanaraman, B.Sikdar, ``Protocol Design Concepts, TCP/IP and the Network Layer," Book Chapter in ``IP over WDM: Building the Next Generation Optical Internet", Sudhir Dixit (Editor), March 2003, *John Wiley-Interscience*, ISBN: 0-471-21248-2.
4. Omesh Tickoo, Vijaynarayanan Subramanian, Shivkumar Kalyanaraman and K. K. Ramakrishnan, `` LT-TCP: End-to-End Framework to Improve TCP Performance over Networks with Lossy Channels", Lecture Notes in Computer Science, Vol. 3552/2005, *Springer-Verlag GmbH*, ISBN: 3-540-26294-6, pp. 81-93, 2005. [**58+ Citations**]
5. Vijay Arya, Thierry Turletti, Shivkumar Kalyanaraman: ``Encodings of Multicast Trees," Lecture Notes in Computer Science , Volume 3462 / 2005, *Springer-Verlag GmbH*, ISBN: 3-540-25809-4, 2005.
6. Jiang Li, Shivkumar Kalyanaraman, ``Generalized Multicast Congestion Control," Lecture Notes in Computer Science (LNCS), Volume 2816/2003, *Springer-Verlag GmbH*, ISBN: 3-540-20051-7, pp. 155 - 167, 2003.
7. S. Raghunath, S. Kalyanaraman, ``Statistical Point-to-Set Edge-based Quality of Service Assurances", Lecture Notes in Computer Science, 2811 / 2003, *Springer-Verlag GmbH*, ISBN 3-540-20192-0, pp. 132-141, 2003.
8. Murat Yuksel, Shivkumar Kalyanaraman, ``Distributed Dynamic Capacity Contracting: A Congestion Pricing Framework for Diff-Serv," *Lecture Notes in Computer Science*, Volume 2496/2002, Springer-Verlag GmbH, ISBN 3-540-44271-5, Pages: 198 - 210, 2002.
9. R. Jain, S. Kalyanaraman, R. Viswanathan, ``The OSU Scheme for Congestion Avoidance in ATM networks Using Explicit Rate Indication," *Selected proceedings of WATM'95, Published in book form by Chapman and Hall*.

Peer-Reviewed/Refereed Journal Articles [52 articles accepted/published]

Accepted or Published:

1. T. Ganu, D. P. Seetharam, V. Arya, J. Hazra, D. Sinha, S. A. Husain, L. C. De Silva, R. Kunnath, S. Kalyanaraman, "nPlug: An Autonomous Peak Load Controller," *IEEE Journal on Selected Areas in Communications, Smart Grid Communications Series*, 2013 (accepted)
2. U. Devi, R. K. Kalle, S. Kalyanaraman, "Multi-Tiered, Burstiness-Aware Bandwidth Estimation and Scheduling for VBR Video Flows," *IEEE Transactions on Network and Service Management (TNSM)*, accepted, to appear, 2013.
3. V. Gabale, B. Raman, P. Dutta, S. Kalyanaraman, "A Classification Framework for Scheduling Algorithms in Wireless Mesh Networks," *IEEE Communications Surveys and Tutorials*, Vol. 15, No. 1, pp. 199-222 , 2013.
4. V. Tyagi, S. Kalyanaraman, R. Krishnapuram, "Vehicular Traffic Density State Estimation Based on Cumulative Road Acoustics," *IEEE Transactions on Intelligent Transportation Systems*, Vol. 13, No. 3, pp. 1156-1166, 2012.
5. M. Yuksel, K. K. Ramakrishnan, S. Kalyanaraman, J. D. Houle, R. Sadhvani, "Required extra capacity: A comparative estimation of overprovisioning needed for a classless IP backbone," *Computer Networks*, Vol. 56, No. 17, pp. 3723-3743, 2012

6. V. Sharma, S. Kalyanaraman, K.K. Ramakrishnan, and K. Kar, “A Transport Protocol to Exploit MultiPath Diversity in Wireless Networks,” *IEEE/ACM Transactions of Networking*, Vol. 20, No. 4, pp. 1024-1039, 2012.
7. Utku Günay Acer, Shivkumar Kalyanaraman, Alhussein A. Abouzeid, “DTN routing using explicit and probabilistic routing table states,” *Wireless Networks*, Vol. 17, No. 5, pp: 1305-1321, July 2011.
8. B.Chen, M. Yuksel, S. Kalyanaraman, “Using Directionality in Mobile Routing,” *Wireless Networks (WINET)*, Vol. 16, No. 7, pp. 2065-2086, Oct 2010.
9. Utku Gunay Acer, Shivkumar Kalyanaraman, Alhussein Abouzeid, “Weak State Routing Protocol for Large Scale Dynamic Networks,” *IEEE/ACM Transactions of Networking*, Vol. 18, No. 5, pp. 1450-1463, 2010. [**62+ Citations**]
10. M. Chetlur, U. Devi, P. Dutta, P. Gupta, L. Chen, Z-B. Zhu, S. Kalyanaraman, Y-H. Lin, “A Software WiMAX Medium Access Control Layer over Massively Multi-Threaded Processors,” *IBM Journal of Research and Development*, Vol. 54, No. 1, January/February 2010.
11. A. Vishwanath, P. Dutta, M. Chetlur, P. Gupta, S. Kalyanaraman, A. Ghosh: Perspectives on quality of experience for video streaming over WiMAX. *ACM Mobile Computing and Communications Review (SIGMOBILE M2CR)*, Vol. 13, No. 4, pp. 15-25, December 2009.
12. Yufeng Shan, Ivan Bajic, John W. Woods and Shivkumar Kalyanaraman ``Scalable video streaming with fine grain adaptive forward error correction" *IEEE Transactions on Circuits and Systems for Video Technology (CSVT)*, Vol. 19, No. 9, pp. 1302 - 1314, September 2009.
13. B. Cheng, M. Yuksel, and S. Kalyanaraman, Orthogonal Rendezvous Routing Protocol for Wireless Mesh Networks, *IEEE/ACM Transactions on Networking*, Vol. 17, No. 2, pp. 542-555, April 2009. [**43+ Citations**]
14. M. Yuksel, J. Akella, S. Kalyanaraman, and P. Dutta, Free-Space-Optical Mobile Ad-Hoc Networks: Auto-Configurable Building Blocks, *ACM/Springer Wireless Networks*, Vol. 15, No. 3, pages 295-312, April 2009. [**34+ Citations**]
15. Y. Xia, L. Subramanian, I. Stoica and S. Kalyanaraman, “One more bit is enough,” *IEEE/ACM Transactions of Networking*, Vol. 16, No. 6, pp. 1281-1294, December 2008. [**34+ Citations; earlier SIGCOMM’05 paper: 175+ citations**]
16. L. Du, S. Ukkusuri, W. Yushomito, and S. Kalyanaraman, “Characterizing Interference in Vehicle Ad Hoc networks on Freeway Segments under Different Traffic Flow conditions,” *Journal of Transportation Research - C, Part-C (Emerging Technologies)* Vol. 17, No. 6, pp. 571-585, 2009.
17. T. Ye, H. T. Kaur, S. Kalyanaraman, and M. Yuksel, "Large-Scale Network Parameter Configuration Using an On-line Simulation Framework," *IEEE/ACM Transactions on Networking*, Vol. 16, No. 4, pp. 777-790, August 2008.
18. S. Raghunath , K. K. Ramakrishnan , S. Kalyanaraman, “Measurement-based characterization of IP VPNs,” *IEEE/ACM Transactions on Networking*, Vol. 15, No. 6, pp.1428-1441, December 2007.
19. Su Yi, S. Kalyanaraman, B. Azimi-Sadjadi and Hsin-Yi Shen, “Energy-efficient cluster-based cooperative FEC in wireless networks,” *ACM/Springer Wireless Networks, December 2007 (SpringerLink onlinefirst), Print version: Wireless Networks:* Vol. 15, No. 8 (2009), *Page 965.*
20. Su Yi, Y. Pei, S. Kalyanaraman, B. Azimi-Sadjadi, “How is the Capacity of Ad hoc Networks Improved with Directional Antennas?” *ACM/Springer Wireless Networks*, Vol. 13, No. 5, October 2007. [**24+ Citations; earlier MOBIHOC’03 paper: 390+ citations**]
21. Jiang Li, Murat Yuksel, Xingzhe fan, Shivkumar Kalyanaraman, ``Generalized Multicast Congestion Control," *Computer Networks*, Vol. 51, No. 6, pp. 1421-1443, April 2007.
22. X. Fan, K. Chandrayana, M. Arcak, S. Kalyanaraman, J. T. Wen, ``A Two-Time-Scale Design for Edge-Based Detection and Rectification of Uncooperative Flows," *IEEE/ACM Transactions on Networking*, Volume 14, Issue 6, pp. 1313-1322, December 2006.
23. A. Gupta, S. Kalyanaraman, L. Zhang, ``Pricing of Risk for Loss Guaranteed Intra-domain Internet Service Contracts," *Computer Networks*, Vol. 50, No. 15, pp. 2787-2804, October 2006.
24. Jiang Li, Murat Yuksel and Shivkumar Kalyanaraman, ``Explicit Rate Multicast Congestion Control," *Computer Networks*, Vol. 50, No. 15, pp. 2614-2640, October 2006
25. K. Chandrayana, S. Ramakrishnan, B. Sikdar, S. Kalyanaraman, A. Balan, O.Tickoo, ``On Randomizing the Sending times in TCP and Other Window Based Algorithms," *Computer Networks*, Vol. 50, No. 3, pp. 422 – 447, February 2006.

26. Yufeng Shan, Ivan V. Bajic, Shivkumar Kalyanaraman and John W. Woods ``Overlay Multi-hop FEC scheme for Video Streaming,'' *Journal on Signal Processing: Image Communications, Special Issue on Video Networking* , Elselvier, Vol. 20, No. 8, pp. 710-727, 2005.
27. Muhammad-Amri Abdul-Karim, Badrinath Roysam, Natalie Dowell, Andreas Jeromin, Murat Yuksel, and Shivkumar Kalyanaraman, ``Automatic Selection of Parameters for Vessel/Neurite Segmentation Algorithms,'' *IEEE Transactions on Image Processing, Special Issue on Molecular and Cellular Bioimaging*, Vol. 14, No. 9, pp. 1338, September 2005.
28. A. Gupta, S. Kalyanaraman, and L. Y. Zhang, "A spot pricing framework for pricing intra-domain assured bandwidth services," *International Journal of Information Technology and Decision Making*, Vol. 4, No. 1, pp. 35-58, March 2005.
29. Y. Xia, D. Harrison, S. Kalyanaraman, K. Ramachandran and A. Venkatesan., ``Accumulation-based Congestion Control,'' *IEEE/ACM Transactions on Networking* , Vol. 13, No. 1, pp. 69-80, February 2005.
30. Murat Yuksel and Shivkumar Kalyanaraman, ``Effect of Pricing Intervals on Congestion-Sensitivity of Network Prices'', *Telecommunication Systems*, Kluwer Academic Publishing, Vol. 28, No. 1, pp. 79-99, January 2005.
31. Murat Yuksel, S.Kalyanaraman, ``An Implementation Framework for Trajectory-Based Routing in Ad Hoc Networks," *Ad Hoc Networks*, Elselvier, Vol. 4, No. 1, pp. 125-137. January 2006. [**34+ Citations**]
32. Tao Ye, S. Kalyanaraman, ``A Recursive Random Search Algorithm for Black-box Optimization," *ACM SIGMETRICS Performance Evaluation Review*, Vol. 32 , No. 3, December 2004. pp. 44 – 53. [**55+ Citations**]
33. Jiang Li, S. Kalyanaraman, ``MCA: An End-to-End Multicast Congestion Avoidance Scheme with Feedback Suppression," *Journal of Computer Communications* , Elselvier, Vol. 27, No. 13, 15 August 2004, pp. 1264-1277.
34. David Harrison, Yong Xia, Shiv Kalyanaraman, Arvind Venkatesan, ``An Accumulation Based, Closed-loop Scheme for Expected Minimum Rate and Weighted Rate Services," *Computer Networks*, Elselvier, Vol. 45, No. 6, pp. 801-818, August 2004.
35. Murat Yuksel, Shivkumar Kalyanaraman, ``Distributed Dynamic Capacity Contracting: An overlay congestion pricing framework", *Computer Communications, Special Issue on Internet Pricing and Charging* , Elselvier, Vol. 26, No. 13, August 2003, Pages 1484-1503.
36. Garrett R. Yaun, David Bauer, Harshad L. Bhutada, Christopher D. Carothers, Murat Yuksel, Shivkumar Kalyanaraman, ``Large-Scale Network Simulation Techniques: Examples of TCP and OSPF Models", *ACM SIGCOMM Computer Communication Review (CCR), Special Issue on Tools and Technologies for Networking Research and Education*, Vol. 33, No 3, July, 2003. [**42+ Citations**]
37. B. Sikdar, S. Kalyanaraman and K. S. Vastola, ``Analytic Models for the Latency and Steady-State Throughput of TCP Tahoe, Reno and SACK,'' *IEEE/ACM Transactions on Networking*, Vol. 11, No. 6, December 2003. [**93+ Citations**]
38. Sonia Fahmy, Raj Jain, Shivkumar Kalyanaraman, Rohit Goyal, Bobby Vandalore, ``On Determining the Fair Bandwidth Share for ABR Connections in ATM Networks," *Journal of High Speed Networks*, Vol. 11, No. 2, pp. 121-135, 2002.
39. Pierre-Franois Quet, Banu Ataslar, Altug Iftar, Hitay Ozbay, Shivkumar Kalyanaraman and Taesam Kang, ``Robust Rate-Based Controllers for High Speed Networks: The Case of Uncertain Time-varying Multiple Time delays," *Automatica*, Vol. 38, No. 6, June 2002, pp. 917-928. [**100+ Citations**]
40. P. Thapliyal, Sidhartha, J. Li, S. Kalyanaraman, ``LE-SBCC: Loss-Event oriented Source-based Multicast Congestion Control," *Multimedia Tools and Applications Journal*, Kluwer Academic Publishers, Vol. 17, No. 2/3, 2002.
41. B. Sikdar, S. Kalyanaraman and K. S. Vastola, ``An integrated model for the latency and steady state throughput of TCP connections," *Performance Evaluation* , Vol. 46, No. 2-3, pp. 139-154, October 2001. [**96+ Citations**]
42. G.L. Monoco, F. Azeem, S. Kalyanaraman, Y. Xia, ``TCP-Friendly Marking for Scalable Best-Effort Services on the Internet," *ACM SIGCOMM Computer Communication Review (CCR),* Vol. 31, No. 5, October 2001.

43. N. Natu, P. Rajagopal, S. Kalyanaraman, ``GSC: A Generic Source-based Congestion Control Algorithm for Reliable Multicast," *Journal of Computer Communications,* Vol. 24, No. 5-6, 15 March 2001, pp. 575-589.
44. S. Kalyanaraman, R. Jain, S. Fahmy, R. Goyal, and B. Vandalore, ``The ERICA Switch Algorithm for ABR Traffic Management in ATM Networks," *IEEE/ACM Transactions on Networking*, Vol. 8, No 1, February 2000, pp. 81-98. [**190+ Citations**]
45. S. Karandikar, S. Kalyanaraman, P. Bagal, B. Packer, ``TCP Rate Control," *ACM SIGCOMM Computer Communications Review (CCR)*, Vol 30, No. 1, January 2000, pp. 45-58. [**99+ Citations**]
46. S. Fahmy, R. Jain, R. Goyal, B. Vandalore, and S. Kalyanaraman, ``Design and Evaluation of Feedback Consolidation for ABR Point-to-Multipoint Connections in ATM Networks," *Journal of Computer Communications* , 25 July 1999, Vol. 22, Issue 12, pp. 1085-1103.
47. S. Kalyanaraman, R. Jain, R. Goyal, S. Fahmy, and S.C. Kim, ``Use-it or Lose-it Policies for the Available Bit Rate (ABR) Service in ATM Networks," *Computer Networks and ISDN Systems* , Vol. 30, No. 24, 14 December 1998, pp. 2293-2308.
48. S. Kalyanaraman, R. Jain, J. Jiang, R. Goyal, S. Fahmy, ``Design Considerations for the virtual source/virtual destination (VS/VD) feature in the ABR service of ATM networks," *Computer Networks and ISDN Systems Journal* , Vol 30, No. 19, October 1998, pp. 1811-1824.
49. Rohit Goyal, Raj Jain, Shiv Kalyanaraman, Sonia Fahmy and Bobby Vandalore, ``Improving the Performance of TCP over the ATM-UBR service," *Journal of Computer Communications*, Volume 21, Issue 10, July 1998, pp. 898-911. [**33+ Citations**]
50. S. Kalyanaraman, R. Jain, S. Fahmy, R. Goyal and S.C. Kim, ``Performance and Buffering Requirements of Internet Protocols over ATM ABR and UBR Services," *IEEE Communications Magazine*, Vol. 36, No. 6, June 1998, pp. 152-157.
51. Raj Jain, Shiv Kalyanaraman and Ram Viswanathan, ``The OSU Scheme for Congestion Avoidance in ATM Networks: Lessons Learnt and Extensions," *Performance Evaluation*, Vol. 31, No. 1-2, November 1997, pp. 67-88. [**37+ citations; earlier version: 130+ Citations**]
52. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, ``Source Behavior for ATM ABR Traffic Management: An Explanation," *IEEE Communications Magazine*, Vol. 34, No. 11, November 1996, pp. 50-55. [**110+ Citations**]

Peer-Reviewed (Refereed) Conference Articles [136 articles accepted/published]

1. V. Arya, T.S. Jayram, S. Pal, S. Kalyanaraman, "Inferring Connectivity Model from Meter Measurements in Distribution Networks," *In Proceedings of 4th International Conference on Future Energy Systems, (**ACM e-Energy 2013**)*, Berkeley, CA, May 2013. To Appear.
2. V. Arya, P. Dutta, S. Kalyanaraman, "On mitigating wind energy variability with storage", *In Proceedings of the Fourth IEEE International Conference on COMmunication Systems and NETworkS **(COMSNETS 2013),*** pp. 1-9, Bangalore, India, January 2013.
3. V. Mann, A. Vishnoi, K. Kannan, S. Kalyanaraman, "CrossRoads: Seamless VM mobility across data centers through software defined networking," ***NOMS 2012,*** pp. 88-96.
4. J. Chen, L. Ramaswamy, D. Lowenthal, S. Kalyanaraman, "Comet: Decentralized Complex Event Detection in Mobile Delay Tolerant Networks", *In Proceedings of 13th International Conference on Mobile Data Management (**MDM-2012**)*, July 2012. (short paper)
5. V. Gabale, P. Dutta, R. Kokku, S. Kalyanaraman, "InSite: QoE-Aware Video Delivery from Cloud Data Centers," *In Proceedings of **ACM/IEEE International Workshop on Quality of Service*** (***IwQoS 2012***), Coimbra, Portugal, June 2012.
6. U. Devi, R. Polavarapu, M. Chetlur, S. Kalyanaraman, "On the Partial Caching of Streaming Video," *In Proceedings of **ACM/IEEE International Workshop on Quality of Service*** (***IwQoS 2012***), Coimbra, Portugal, June 2012.
7. T. Ganu, J. Hazra, D. P. Seetharam, S. A. Husain, V. Arya, L. C. De Silva, R. Kunnath, S. Kalyanaraman, "nPlug: a smart plug for alleviating peak loads," *In Proceedings of 3rd International Conference on Future Energy Systems, (**ACM e-Energy 2012**)*, Madrid, Spain, May 2012.

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Articles (Non-refereed) [Note: Many Standards Contributions have been extensively Cited]

Shiv published a number of articles in the ATM Forum, the body which forms international standards for the ATM networking technology and the Internet Engineering Task Force (IETF) which forms standards for Internet protocols. The following is a selected subset.
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External Service: Conference Activities, Editorship of Journals etc

- **General Co-Chair, ACM/IEEE COMSNETS 2013,** Bangalore, January 2013
- **Area Chair, IEEE INFOCOM 2013**, Wireless & Sensor Networks.
- Member, **Technical Program Guidance Committee (TPGC), Robert Bosch Center on Cyber-Physical Systems, IISc, Bangalore**. {Invited by the Director, IISc, Bangalore}

- Technical Program Committee (TPC) Member, HotICE 2012,
- Technical Program Committee (TPC) Member, SYSTOR 2012,
- Technical Program Committee (TPC) Member, ICDCS 2012 (PIC Top),
- Technical Program Committee (TPC) Member, ACM e-Energy (PIC top) 2012.
- **Co-Chair, E6 (Energy in Communication, Information, and Cyber-physical Systems) workshop,** IEEE COMSNETS 2012.
- **Area Chair, IEEE INFOCOM 2012**, Wireless & Sensor Networks.
- **Co-Chair, Green Networking & Smarter Systems workshop,** ACM SIGCOMM 2011.
- **General Co-Chair, ACM SIGCOMM 2010** (the topmost ACM conference in networking).
- **Area TPC Chair,** IEEE INFOCOM 2010, Wireless and Mobile Networks.
- Technical program committee (TPC) member, IEEE International Conference on Network Protocols (ICNP) 2010.
- Technical program committee (TPC) member, IEEE COMSNETS 2011.
- Technical program committee (TPC) member, National Communications Conference (NCC) 2011.
- Technical program committee (TPC) member, IEEE International Conference on Network Protocols (ICNP) 2009.
- **Area TPC Chair,** Wireless and Mobile Networks technical area, ***IEEE INFOCOM 2009*** (the topmost IEEE conference in networking, work spans 2008 and 2009).
- Technical program committee (TPC) member, IEEE International Conference on Network Protocols (ICNP) 2008.
- Technical program committee (TPC) member, 10th International Conference on Distributed Computing and Networks (ICDCN), January 2009.
- **Member of Editorial Board,** ***IEEE/ACM Transactions of Networking*** (the topmost networking journal)
- **Guest Editor,** Special Issue on "Network Technologies for Emerging Broadband Multimedia Services," Journal of Visual Communication and Image Representation (JVCI), 2008-2009.
- **Technical Program Committee (TPC) Co-Chair**, *The First IEEE International Conference on COMmunication Systems and NETworkS (COMSNETS 2009*), Bangalore, India, January 2009.
- **Technical Program Committee (TPC) Co-Chair**, IEEE INFOCOM 2008, Phoenix, AZ (the topmost IEEE conference in networking, with over 1200 submissions).
- **Editor**, ACM/Springer Journal on Wireless Networks, June 2005 - 2008.
- Technical Program Committee (TPC) Member, IEEE/Create-Net/ICST International Conference on COMmunication System softWAre and MiddlewaRE (COMSWARE), 2008.
- Technical Program Committee (TPC) Member, ACM Sigmetrics Student Workshop 2007.
- Reviewer and Panelist, NSF NeTS CAREER Panel, Reviewed 10 NSF proposals and participated in panel in October 2007.
- Technical Program Committee (TPC) Member, IEEE BroadNets 2007 Internet technologies symposium, 2007.
- Session Chair, IEEE Workshop on Local and Metropolitan Area Networks (LANMAN), June 2007.
- **Guest Editor**, Journal of Network and Systems Management, Special Issue on Management of Active and Programmable Networks, March 2006. (co-edited with Stephen Bush, GE)
- **Area Editor,** ***ACM Computer Communication Review (CCR)*** Journal. Fall 2002 - January 2005.
- **TPC Co-Chair**, Technical Program Committee (TPC) Chair of Create-Net ***TridentCom*** 2005, First International Conference on Testbeds and Research Infrastructures for the DEvelopment of NeTworks and COMmunities, Trento (Italy), February 23 - 25, 2005. Co-Sponsored by IFIP WG 6.3, Create-Net and ICST.
- Technical Program Committee (TPC) Member, The 15th IEEE Workshop on Local and Metropolitan Area Networks (LANMAN 2007).
- **Panel Co-Chair, ACM MOBICOM 2006**, Marina Del Ray, CA. ``Wired vs Wireless access: the Race to Higher Speeds"
- Technical Program Committee (TPC) Member, ***IEEE INFOCOM 2007***. Reviewed 20+ papers + TPC decision making meeting in Evanston, IL in Nov 2006.
- Technical Program Committee Member, ***IEEE IwQoS 2006***, Fourteenth IEEE International Workshop on Quality of Service, 2006.
- Technical Program Committee Member, IEEE/Create-Net Broadnets 2006 Conference, 2006.

- Technical Program Committee (TPC) Member, 7th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (IEEE WOWMOM 2006).
- Technical Program Committee (TPC) Member, ***IEEE INFOCOM 2006.*** Reviewed 20+ papers + TPC decision making.
- Technical Program Committee (TPC) Member, ***ACM SIGMETRICS 2005***, June 6-10, 2005, Banff, Canada. Reviewing 20 papers (late 2004) + TPC meeting in NY City.
- Technical Program Committee (TPC) Member, NETWORKING 2005, International Conference on Networking, IFIP Technical Committee on Communication Systems (TC 6). Reviewing 15 papers.
- Technical Program Committee (TPC) Member, ***IEEE INFOCOM 2005***. Reviewed 20+ papers and participated in TPC decision making.
- Technical Program Committee (TPC) Member, IEEE UPSTATE NY Sensor Networks Workshop, Syracuse, NY, 2003.
- Local Host and Organization Chair, Planetlab Users Meeting, Rensselaer Polytechnic Institute, 19th Oct 2003.
- Technical Program Committee (TPC) Member, 12th IEEE International Conference on Network Protocols (***ICNP'04***), 2004.
- Technical Program Committee (TPC) Member, ***IEEE Globecom 2004*** - Global Internet and Next Generation Networks (GI/NGN Symposium), 2004.
- Technical Program Committee Member, IEEE IwQoS, International Workshop on QoS, 2004.
- Technical Program Committee (TPC) Member, ***IEEE INFOCOM 2004***. Reviewed 20 papers and participated in TPC decision making.
- Session Chair and Co-Organizer, ACM SIGCOMM Workshop on Networking Education: How to Educate the Educators? (NetEd) (in conjunction with ACM SIGCOMM 2003), August 25, 2003, Karlsruhe, Germany.
- Session Chair, IEEE International Communications Conference (ICC) 2003, Anchorage Alaska, 2003.
- Reviewer for ``Ad-Hoc Wireless Networks: Architectures and Protocols,'' textbook by C Sivaramamurthy, 2003, (Prentice Hall, Upper Saddle River, New Jersey, USA).
- Technical Program Committee Member, ``Networking and Protocols'' Area, IEEE International Conference on Parallel Processing (ICPP-2003), 2003.
- Technical Program Committee Member, The 23rd IEEE International Conference on Distributed Computing Systems ***(ICDCS), 2003***.
- Session Chair, ``Overlay and Peer-to-Peer Networks,'' IEEE Computer Communications Workshop (CCW), 2002, Santa Fe, October 2002.
- Technical Program Committee Member, IEEE IwQoS, International Workshop on QoS, 2003.
- Technical Program Committee Member, ***IEEE INFOCOM 2003***. Reviewed 20 papers and participated in TPC decision making.
- Program Committee Member, Second New York Metro Area Networking Workshop, 2002.
- Session Chair, Multicast, IwQoS, Miami, April 2002. Reviewer of famous networking book ``Computer Networking: A Top-Down Approach'' by Kurose/Ross, Addison-Wesley, 2nd Edition. Co-Chair, DARPA NMS PI meeting, Breakout Session on ``QoS and Overlay Networks,'' April 2002.
- Reviewer and Panelist, NSF Networking Panel, Reviewed 15 NSF proposals and participated in panel on April 9-10, 2002.
- Co-Chair, DARPA NMS PI meeting, Breakout Session on "QoS and Overlay Networks," October 2001.
- Reviewer for INFOCOM 2001, reviewed over 15 papers.
- Co-Chair, DARPA NMS PI meeting, (with Jean Walrand, UC Berkeley), Breakout Session on "QoS and Overlay Networks," April 2001.
- Technical Program Committee Member, First New York Metro Area Networking Workshop, IBM TJ Watson Research Center, Hawthorne, New York, March 2001.
- Reviewer and Panelist, NSF SBIR/STTR Panel, Reviewed 10 NSF proposals and participated in panel on Sept 6th 2000.
- Technical Program Committee (TPC) member, IEEE Infocom 2000, (helped review over 20 papers) and in TPC meeting.

- **Guest Editor**, ***Computer Networks and ISDN Systems Journal***, Special Issue on ATM Traffic Management, 1997-1998.
- Reviewer of over 100 papers for the following journals and magazines
  IEEE/ACM Transactions on Networking, Computer Networks and ISDN Systems, Computer Communication Review. Journal of Computer Communication., ACM Computer Communications Review, IEEE Network Magazine, IEEE Communications Magazine, ACM SIGCOMM, IEEE ICC, IEEE GLOBECOM.
- Reviewer of book for Macmillan Technical Publishing.``Differentiated Services'' by Kalevi Killki (review acknowledged in published version of the book)

Professional and Public Lectures, Including Invited Talks

1. **Invited Seminar:** "Smarter Energy: Challenges and Opportunities in realizing the potential of cyber-physical systems," Smart Grid Workshop, NICTA & University of Melbourne, 5-6th July 2012.
2. Smarter Planet Research at IBM Research – India & UBD | IBM Centre, IBM Research – Australia, Melbourne, July 2012.
3. **Invited Seminar:** "Smarter Planet Research at IBM Research – India & UBD | IBM Centre," I2R Singapore, May 28th 2012.
4. **Invited Seminar:** Wireless Network Cloud, AT&T Labs Research, May 7th 2012.
5. **Invited Seminar:** Smart Cities Workshop, IISc Bangalore, "Technologies for Smarter Cities: Possibilities and Lessons Learned," Bangalore, India, May 2012.
6. **Invited Seminar:** "Smarter Energy: Applying Networking Ideas for Energy Efficiency", Green Telecom & IT Workshop by IISc & Bell labs, Bangalore, April 4-5th, 2012. https://sites.google.com/site/greenworkshops4/speakers-bio
7. Smarter Energy: The Potential of Cyber-Physical Systems, Amrita University, Coimbatore, India, January 2012.
8. Wireless Network Cloud, IIT Jodhpur, December 2011.
9. **Invited Seminar:** "Smarter Energy: The Promise of Cyber-Physical Energy Systems," Robert Bosch Center on CyberPhysical Systems Inaguration by Abdul Kalam (former President of India), November 2011.
10. **Keynote**: "Smarter Energy: The Promise of Cyber-Physical Energy Systems," NATFoE 2011, 6th Symposium on National Frontiers of Engineering, IIT Hyderabad, Sept 3, 2011.
11. Convergence of IT & Wireless Infrastructure, NTU Singapore, May 31st, 2011.
12. Convergence of IT & Wireless Infrastructure, Dept of Electrical Engineering, IIT Madras, March 2011
13. Smarter Energy: The Promise of Cyber-Physical Energy Systems, Dept of Computer Science, IIT Madras, March 2011
14. **Invited Lecture Series (one out of 4 distinguished lecturers worldwide)**, Wireless Broadband Networks and Cyber-Physical Systems, **Tata Excellence in Computer Science (TECS) Week, TRDDC,** Pune, India, Jan 3-6th, 2011.
15. **Industrial keynote:** "Smarter Energy: The Promise of Cyber-Physical Energy Systems," SESA 2011. Workshop on Sensor-Enabled Situational Awareness (In Conjunction with ICDCN 2011), January 2, 2011.
16. PhasorNet – A Stream Computing Architecture for Synchrophasors, IEEE International Workshop on Challenges in Smart Grids and Renewable Resources, Mysore (May 15, 2010).
17. The Future of Software Radio - Wireless Network Cloud, **IEEE** invited seminar, **IISc Bangalore**, (April 19, 2010)
18. Smart Grids & Standards, IEEE Outreach Meeting, Bangalore, India, March 2010.
19. Building a Smarter Planet, International Conference on Distributed Computing and Information Technology (**ICDCIT**), 2010, **KEYNOTE Seminar**, Feb 17th, 2010
20. Smarter Energy: The Promise of Cyber-Physical Systems, **IEEE Talk**, IBM, Bangalore, February 2010.
21. Smarter Energy: The Promise of Cyber-Physical Systems, **IEEE Power Engineering Society (Bangalore Chapter) Invited talk**, PowerGrid, Bangalore, India, February 2010.
22. The Future of Software Radio - Wireless Network Cloud, **Mysore Park Series** (Cloud Computing, Jan 13-15th, 2010)

23. IBM Research – India: University & Global Collaboration, UD-India Workshop on infrastructure security, **IISc**, Jan 10th 2010
24. The Future of Software Radio - Wireless Network Cloud, **Infosys**, Bangalore India (Dec 4, 09).
25. Smarter Cities: Leveraging Synergies Between Energy, Utilities and Transportation, **IBM Research – China** , Beijing, China (Dec 10th, 2009)
26. Smarter Energy: The Promise of Cyber-Physical Systems, **NEC Labs China** , Beijing, China (Dec 11th 2009)
27. Smarter Energy: The Promise of Cyber-Physical Systems, **IISc**, Smarter Planet Edge Series, Bangalore, India, Dec 18th 2009.
28. "Smarter Energy: The Potential of Cyber-Physical Energy Systems"
    a. University of Melbourne, Australia, 5th Oct 2009
    b. Monash University, Melbourne, Australia, 5th Oct 2009
    c. University of Sydney, Sydney, Australia, 9th Oct 2009
    d. Bell Labs, Bangalore, India, 23th Oct 2009.
    e. IIT Madras, Chennai, India 24th Oct 2009
    f. University of Massachussetts, Amherst, 2009.
    g. RPI, 2009.
29. "Cloud Computing: Evolution of Enterprise Data Centers to Cloud", Cloud Computing Panel, IEEE COMSNETS 2009, January 9th 2009.
30. "The Future of Rich Media in Enterprise Communications":
    Tools for a Global Integrated Enterprise, RIMCeT Panel: The Future of Rich Media in Enterprise Communications, January 5th 2009.
31. "WiMAX System Design and Evaluation Methodology using the NS-2 Simulator", Invited Paper/Talk at IEEE WISARD 2009 Workshop, Jan 6th, 2009.
32. "Spoken Web," Invited Seminar at IIT Bombay, January 17, 2009
33. "Spoken Web," Invited Seminar at IBM Asia-Pacific University Relations Summit, November 2008.
34. "Spoken Web," Invited Seminar at University of Massachussets, Amherst, MA, September 2008.
35. "Spoken Web," Invited Seminar at Rensselaer Polytechnic Institute, Troy, NY, September 2008.
36. "Next Generation networking", Invited Seminar at National Institute of Technology (NIT), Warangal, India, July 2008.
37. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group, MITRE, McLean, VA, November 2007.
38. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group, AT&T, San Jose, CA, September 2007.
39. Loss- and Disruption-Tolerance in MANETs: Experimental Work and MultiPath LT-TCP, MIT Lincoln Labs and Airborne Networks Program Review, Lexington, MA, September 25th, 2007.
40. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group, Sprint Campus, Vienna VA, June 2007.
41. Large-Scale Network Parameter Configuration Using An On-line Meta-Simulation Framework, Invited Talk, IBM India Research Labs, Bangalore, India, June 2007.
42. Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks, Invited Talk, Microsoft Research, Bangalore, India, June 2007.
43. Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks, Invited Talk, Tata Research Development and Design Centre (TRDDC), Pune, India, June 2007.
44. A Cross-Layer Approach to Loss- and Disruption-Tolerance in Airborne MANETs, MIT Lincoln Labs and Airborne Networks Program Review, Lexington, MA, May 11, 2007.
45. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, Bell Labs, Alcatel-Lucent, Murray Hill, NJ, April 12, 2007.
46. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group, NIST, Gaithersburg, MD, March 2007.
47. Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks, Invited Talk, University of Nebraska, Lincoln, Lincoln, NE, March 8th, 2007.
48. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, Iowa State University, Ames, IA, March 7th, 2007.
49. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum Members Conference, AATG Working Group, Waikaloa, Hawaii, January 29, 2007.

50. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, Motorola Labs, India, Bangalore, India, January 12, 2007.
51. Hybrid Packet FEC and Retransmission-based Erasure Recovery Mechanisms (HARQ) for Lossy Networks: Analysis and Design,, Invited talk, IEEE Workshop on WIreless Systems: Advanced Research and Development (WISARD 2007), Bangalore, India, January 2007.
52. Towards Multi-Hop Free-Space-Optical (FSO) Mesh Networks and MANETs: Low-Cost Building Blocks, Invited Seminar, University of Wisconsin, Madison, WI, November 3, 2006.
53. Tetherless Networking: Towards Ultra-High-Speeds, Disruption-Tolerance, Upstate New York Electronic Crimes Coalition Conference, Troy NY, November 2, 2006.
54. WiMax NS-2 SLS Simulator: RPI Modeling Update, Invited Talk, WIMAX Forum Members Conference, AATG Working Group, Seoul, South Korea, October 18, 2006.
55. Tetherless Networking at RPI: Towards Ultra-High-Speeds and Disruption-Tolerance, RPI ACM Student Chapter, Troy NY, October 10, 2006.
56. New Directions In Internet Congestion Control: Quality-of-Service (QoS), Uncooperative Users, Large Bandwidth-Delay and Lossy Networks, Invited Seminar, Northwestern University, Evanston, IL, August 28, 2006.
57. New Directions In Internet Congestion Control: Quality-of-Service (QoS), Uncooperative Users, Large Bandwidth-Delay and Lossy Networks, Invited Seminar, Tsinghua University, Beijing, China, August 7, 2006.
58. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, NEC Labs China, Beijing, China, August 7, 2006.
59. New Directions In Internet Congestion Control: Quality-of-Service (QoS), Uncooperative Users, Large Bandwidth-Delay and Lossy Networks, Invited Seminar, Chinese University of Hong Kong (CUHK), Hong Kong, August 5, 2006.
60. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, Nanyang Technological University (NTU), Singapore, August 3, 2006.
61. New Directions In Internet Congestion Control: Quality-of-Service (QoS), Uncooperative Users, Large Bandwidth-Delay and Lossy Networks, Invited Seminar, National University of Singapore (NUS), Singapore, August 2, 2006.
62. Evolution path for WiMax NS-2 Simulator, Invited Talk, WIMAX Forum Members Conference, AATG Working Group, San Diego, CA, July 12, 2006.
63. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, BAE/AIT Systems, Burlington, MA, June 23, 2006.
64. LT-TCP: End-to-End Framework to Improve TCP Performance over Networks with Lossy Channels, Briefing Seminar, MIT Lincoln Laboratory, Lexington, MA, June 22, 2006.
65. Baseline NS-2 WiMax System Simulator, Invited Talk, WIMAX Forum AATG Working Group, F2F Meeting, AT&T Labs, Middletown, NJ, June 1, 2006.
66. Information Technology: Trends and Implications, Invited Seminar, EMBA Program, RPI, Troy, NY, April 22nd, 2006.
67. Experimental Networking Education at RPI, Key Executive Conference: Academic Subcommittee, Troy, NY, April 7, 2006.
68. Proposal for a Baseline NS-2 WiMax System Simulator, Invited Talk, WIMAX Forum Members Conference, AATG Working Group, Orlando, FL, April 4, 2006.
69. LT-TCP: End-to-End Framework to Improve TCP Performance over Highly Lossy MANET Environments, Invited Seminar, Lockheed Martin/ATL, Cherry Hill, NJ, February 21, 2006.
70. WiMax Simulation Framework, Invited Talk, WIMAX Forum Members Conference, AATG Working Group, Paris, France (by phone), February 7, 2006.
71. Tetherless Networking: Towards Ultra-High-Speeds and Disruption-Tolerance and Opportunistic Networks, Presentation to Barry Perlman, DARPA, Commn Electronics, Research Engg Director, RPI, Troy, November 28th, 2005
72. Error Control and Traffic Control, Faculty Opponent Presentation, KTH Royal Institute of Technology, Stockholm, Sweden, November 11th, 2005.
73. New Directions In Internet Congestion Control: Quality-of-Service (QoS), Uncooperative Users, Large Bandwidth-Delay and Lossy Networks, Invited Seminar, KTH Royal Institute of Technology, Stockholm, Sweden, November 10th, 2005.

74. A Sampling of RPI Research in Tetherless Networking Technologies, RPI ECSE Advisory Committee Talk, Troy NY, October 18th, 2005.
75. A Sampling of RPI Research in Tetherless Networking Technologies, RPI FundRaising Talk to Lou Bellardo (Cisco Systems), Troy NY, September 28, 2005.
76. Free-Space-Optical Mobile Ad-Hoc Networks (FSO-MANETS), Presentation to Lockheed Martin, Troy NY, September 27, 2005.
77. Free-Space-Optical Mobile Ad-Hoc Networks (FSO-MANETS), DARPA CBMANETs Proposers Day Conference, Arlington, VA, August 30th, 2005.
78. LT-TCP: End-to-End Framework to Improve TCP Performance over Networks with Lossy Channels, MIT Lincoln Labs and Airborne Networks AFOSR Program, Lexington, MA, August 10th, 2005.
79. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Seminar, Dept of EE and CEDT, Indian Institute of Science (IISc), Bangalore, India, June 16th, 2005.
80. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Seminar, Bell Labs, Lucent Technologies, Bangalore, India, June 15th, 2005.
81. Quality-of-Service (QoS) over Best-Effort Networks, Keynote Lecture, Technology Day, Tata Consulting Services (TCS) Reseach, New Delhi (Gurgaon), India, June 8th, 2005.
82. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Talk, Indian Institute of Technology (IIT), Mumbai, India, June 6th, 2005.
83. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Talk, Microsoft Research, Bangalore, India, June 3rd 2005.
84. High Speed Router Design, Invited Full-Day Tutorial, HCL Technologies, Chennai, India, May 20th 2005.
85. Voice-over-IP, SIP and Quality-of-Service (QoS), Invited Full-Day Tutorials, Tata Elxsi, Bangalore, India, May 4-5th 2005.
86. Transport-Level (TCP) Hybrid ARQ and MAC Scheduling Policies For WiMax Mesh Networks, Invited Seminar, Intel Corporation, Hillsboro,OR, March 31st, 2005.
87. Building Blocks for Mobile Free-Space-Optical Networks, Talk at IFIP/IEEE International Conference on Wireless and Optical Communications Networks (WOCN), Dubai, United Arab Emirates, March 8th 2005.
88. Towards Ultra-High-Speed Wireless Distribution Networks, Panel Presentation at IFIP/IEEE International Conference on Wireless and Optical Communications Networks (WOCN), Dubai, United Arab Emirates, March 7th 2005.
89. Multi-Element Array Antennas for Free-Space-Optical Communication, Talk at IFIP/IEEE International Conference on Wireless and Optical Communications Networks (WOCN), Dubai, United Arab Emirates, March 7th, 2005.
90. A Geography-Aware Scalable Community Wireless Network Test Bed, Talk at IFIP/IEEE Testbeds and Research Infrastructures for the Development of Networks and Communities (TRIDENTCOM), Trento, Italy, February 24th 2005.
91. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Talk, IEEE-ComSOC, Rochester Institute of Technology (RIT), December 7, 2004.
92. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Talk, Northeastern University, December 2, 2004.
93. Building Blocks for Engineering QoS Expectations over Best-Effort Networks, Invited Talk, Boston University, December 1, 2004.
94. Overlay Multi-hop FEC scheme for Video Streaming over Peer-to-Peer Networks, International Conference on Image Processing (ICIP), Singapore, October 2004.
95. Efficient Path Aggregation and Error Control for Video Streaming, International Conference on Image Processing (ICIP), Singapore, October 2004.
96. Intel IXA and Experimental Networking Education at Rensselaer, Intel IXA Workshop, Hudson, MA, September, 2004.
97. Infrastructure Mesh Wireless Networks (IWMNs) Intel Research Workshop, Portland, OR, April 2004.
98. Overlay QoS using Closed-Loop Control and Multi-Paths, DARPA PI Meeting, January 2004.
99. Ultra-High-Speed Wireless Last-Mile Networks, NSF Broadband Workshop, Chicago, IL, Oct 25, 2003.

100. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, UC Riverside, Riverside, CA, 2003.
101. Generalized Multicast Congestion Control, International Workshop on Network Group Communications (NGC 2003), Munich, Germany, September 2003.
102. Integrated end-to-end buffer management and congestion control for scalable video communications, IEEE ICIP'03, Barcelona, Spain, September 2003.
103. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, SIGCOMM Future Directions on Network Architectures (FDNA) Workshop, Karlsruhe, Germany, August 2003.
104. Online and Distance Educational Intiatives at Rensselaer, SIGCOMM NetEd03 Workshop, Karlsruhe, Germany, August 2003.
105. BANANAS Traffic Engineering and Ultra-High-Speed Wireless Networking, Telcordia Technologies, Morristown, NJ, July 2003.
106. Traffic Management: Protocols and Tools, AT&T Labs Research, Basking Ridge, NJ, June 2003.
107. Overlay QoS, DARPA PI Meeting, San Diego, CA, May 2003.
108. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, France Telecom, Paris, France, March 2003.
109. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, Institut Eurecom, Sophia Antipolis, France, March 2003.
110. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, Politechnico di Torino, Torino, Italy, March 2003.
111. Overlay QoS using Closed-Loop Control, INRIA, Sophia Antipolis, France, March, 2003.
112. BANANAS: A Connectionless Framework for Traffic Engineering in the Internet, UC Berkeley, Berkeley, CA, 2003.
113. Overlay QoS using Closed-Loop Control: Expected Minimum Rate Service, DARPA NMS PI Meeting, Chicago, IL, November 13th, 2002.
114. Overlay Network Services: New QoS and Traffic Engineering Techniques, IEEE Computer Communications Workshop (CCW), Santa Fe, NM, October 17th 2002.
115. Low-Power Low-Cost Multi-Hop Hybrid Optical/RF Sensor Networks, First IEEE Upstate NY Workshop on Sensor Networks, Syracuse NY, October 11th, 2002.
116. A Closed-Loop Scheme for Expected Minimum Rate (QoS) Service, University of Illinois at Urbana Champaign (UIUC), Champaign, IL, October 7th, 2002.
117. A Connectionless Approach to Intra- and Inter-Domain Traffic Engineering, Second NY Metro Area Networking Workshop, Columbia University, New York City, September 3rd, 2002.
118. ACM SIGCOMM Workshop on Computer Networking Curriculum Designs and Educational Challenges, Chair of Breakout Session on Lab Courses, Pittsburgh, August 20th, 2002.
119. Connectionless Traffic Engineering: Towards Better Building Blocks, AT&T Labs Research, Murray Hill, NJ, August 15th, 2002.
120. Ultra-High-Speed (100 Mbps - 100 Gbps) Wireless Distribution Networks, Intel Architecture Lab, Portland, OR, June 5th, 2002.
121. Overlay Network Services: New QoS and Traffic Engineering Techniques, Intel Architecture Lab, Portland, OR, May 30th, 2002.
122. Ultra-High-Speed (100 Mbps - 100 Gbps) Wireless Distribution Networks, DARPA Director (Tony Tether) Visit, Troy, NY, May 16th, 2002.
123. Connectionless Traffic Engineering: Towards Better Building Blocks, Lucent Bell Labs, Murray Hill, NJ, May 9th, 2002.
124. Edge-based Traffic Management Building Blocks for Overlay QoS, DARPA NMS PI Meeting, Baltimore, MD, April 19th, 2002.
125. Edge-based Traffic Management Building Blocks for The Internet, University of Massachussets at Amherst, Amherst, MA, March 27th 2002.
126. Performance Optimization of TCP/IP over Asymmetric Wired and Wireless Links, European Wireless (EW 2002), February 27th, 2002, Florence, Italy.
127. Edge-based Traffic Management Building Blocks for The Internet, Politecnico Di Milano, February 25th, 2002, Milan, Italy.
128. Load Balancing Traffic in a BGP Environment Using On-line Simulation and Dynamic NAT Techniques, Internet Statistic and Metrics Analysis (ISMA) Winter Workshop on Routing Data and Analysis, San Diego, CA, 17th December, 2001.

129. Analytic Models for the Latency and Steady-State Throughput of TCP Tahoe, Reno and SACK, IEEE Globecom'2001, San Antonio, TX, 27th November, 2001, with Biplab Sikdar.
130. Scalable Online Simulation for Network Management, DARPA NMS PI meeting, Atlanta, GA, 22nd October, 2001.
131. Edge-based Traffic Management Building Blocks for The Internet, Intel, Chandler, AZ, 5th October, 2001.
132. Congestion-control as a building block for QoS, ACM SIGCOMM Poster Session, San Diego, CA, 28th August, 2001.
133. Edge-based Traffic Management Building Blocks for The Internet, Microsoft Research, Redmond, WA, 17th August 2001.
134. Edge-based Traffic Management Building Blocks for The Internet, California Institute of Technology, Pasadena (Caltech), Lee Center Seminar Series, 17th June 2001.
135. Edge-to-edge Overlay QoS and Joint Source-Channel Coding (JSCC) on Internet 2, Internet 2 Research Workshop, April 18/19, 2001, Chicago, IL. (Joint talk with Jim Modestino)
136. Edge-based Traffic Management Building Blocks for The Internet, University of California, Los Angeles (UCLA), 5th April 2001.
137. QoS and Overlay Networks, DARPA NMS PI meeting, San Diego, CA, April 4th 2001.
138. Edge-based Traffic Management Building Blocks for The Internet, Massachussetts Institute of Technology (MIT) Laboratory for Computer Science (LCS), Cambridge, MA, 15th March 2001.
139. Edge-based Traffic Management Building Blocks for The Internet, Intel Architecture Labs, Portland, OR, 7th March 2001.
140. Edge-based Traffic Management Building Blocks for The Internet, Carnegie Mellon University (CMU), Pittsburg, PA, 1st March 2001.
141. Edge-based Traffic Management Building Blocks for The Internet, Univ of Pennsylvania, Center for Telecommunications, Philadelphia, PA, 7th Feb 2001.
142. Edge-based Traffic Management Building Blocks for The Internet, University of California, Berkeley, CA, 19th Jan 2001.
143. Edge-based Traffic Management Building Blocks for The Internet, Nortel Networks, Ottawa, Canada (by teleconference), 24th Jan 2001.
144. Traffic Management for the Next Generation Internet, IBM Site Visit, 11th Jan 2001.
145. Edge-based Traffic Management Building Blocks for The Internet, RPI, CS Colloquim, Troy, NY, 10th Jan 2001.
146. Edge-based Traffic Management (TM) Building Blocks for The Internet, Purdue University, Lafayette, IN, 20th Dec 2000.
147. Edge-based Traffic Management (TM) Building Blocks for The Internet, Columbia University, New York, NY, 6th December 2000.
148. Hierarchical Packet Shaping Technology, Talk at Packeteer, Inc., San Jose, CA, 1 Dec 2000.
149. Scenarios for 2050: After the BT/IT Revolution, Trustee/Faculty Dinner: Panelist with Paul Severino and other trustees, 30 Nov 2000.
150. Source-based Multicast Congestion Control, Invited Poster/Presentation at NGC'2000, Stanford, CA, 9th Nov 2000.
151. Traffic Management Building Blocks for the next generation Internet, Motorola Research, Arlington, IL, 11th August, 2000.
152. Source Multicast CC for NAK-based transport protocols, IETF Pittsburg, Pittsburg, PA, 1st August 2000.
153. Generic Source-based Multicast Congestion Control (GSC), ISI East/RMRG, Arlington, VA, 28th July 2000.
154. Edge-based services for VPNs, Global Crossing, Sunnyvale, CA, 20th July 2000.
155. Online Simulation for Network Management: Closing Report, DARPA, Arlington, VA, 18th July 2000.
156. Traffic Management Building Blocks for the next generation Internet, Invited Talk at Telcordia Technologies (Bellcore Labs), Morristown, NJ, 14th July 2000.
157. Traffic Management Building Blocks for the next generation Internet, Invited Talk at IBM TJ Watson Labs, Hawthorne, NY, 13th July 2000.
158. TCP-Friendly Traffic Marker for IP Differentiated Services, International Workshop on Quality of Service (IwQoS'2000), Pittsburg, PA, June 2000.

159. Generic Source-based Congestion Control Algorithm for Reliable Multicast, Invited presentation to IETF RMT Working Group, Berkeley CA, February 10th, 2000.
160. Network Management and Control using Collaborative Online Simulation, DARPA PI meeting, Washington DC, December 16th, 1999.
161. TCP/IP over ADSL, Invited talk at Pulsecom, Herndon, VA, December 14th, 1999.
162. Networking Research at Rensselaer, Invited presentation to Telcordia Technologies, November 19th, 1999.
163. Edge-to-edge Congestion Control, Invited Talk at Nortel Networks Research Conference, Ottawa, Canada, October 28th, 1999
164. Traffic Management for the Next Generation Internet, Invited Talk at SUNY Albany, Dept of CS, October 19th 1999.
165. Feedback-based Congestion Control for the Next-Generation Internet, Invited Talk at Ohio State University, Dept of EE, September 30th, 1999.
166. Protocol Issues for 10Gb/s Ethernet LANs, Invited Talk at Cisco Systems, Optical Internetworking Group, Ottawa, Ontario, Canada, Sept 14th, 1999.
167. Content-customization for Broadband End-users through Server-side Enhancements , Invited Talk at Amazon.com, Seattle, WA, July 23rd, 1999.
168. Congestion Control for the Next-Generation Internet, Invited Talk at Motorola Research, Schaumberg, IL, July 22nd, 1999.
169. QoS building blocks in Internet and ATM Standards, Invited Talk at xDSL Comforum, Chicago, IL, July 21st, 1999
170. Traffic Management for the Next Generation Internet, Invited Talk at Tata Consultancy Services Research Division (TRDDC), Pune, India, June 24th, 1999.
171. Hot Topics in Internetworking, Invited Talk at Infosys Ltd, Bangalore, India, June 17th, 1999.
172. IP Telephony, Invited Talk at BPL Telecom Ltd, Bangalore, India, June 16th, 1999.
173. Hot topics in Internetworking, Invited Talk at Tata Elxsi Ltd, Bangalore, India, June 14-15th, 1999.
174. Using Differentiated Services to Build a Multi-service backbone in India, Invited Talk at Worldtel. Ltd and Satyam Infoway Ltd, Chennai, India, May 31st, 1999.
175. Internet Protocols, Short Course at Indian Institute of Science, Bangalore, India, May 17-28th, 1999.
176. Virtual Private Networks based upon Packeteer TCP Rate Control, Invited Talk at Packeteer, Inc., March 9th 1999.
177. Problems in Feedback-based Congestion Control for the Next Generation Internet, Invited Talk at Intel, Portland, Oregon, March 3rd 1999.
178. Differentiated Services and Multi-protocol Label Switching (MPLS), Invited Talk at Tellabs, Inc., March 1st 1999.
179. Virtual Private Networks: Building Blocks, Invited Talk at Sprint, Herndon, VA, 14th February 1999
180. TCP Friendly Traffic Conditioners, Talk at IETF, March 1999, Minneapolis, MN.
181. Internet performance on a variable capacity channel with millions of flows, Talk at IETF, Dec/Jan 1998, Orlando, FL.
182. Internet Traffic Management, Invited Seminar in Nokia, Cisco Systems, Bay Networks, Reuters, Torrent Network Technologies, NIST, Summer 1998.
183. Congestion Control for the Available Bit Rate (ABR) Service in Asynchronous Transfer Mode (ATM) Networks, Joint Seminar by Dept of CSA, ECE, SERC, CEDT, Indian Institute of Science, Bangalore, India, 1997.
184. Introduction to ATM Networks, Invited presentation at Infosys Co., Bangalore, India (Dec 1994) and at NRSA, Hyderabad, India (Dec 1996).

Research Grants and Contracts: (Selected)

1. *Collaborative Research: FIND:* Value Flows and Risk Management Architecture for Future Internet, co-PI (lead-PIs: Aparna Gupta, Murat Yuksel (UNR)),
   Time of award: September 2007 - August 2010 (3 years),
   Funds: RPI total funds $270,000,
   Program: National Science Foundation (NSF), Networking Technology and Systems (NeTS), Networking Broadly Defined (NBD) Program.

2. *Collaborative Research: NeTS-NBD: Free-Space-Optical Mobile Ad-Hoc Networks (FSO-MANETs),* co-PI (lead-PIs: Mona Hella, Murat Yuksel (UNR)),
Time of award: September 2007 - August 2010 (3 years),
Funds: RPI total funds $270,000,
Program: National Science Foundation (NSF), Networking Technology and Systems (NeTS), Networking Broadly Defined (NBD) Program.

3. *Real-Time Video Distribution*, Sole PI,
Time of award: November 1, 2006 -- December 31, 2007 (1 year),
Funds: RPI total funds $35,000
Program: AT&T Labs Research, Sponsors: Drs. K.K. Ramakrishnan, Chuck Kalmanek

4. *NeTS-NBD: Towards a Disconnection-Tolerant, Opportunistic Internet,*
lead-PI (co-PIs: Alhussein Abouzeid, Petros Drineas, Murat Yuksel),
Time of award: September 2006 - August 2009 (3 years),
Funds: RPI total funds $415,000
Program: National Science Foundation (NSF), Networking Technology and Systems (NeTS), Networking Broadly Defined (NBD) Program.

5. *A NS-2 WiMax System Simulator*,
lead-PI, (co-PI: Biplab Sikdar),
Time of award: August 15, 2006 -- December 31, 2007
Funds: RPI total funds $135,900,
Program: WIMAX Forum (an international consortium of companies for the next generation broadband wireless standard, Wimax),

6. *Robust TCP for Airborne Networks*,
Sole PI (till summer 2007), co-PI with Koushik Kar from Fall 2007
Time of award: March 6, 2006 -- March 5, 2009 (3 years),
Funds: RPI total funds $559,260,
Program: AFOSR Airborne Networks Program, Sub-Contract through MIT Lincoln Laboratories,

7. *NeTS-NR ROSS.Net: A Platform for Integrated Large-Scale Network Design of Experiments and Simulation*,
lead-PI (co-PI: Christopher Carothers),
Time of award: September 2004 - August 2008 (4 years),
Funds: RPI total funds: $350,000
Program: National Science Foundation (NSF), Networking Technology and Systems (NeTS), Networking Research (NR) Program.

8. *Net Neutrality: A Quantitative Model of Key Issues*,
Sole PI
Time of award: May 2006 -- April 2007 (1 year),
RPI total funds: $50,000
Program: AT&T Foundation, AT\&T Sponsor: Helen McGrath

9. Joint Source-Network Coding for Video over Multi-Hop Mobile Ad-Hoc Wireless Networks,
co-PI (lead PI: John Woods),
Time of award: September 2004 - August 2007 (3 years),
RPI total funds: $500,000
Program: Electronics Division, US Army Research Office (ARO)

10. *IGERT: Terahertz Science and Technology - A Studio -Based Approach*,
co-PI (Lead PI: Gwo-Ching Wang; co-PIs: Xi-Cheng Zhang, Michael Shur, Toh-Ming Lu),
Time of award: September 2003 - August 2008 (5 years),

RPI total funds: $3,860,000
Program: National Science Foundation (NSF) Integrative Graduate Education and Research Traineeship (IGERT). Funds 15 fellowships to enhance interdisciplinary graduate study in terahertz (THz) science and technology as it relates to imaging, data transfer and networking systems, and electronics.

11. *Tools and Protocols for Internet Traffic Management*,
lead PI,
Time of award: December 2002 -- December 2007 (5 years),
RPI total funds: $250,000, (100K first year, and 50K/year thereafter)
Program: AT&T Labs Joint Research Program, Dr. Robert Calderbank, VP of Research,
AT&T Technical Sponsor: Dr. K.K. Ramakrishnan

12. *ITR: Community Wireless Distribution Networks for Last-Mile Broadband Interconnectivity: An Experimental Research Program*,
lead-PI (co-PI: Biplab Sikdar),
Time of award: September 2003 - August 2006 (3 year),
RPI total funds: $350,000
Program: National Science Foundation (NSF) Information Technology Research (ITR) Small Grants.

13. *Infrastructure Mesh Wireless Networks (IWMNs)*,
co-PI, (co-PI: Biplab Sikdar), competitive gift won from Intel
Time of award: December 1, 2003 -- November 30, 2006 (3 years),
RPI total funds: $180,000, plus
$25,000 worth of PCs and networking equipment,
Program: Intel Corporation, University Research Program,

14. Multi-Hop Free Space Optics Last-Mile Networks Using Very Low-Cost Components,
co-PI (co-PI: Partha Dutta)
Time of award: January 1, 2003 -- December 31, 2005,
RPI funds: $ 510,000
Program: National Science Foundation (NSF) Strategic Technologies for the Internet Program

15. *Measurement-driven Overlay QoS Control using Closed-loop Techniques*,
sole PI,
Time of award: June 1, 2002 -- Jun 1, 2005,
RPI Total funds: $ 510,000,
Program: U.S. Defense Advanced Research Projects Agency (DARPA), Network Management and Simulation (NMS), ITO Program (BAA 00-18).

16. *NSF/ERC Center for Subsurface Sensing and Imaging Systems*,
One of several co-PIs. (Lead RPI PI: James Modestino),
Time of award: June 1, 2000 -- June 1, 2001,
RPI Total funds: $2,250,000,
Program: National Science Foundation (NSF).

17. *Scalable Online Network Modeling and Simulation*,
co-PI (co-PIs: Boleslaw Szymanski, Kenneth Vastola, Christopher Carothers),
Time of award: July 1, 2000 -- June 30, 2003,
RPI Total funds: $ 950,000,
Program: U.S. Defense Advanced Research Projects Agency (DARPA), Network Management and Simulation (NMS), ITO Program (BAA 00-18).

18. *Streaming Video Compression for Heterogeneous Networks*,
co-PI (lead PI: John Woods),

Time of award: July 1, 2000 -- June 30, 2003,
RPI Total funds: $498,506,
Program: Electronics Division, US Army Research Office (ARO).

19. *Network Management and Control Using Collaborative On-line Simulation,*
lead PI (co-PIs: K. Vastola, B. Szymanski)
Time of award: July 15, 1998 -- July 14, 2000 (terminated in 2000),
RPI Total funds: $ 823,642
Program: U.S. Defense Advanced Research Projects
Agency (DARPA), Next Generation Internet (NGI): Network Engineering.

20. *Rate-Based Flow Control Algorithms for High Speed Networks,*
lead PI (co-PI:Hitay Ozbay,Ohio State University)
Time of award: September 15, 1998 -- August 31, 2001,
RPI funds: $383,628, total funds $563,725,
Program: National Science Foundation (NSF) Special Projects in Networking Program

21. *Congestion-sensitive Pricing for the Internet,*
lead PI (co-PI: T. Ravichandran, Lally School, RPI)
Time of award: May 1, 1999 -- April 30, 2002 (3 years),
RPI total funds: $455,984,
Program: National Science Foundation (NSF) Special Projects in Networking Program

22. *Dynamic Edge-based Services for Next Generation ISP Networks,*
sole PI, competitive gift won from Intel
Time of award: October 1, 2000 -- September 30, 2003 (3 years),
RPI total funds: $240,000, plus
$75,000 worth of PCs and networking equipment,
Program: Intel Corporation

23. IBM Shared University Research Grant,
co-PI (w/ Bolek Szymanski),
Time of award: December, 2000 -- November 30, 2001,
Total RPI funds: $168,000 for equipment purchases
Sponsor: IBM SUR.

24. A Performance Study of Reliability and Congestion Control for multicast Applications,
sole PI,
Time of award: October 1, 1998 -- September 31, 1999,
Total RPI funds: $61,186
Sponsor: Reuters, Inc.

25. *Dynamic Provisioning for Point-to-Anywhere Services on IP networks,*
sole PI,
Time of award: August 1, 2000 -- July 31, 2001 (1 years),
RPI total funds: $39,321,
Program: Nortel Networks, Ottawa, Canada

26. *Evaluation of Scalability and Denial of Service Countering Capabilities of TCP Rate-Control,*
sole PI,
Time of award: March 15, 2000 -- December 31st 2000,
Total RPI funds: $39,365
Sponsor: Packeteer Inc.

27. *A Study of TCP/IP and ATM over ADSL,*

sole PI,
Time of award: Dec 1st 1998 -- Dec 1st 1999,
Total funds: $35,566
Sponsor: Pulsecom, Inc..

28. *Comparative Performance Study of TCP Rate Control,*
sole PI,
Time of award: August 1, 1998 -- December 31, 1998,
Total RPI funds: $26,338
Sponsor: Packeteer Inc.

29. *Proactive Problem Avoidance and QoS Guarantees for Large Heterogeneous Networks*,
Participant (PIs: K. Vastola and C. Ji, joint with Lucent Technologies and Penn State University),
Time of award: September 1, 1997 -- August 31, 1999,
RPI funds: $490,711, total funds requested $1,889,005,
Sponsor: U.S. Defense Advanced Research Projects Agency (DARPA), Program in Active and High Confidence Networks.

Research Interests

My research interests have been in the area of computer networking, concentrated around the theme of network traffic management (TM) and high performance tetherless networking. Within this theme, our group at RPI has made contributions in a wide span of topics: congestion control and reliability, quality of service (QoS), high-speed wireless last-mile networks, free-space optical networks, network management, multicast, pricing, multimedia networking, and large-scale performance analysis. These research activities have helped in deepening the content for the academic courses I developed: ``Internet Protocols,'' ``Broadband and Optical Networks,'' ``Experimental Networking,'' and ``Fundamentals of Wireless Broadband Networks.''

My special interest lies in developing the inter-disciplinary areas between traffic management, wireless communication, optoelectronics, control theory, economics, scalable simulation technologies, and video compression. Such interdisciplinary activity shares the core values and contributes to the Information Technology (IT) initiatives at Rensselaer. The inter-disciplinary activity spans *multiple departments and multiple universities* such as ECSE, Computer Science, Lally School of Management, and extends to universities like Ohio State, UIUC, INRIA and UC Berkeley. Strategic collaboration with industry research (Intel, AT&T, Nortel), large DoD integrators (Lockheed Martin, Raytheon) and Federally funded labs (MIT Lincoln Lab) has been a recent focus in my efforts to scale our program through partnerships and DoD funding.

Selected technical contributions with high impact are described below. Publications corresponding to these topics are available from:
http://www.ecse.rpi.edu/Homepages/shivkuma/research/papers-rpi.html
or Google: ``shiv rpi papers''

- **ATM Traffic Management:** Our definitive work in the area of ATM explicit rate congestion control (with Prof. Raj Jain) has influenced the ATM ABR international standards. Our ATM Forum contributions and the ERICA scheme have been incorporated into ATM ABR standards documents (see http://www.cse.wustl.edu/~jain/atmforum.htm). The papers & patents around this work have **1500+ citations**.
- **Edge-based Traffic Management:** We have developed a deep focus on the area of edge-based traffic management (TM). A recent trend in traffic management architecture is a demand for a simpler core network focussing on packet forwarding, and moving complex TM functions to the edge of the network. However, the design of these edge-based mechanisms is non-trivial, involving a mix of control theory, estimation techniques, measurement and tomography. Examples

include overlay QoS using closed-loop control, emulation of AQM functions (randomization, queue control) from the edge, edge-based control of uncooperative users, point-to-set QoS provisioning, edge-based VPN provisioning using measurements (with AT&T), and TCP rate control (with Packeteer).

- **Transport Protocols for Lossy and Disruption-Prone Networks:** As wireless networks become pervasive and higher speed, it is important for TCP (the dominant transport protocol) to handle vagaries of wireless channels, specifically losses and disruptions over multiple time-scales. Our Loss-Tolerant TCP (LT-TCP) work for wireless networks with Dr. K.K. Ramakrishnan (AT&T Research) is setting an emerging benchmark in this area. It has attracted interest from AFOSR (for airborne networks), DARPA (cross-layer design for extreme wireless ad-hoc networks) and commercial groups (WiMax Forum, IEEE 802.11n standards, IETF end-to-end research group). The technical ideas include adaptive estimation of loss conditions, adaptive segment sizing and just-in-time FEC overhead organized in a proactive and reactive fashion.
- **Multimedia Networking:** We have developed a focus in joint source-network coding and protocol integration for scalable video streaming in overlay, peer-to-peer and wireless networks. Our collaboration with Prof. John Woods in the image processing area, funded by ARO, has led to a number of recognized innovations in flexibly integrating new scalable video coders with error control coding and network protocols such as congestion control, multipath routing, overlay multicast and cross-layer protocol design. Quality gains are remarkable (10+dB) across the board.
- **Modeling and Control-Theoretic Work for Congestion Control**: Congestion control lends itself to multiple modeling approaches: stochastic, optimization and control-theoretic. We have made contributions using all these approaches. Stochastic models include TCP SACK stochastic models, end-system randomization and AQM analysis. Optimization framework modeling has been used for accumulation-based congestion control, QoS emulation, uncooperative congestion control and for a 2-bit congestion control design for large bandwidth-delay product networks. Control-theoretic models include H-infinity models for time-delay systems (with Prof. Hitay Ozbay, OSU), and non-linear control techniques (two-timescale design, small gain approaches) to model the dynamics and robustness of uncooperative congestion control and edge-based AQM designs (in part with Profs. John Wen and Murat Arcak, RPI). We are considering a mix of information- and control-theoretic models to investigate the impact of information increase or distortion in feedback, building on our work in explicit rate control and our ACM SIGCOMM paper (``one more bit is enough" in collaboration with Ion Stoica, UC Berkeley; **175+ citations**). These techniques become important as we push the internet to scale to large bandwidth delay product systems, move functions to edges and depend upon unreliable estimation at small time-scales, or deal with disruptions and performance volatility in multi-hop wireless networks at multiple time-scales.
- **Multicast congestion control:** We have made important contributions to end-to-end single- and multi-rate multicast congestion control. Multicast congestion control is more complex than unicast control because it needs to filter the feedback from multiple receivers and track the worst path (for the single-rate case), or meet the needs of heterogeneous receivers without rapid join/leaves (for the multi-rate case). We have built a series of schemes that effectively tackle the filtering problem for the single-rate case and a generalized multicast congestion control (GMCC) scheme that composes multi-rate schemes using single-rate schemes in a modular fashion with low join/leave overhead.
- **Large-scale and Online Performance Analysis Tools**: Drawing on the performance analysis tradition of my PhD advisor Prof. Raj Jain, and inspired by the work of Sally Floyd/Vern Paxson on why it is hard to simulate the internet, we have explored the area of large-scale and online performance analysis. In a series of DARPA-funded programs, we showed how large-scale experiment design using a recursive random search (RRS) method can be used to find good results fast for a variety of network management problems. We have combined this technique with a new large-scale simulation platform (ROSS) in an NSF project to start systematically exploring performance interactions between large-scale protocols using large-scale measurement-driven inputs. Our RRS technique has also found application in a bioimaging application (automated segmentation of retina images). Our DARPA projects also led to the formation of a startup company, Premonitia Inc., on proactive network management. These projects also significantly

influenced the content of my new course on experimental networking, and my MBA degree to facilitate future technology transfer efforts.

- **Free-Space-Optical and Community Wireless Networks**: In collaboration with a Partha Dutta in the microelectronics group (funded by NSF Strategic Technologies for the Internet program), we have opened up the area of free-space-optical (FSO) wireless ad-hoc networks. FSO using emerging optoelectronic devices (high brightness LEDs and large-area photodetecttors) offers unique possibilities: ultra-high capacities, low power, small form factors and low-cost; but it needs line-of-sight alignment and compensation for weather- or transient obstacle-induced errors. This project is unusual because we had to start from the physical layer (auto-configuration innovations) and then build up link and network layers. This work is now transitioning into a strategic collaboration with Lockheed Martin to put the technology on UAV platforms (and approaching DARPA for seedling support). Another NSF-ITR project (with Biplab Sikdar) involves building auto-configurable community wireless networks by leveraging cheap directional antennas, distributed traffic engineering, loss-tolerant transport protocols (see earlier bullet), and hybrid geographic/topology routing to lower costs and increase capacity. Our well-cited ACM Mobihoc 2003 paper studies the theoretical capacity improvement with directional antennas based upon the celebrated Gupta/Kumar paper, and has influenced RAND Corporation's report ``Future Army Bandwidth Needs and Capabilities" (see: http://www.rand.org/pubs/monographs/2004/RAND_MG156.sum.pdf , pg 8). Our cooperative combining FEC scheme (ICC 2005) can be combined with new opportunistic routing proposals from the GRID project at MIT. These projects have helped build my Broadband and Optical Networks class, and in securing an NSF IGERT grant. Our efforts have also attracted the attention of WIMAX Forum for whom we are developing a simulation model of the high-speed Wimax network protocols.
- **Pricing and Options for QoS:** In collaboration with Ravichandran (Lally School of Mgmt, RPI) and Aparna Gupta (Dept of Decision Sciences, RPI), and supported by an NSF interdisciplinary grant, we have applied short-term contracting and spot/options pricing techniques to manage the risk and congestion-costs of QoS contracts. This work also motivated me to pick up an Executive MBA degree, and in part facilitating the placement of some of my graduate students in Wall Street firms. Recently we have also secured a NSF FIND (Future Internet Design) grant based upon the work on options pricing of QoS contracts.
- **New Topics: Disruption Tolerance, Vehicular Networks:** Recently we have gotten interested in Disruption Tolerant Networks. One theme is to build disruption tolerance into link and transport layers (collaboration with AT\&T). With RPI collaborators (Alhussein Abouzeid, Petros Drineas and Murat Yuksel) we have a new NSF grant to systematically study the use of guided random walks in large-scale time-varying graphs. We will be studying the mathematical properties of such random walks using tensor models and information theoretic techniques. In collaboration with Prof. Satish Ukkusuri in the Civil Engg department, we are combining transportation traffic management (of vehicles) with ad-hoc opportunistic networking.

Our work has been published in a variety of forums: networking conferences and journals (eg: IEEE/ACM Transactions on Networking, ACM SIGCOMM, IEEE INFOCOM, ACM SIGMETRICS, ACM Internet Measurement Conference (IMC), ACM MOBIHOC, IEEE ICC & GLOBECOM, Computer Networks Journal, Performance Evaluation journal), Simulation and Parallel and Distributed Systems conferences (eg: ACM PADS, IEEE Transactions on Parallel and Distributed Systems, IEEE CNDS, WSC etc), Multimedia, Image and Signal processing, and Control-Theory forums (IEEE ICIP, IEEE CDC, IEEE ACC, Automatica Journal, MMDS, IEEE Transactions on Image Processing). We expect this trend to continue.

Like any university research group, our group depends upon the strengths, synergies, energy levels and execution focus of our students. In steady state, our group tends to have 5-6 PhD students and 1-2 post-docs. MS and BS students also actively participate in the group. Execution discipline is maintained by targeting a paper submission every semester.

Program funding comes from diversified sources including Federal (NSF, DARPA, ARO, AFOSR) and Industry (AT&T, WIMAX Forum and Intel) funds. We are actively setting up partnerships with DoD system integrators like Lockheed Martin, Raytheon and federally funded labs like MIT Lincoln Labs to be able to contribute and get funded in DARPA ATO and other DoD 6-2 (advanced systems) programs. Technology transfer is facilitated through industry partnerships, international standards activities and startup efforts (eg: Premonitia for our network management work). With my Executive MBA degree, I anticipate more entrepreneurial spinoffs and working with centers like CAT and SBIR/STTR type technology transfer modes.

The research work and the literature surveys done for PhD theses directly feeds through into courses (Internet Protocols, Broadband and Optical Networks, Experimental Networking, Fundamentals of Wireless Broadband Networks (newest course)). Outreach for our research includes online dissemination of papers and powerpoint talks. I have also experimented with audio talks online. Invited talks worldwide have also helped cement the reputation of our group. In addition to vibrant student intern programs with companies like AT\&T and Intel, I have also experimented with student exchanges with institutions such as INRIA (France), Ecole Polytechnic (France), Chinese University of Hong Kong (CUHK), University of California, Berkeley and Northestern University.

My research program was recognized by **MIT's Technology Review Magazine** when it named me one of the **top 100 young innovators for the next millenium**. RPI named me as the recipient of the **School of Engineering Research award** (2003) and the **Faculty Early Career Award** (2001).