BIOGRAPHICAL SKETCH AND PROFESSIONAL ACTIVITIES
RENSSELAER POLYTECHNIC INSTITUTE
December 1, 2007

Instructions: Type in the information. If you feel that there is significant information about yourself that is not covered by the listed categories, make the necessary additions. Use extra sheets, if necessary.

I.	**Name**	Shivkumar Kalyanaraman	**Department**	Electrical, Computer and Systems Engineering (ECSE)
	Current Rank	Professor	**School**	Engineering

Year and rank of first academic appointment at Rensselaer (e.g., instructor, assistant, associate, or full professor). Give dates and rank for subsequent promotions.

July 1, 2006 - current: Full Professor

December 2001 - June 2006: Associate Professor

August 1997 - December 2001: Assistant Professor

1998 - Present, Courtesy Joint Appointment to Dept of Computer Science as Associate Professor (current).

1998 - Present, Joint Appointment to the Faculty of Information Technology as Associate Professor (current).

Date of Birth: April 30, 1971

Educational Preparation

1. **Baccalaureate and graduate degree(s), institution, date**

   Executive MBA (EMBA), Lally School of Management and Technology, Rensselaer Polytechnic Institute, Troy, NY, U.S.A., 2005.

   Ph.D., Computer and Information Sciences, The Ohio State University, Columbus, OH, U.S.A., 1997.

   M.S., Computer and Information Sciences, The Ohio State University, Columbus, OH, U.S.A., 1994.

   B.Tech., Computer Science, Indian Institute of Technology (I.I.T), Madras, India, May 1993.

2. **Non-degree preparation**

   None

II. PROFESSIONAL EXPERIENCE

(Give postdoctoral, teaching, industrial, governmental, and private practice experience prior to joining Rensselaer, giving position, employer, and dates.)

None.

III. TEACHING

A. Courses

(List the number and title of each course taught and approximate number of students in each course; include undergraduate project supervision and courses that you have supervised with the number of instructors and students involved.)

ECSE-6600, *Internet Protocols*, 29 students, Spring 2007. IDEA: 3.5 (out of 5.0).

ECSE-6961, *Fundamentals of Wireless Broadband Networks*, 24 students, Spring 2007. IDEA: 3.3 (out of 5.0).

ECSE-4690/6966, *Experimental Networking*, 21 students, Fall 2006. IDEA: 4.1 (out of 5.0).

ECSE-6600, *Internet Protocols*, 30 students, Spring 2006. IDEA: 4.2 (out of 5.0).

ECSE-4963, *Experimental Networking*, 15 students, Fall 2005. IDEA: 3.8 (out of 5.0).

Sabbatical and Parental Leave Fall 2004, Spring 2005 (no teaching). Sabbatical at Dept of CS, University of Massachussetts, Amherst (visiting Prof. Jim Kurose).

ECSE-6600, *Internet Protocols*, 50 students, Spring 2004. IDEA: 4.3 (out of 5.0).

ECSE-4963, *Experimental Networking*, 20 students, Fall 2003. Second offering of a new laboratory/studio course. Very popular with students. IDEA: 4.7 (out of 5.0).

ECSE-6660, *Broadband Networking*, 60 students, Spring 2003. Major revision of course and renamed it as "Broadband and Optical Networking." First time teaching this class. This course is one of the portfolio of courses in the $3.8 million NSF IGERT program (see section V, research contracts). IDEA: 4.6 (out of 5.0).

ECSE-4963, *Experimental Networking*, 20 students (first time offering this course), Fall 2002. A laboratory course designed over the last 2 years, and with $150,000 worth of donations from industry (Intel, Cisco, CAIDA). IDEA: 4.8 (out of 5.0). This course is one of the portfolio of courses in the $3.8 million NSF IGERT program (see section V, research contracts).

ECSE-6600, *Internet Protocols*, 80 students, Spring 2002. IDEA: 4.2 (out of 5.0).

ECSE-4670, *Computer Communications Networks*, 135 students, Fall 2001. IDEA: 4.2 (out of 5.0)

ECSE-6600, *Internet Protocols*, 125 students, Spring 2001. IDEA: 4.3 (out of 5.0)

ECSE-2610, *Computer Components and Operations*, 150 students, Fall 2000. IDEA: 3.0 (out of 5). The dean and department chair agreed that this rating was not representative due to factors outside the control of instructors (self and Badri Roysam).

ECSE-6600, *Internet Protocols*, 65 students, Spring 2000. IDEA: 4.5 (out of 5.0)

ECSE-4670, *Computer Communications Networks*, 75 students, Fall 1999. IDEA: 4.0 (out of 5.0).

ECSE-6961, *Internet Protocols*, 90 students, Spring 1999. (RSVP/PDE course). IDEA: 4.5 (out of 5.0)

35.473, *Computer Systems Architecture*, 86 students, Fall 1998. TBP: 2.9 and 3.1 (out of 4.0)

35.6961, *Internet Protocols*, 35 students, Spring 1998. TBP: 3.3 and 3.4 (out of 4.0)

35.473, *Computer Systems Architecture*, 90 students, Fall 1997. TBP: 1.8 and 1.6 (out of 4.0)

B. Student Thesis Supervision, Post-Doctoral and Visiting Students

(List student's name, title of thesis and year completed.)

1. Doctoral Theses Supervised

(After listing these, add the number of theses in which you participated as a committee member.)

GRADUATED Ph.D. STUDENTS

1. **David Harrison (CS)**, *Edge-to-edge Control: A Congestion Avoidance and Service Differentiation Architecture for the Internet,*, defended Fall 2001. Currently: Bittorrent Inc, CA (a top video distribution p2p company. Formerly: Post-Doctoral Fellow, University of California, Berkeley, CA).
2. **Murat Yuksel (CS)**, *Architectures for Congestion-Sensitive Pricing of Network Services,*, defended Summer 2002. **Currently: Tenure-Track Assistant Professor, University of Nevada, Reno.** (Formerly, Post-Doctoral Fellow, RPI).
3. **Hema Tahilramani Kaur (ECSE)**, *Traffic Sensitive Routing and Traffic Engineering,* defended Fall 2002. Co-advised with Prof. Ken Vastola. Currently: Intel Corp, OR.
4. **Ye Tao (ECSE)**, *Large-Scale Network Parameter Configuration Using On-line Simulation Framework*, defended Spring 2003. Currently: Goldman-Sachs, NY.
5. **Li Jiang (CS)**, *End-to-End Multicast Congestion Control and Avoidance,* defended Summer 2003. **Currently: Assistant Professor, Howard University, Washington DC**.
6. **Karthikeya Chandrayena (ECSE)**, *Novel Placement of Congestion Control Functions in the Internet,* defended Spring 2004. Currently: Cisco Systems, San Jose, CA.
7. **Satish Raghunath (ECSE)**, *Edge-based Point-to-Multipoint Quality of Service Guarantees in Private Networks*, defended Spring 2004. Currently: Juniper Networks, Sunnyvale, CA.
8. **Yong Xia (ECSE)**, *Overlay QoS Using Closed-Loop Building Blocks,* defended Spring 2004. **Charles Close Prize Recipient**. Currently: NEC Labs China, Beijing. (formerly Microsoft, Redmond, WA).
9. **Stephen Fitzhugh (ECSE)**, *Explicit Rate Congestion Management for Packet Switched Networks,* defended Spring 2004. **Currently: Assistant Professor, Norwich University, VT**.
10. **Omesh Tickoo (ECSE)**, *End-to-end Solutions for Efficient Real-time Transmission over Resource Deficient Networks*, defended Spring 2005. Currently: Intel Corporation, Hillsboro, OR.

11. **David Bauer (CS)**, *Meta-Simulation Design and Analysis for Large-Scale Networks* defended Fall 2005. Co-advised with Prof. Christopher Carothers. Currently: MITRE Corp., VA.
12. **Su Yi (ECSE)**, *Error Control Schemes and Directional Antennas in Wireless Networks*, defended Fall 2005. Currently: Turin Networks, CA.
13. **Jayasri Akella (ECSE)**, *Building Blocks for Multi-Hop and Mobile Ad-Hoc Networks with Free Space Optics*, defended Spring 2007.
14. **Yufeng Shan (ECSE)**, *Scalable Joint Source-Network Coding of Video*, defended Spring 2007. Co-advised with Prof. John Woods. Currently: Cisco Systems, MA.

IN PROGRESS Ph.D. STUDENTS

15. **Vijay Subramanian (ECSE)**, *Transport Protocols for Wireless Networks*, Completed DQE, Fall 2004. DCE Completed: Fall 2006, Expected graduation: Spring 2008.
16. **Hsin-Yi Shen (ECSE)**, *Cooperative Cross-Layer Design in Wireless Networks: Space-Time Coding, MIMO and Routing*, Completed DQE, (former advisor: Mercado). Expected Graduation: Spring 2008.
17. **Bow-nan Cheng (ECSE)**, *Scalable Community Wireless Networks: Design and Implementation*. Completed DQE, Fall 2005. Expected Graduation: Spring 2008.
18. **Vicky Sharma (ECSE)**, *Robust TCP for Airborne Wireless Networks*, Completed DQE, Fall 2004 (topped DQEs in ECSE). Co-advised with Prof. Koushik Kar. Expected DCE: Fall 2007, Expected graduation Summer 2008.
19. **Utku Gunay-Acer (ECSE)**, *Weak State Routing for Mobile Ad-Hoc and Delay-Tolerant Networks*, Completed DQE, Co-advised with Prof. Alhussein Abouzeid. Expected DCE: Fall 2007, Expected graduation Fall 2008.
20. **Akintayo Holder (CS)**, *Sparse Empirical Models For Large Scale Network Performance Analysis*, New PhD student. Expected Graduation: Fall 2009. Co-Advised with Chris Carothers (CS).
21. **David Brigada (ECSE)**, *Terahertz Free-Space-Optical Communication and Sensing*, Co-advised with X.-C. Zhang, Mona Hella. Expected Graduation Fall 2010.

2. Post-Doctoral Students

1. Murat Yuksel, Fall 2002 - Summer 2006 **[Currently at University of Nevada, Reno as tenure-track Assistant Professor]**. Murat also taught two sections of Signals and Systems in 2002-2003, and CANOS (upto 2006). http://networks.ecse.rpi.edu/ yuksem/
2. Xingzhe Fan, Summer 2005 - Fall 2005. **Currently, University of Miami, EE Dept, as a visiting assistant professor**.
3. Yong Pei, Summer 2002 (post-doctoral fellow). **Now a tenure-track assistant professor, Wright State University, Dayton, OH**. http://www.cs.wright.edu/ ypei/
4. David Harrison, Fall 2002. David also taught two classes (LITEC and Electronics Instrumentation). In Spring 2003 he joined UC Berkeley, Dept of EECS as a post-doc. Currently at Bittorrent, Inc (a top p2p video distribution company).

3. Doctoral Committee Member

1. Sheng Ma, ECSE, Candidacy and final defense 1998, C. Ji, advisor.
2. Anindadeb Dasgupta, Candidacy, 1998. Kenneth Vastola, advisor.
3. Marina Thottan, ECSE, Candidacy and final defense, 1999, Advisor: Chuanyi Ji.
4. Patrick Fry, Candidacy, 1999. Boleslaw Szymanski, advisor.
5. Ragip Kurceren, Candidacy, 1999; and final defense, March 2001. James Modestino, advisor.
6. Philip Vazzola, Candidacy, 2000. Alan Derochers, advisor.
7. Biplab Sikdar, Candidacy and Final Defense, 2001. Kenneth Vastola, advisor.
8. Xusheng Tian, ECSE, Candidacy and Final Defense, April 2002, Chuanyi Ji, advisor.
9. Alan Bivens, Candidacy and final defense, December 2002 and January 2003. Boleslaw Szymanski, advisor.
10. Yong Pei, ECSE, Candidacy and Final Defense, April 2002, Jim Modestino, advisor.
11. Ivan Bajic, ECSE, Candidacy and Final Defense, Summer 2003, John Woods, Advisor.
12. Lisa Shay, ECSE, Candidacy and Final Defense, Fall 2002, Ken Vastola, Advisor.
13. Peter Curran, ECSE, Candidacy and Final Defense, Fall 2002 and Summer 2005, John McDonald, Advisor.
14. Peisong Chen, ECSE, Candidacy and Defense, Spring 2003, John Woods, Advisor.
15. Jun Peng, ECSE, Candidacy and final defense, Fall 2003 and Spring 2004, Biplab Sikdar, Advisor.
16. Yu Liu, CS, Candidacy and final defense, Spring 2003 and Fall 2004, Bolek Szymanski, Advisor.
17. Xingzhe Fan, ECSE, Candidacy and final defense, Spring 2004 and Fall 2004, Murat Arcak, Advisor.
18. Nianjun Zhou (Joe), ECSE, Candidacy and final defense, Spring 2004 and Fall 2004, Alhussein Abouzeid, Advisor.
19. Garrett Yuan, CS, Candidacy and Final Defense, Summer 2004 and Summer 2005, Christopher Carothers, Advisor.
20. Muhammad Amri Abdul Karim, ECSE, Candidacy and Final defense, Spring 2005 and Fall 2005. Badri Roysam, Advisor.
21. Lingyi Zhang, DSES, Candidacy and Final defense, Spring 2005 and Fall 2005. Aparna Gupta, Advisor.
22. Sujatha Sridharan, ECSE, Candidacy and Final defense, Summer 2006 and Fall 2006, Partha Dutta, Advisor.
23. Gerwin Schalk, ECSE, Candidacy and Final defense, Fall 2005 and Fall 2006. Lester Gerhardt, Advisor.
24. Xin Wang, ECSE, Candidacy and Final Defense, Fall 2005 and Spring 2007. Koushik Kar, advisor.
25. Shivani Deshpande, ECSE, Candidacy and Final defense, Fall 2005 and Spring 2007. Biplab Sikdar, advisor.
26. Raj Iyengar, ECSE, Candidacy and Final defense, Fall 2005 and Spring 2007. Biplab Sikdar, advisor.
27. Neeraj Jaggi, ECSE, Candidacy and Final defense, Fall 2006 and Spring 2007. Koushik Kar, advisor.

28. Jing Ai, ECSE, Candidacy, Fall 2006, Alhussein Abouzeid, advisor.
29. LiLi Du, Candidacy, Spring 2007, Satish Ukkusuri, advisor.

4. Bachelors Senior Design Projects Supervised

1. Khem Wanglee, *Design of edge-to-edge ECN in differentiated services networks*, April 1998.
2. Surendra Arora, *Design of edge-to-edge ECN in differentiated services networks*, April 1998.
3. William Matthew Hartley, *Implementation of a firewall for ECSE*, April 1998.
4. Manish Keemtee, *Implementation of an ATM model in the "ns"simulator,* December 1998.
5. Muthla Al-Sayer, *Implementation of an ATM model in the "ns" simulator,* December 1999.
6. Jameel Akari, *Design and Implementation of a Multiprocessor System Using Off-the-shelf components*, April 1999.
7. Umair Aly Hoodbhoy, *Implementation of a edge-to-edge flow control scheme in a Linux Testbed,* December 1999.
8. Adam D Vito, *Implementation of Adaptive RED in a Linux Testbed,* April 2000.
9. Michael Ahrens, *Implementation of Flow RED in a Linux Testbed,* April 2000.
10. Michael Healey, *Implementation of a Multicast Congestion Control Scheme in a Linux Testbed,* April 2000.
11. Nick Lessard, *Implementation of a Large-scale Farmer-Worker Distributed Computing Model*, December 2001.
12. Bradley S. Jonas, *Intel IXP1200 Development of a Simple Switch*, April 2002.
13. Jonathan H. Gunner, *Intel IXP1200 Development of a Simple Firewall*, December 2002.
14. Rahul Dhar, *Experimental Wireless Ad-Hoc Networking*, April 2003. **URP student, Graduate School: CMU**
15. Rohit Agrawal, *Multimedia over Wireless Ad-Hoc Networks*, April 2003.
16. Seth Hinze, *Implementation of BANANAS traffic engineering architecture on the Linux Click Platform*, April 2003, BS Senior Design Project.
17. Alan Leung, *Implementation of BGP modules on the ROSS Simulation Platform*, April 2003, BS Senior Design Project.
18. Edward Sukendar, *Mechanical Implementation of An Auto-Aligning Free-Space-Optical Sphere Design*, April 2003, BS Senior Design Project.
19. Chen Chingpo, *Hardware Design for a Free-space-optical Antenna System*, Fall 2002, BS Senior Design Project.
20. Peter Cheung, *Alignment Circuit Design for a Free-space-optical Antenna System*, April 2003, BS Senior Design Project.
21. David Partyka, *Simulation of Free-space-optical channels in the ns-2 network simulator*, April 2003, BS Senior Design Project.
22. Ryan Jennings, *Optical Wireless: Mechanical Design of A Spherical Auto-Aligning System*, April 2003, BS Senior Design Project.

23. Uman Chan, *Optical Wireless: Circuit Design for High Speed Communication*, April 2003, BS Senior Design Project.
24. Nate Diller, *A multi-channel free-space-optical computer-to-computer communication system: design and implementation*, Summer 2003, BS Senior Design Project.
25. Max Klein, *Initial Design and Implementation of a Community Wireless Network*, Spring 2004, BS Senior Design Project (ECSE), **Recipient of the Founder's Award for top RPI undergraduates. Graduate School: Stanford University.**
26. Lurene Angela Grenier, CS dept, *Implementation of BANANAS on the World-Wide Planetlab Infrastructure*, Spring 2004, BS Senior Design Project.
27. Jim Failla, ECSE, *Interfacing Free-Space Optical (FSO) networks to RF Wireless Networks*, Spring 2004, BS Senior Design Project.
28. Stanley Mak, ECSE, *Free-Space Optical (FSO) network components*, Spring 2004, BS Senior Design Project.
29. Justin Rohrer, ECSE, *Implementation of Autoconfiguring FSO systems* , Spring 2004, BS Senior Design Project.
30. Alex Newman, CS Dept, *Implementation of BANANAS Traffic Engineering Architecture in C#*, Spring 2005, BS Senior Design Project.
31. David Brigada, ECSE, *Implementation of a FSO 3d Sphere Communication System*, Spring 2007. **Recipient of NSF IGERT Fellowship. Graduate School: RPI.**
32. David Doria, ECSE, *Implementation of WIMAX PHY in ns-2*, Spring 2007. **Recipient of the Founder's Award for top RPI undergraduates. Graduate School: RPI.**

5. Masters Theses Supervised

1. Ketan Prabhakar Duvedi, *Performance Evaluation of Explicit Feedback Alternatives for TCP/IP Networks,* December 1997.
2. Ramakrishna Satyavolu, *Improving TCP/IP Congestion Control using Explicit Feedback,* December 1997.
3. Seung Kim, *Matching Quality of Service requirements of Video applications with ATM Network Services,* April 1998.
4. Ping Guo, *Study of HTTP 1.1 vs HTTP 1.0,* April 1998.
5. Yu Jiang, *Study of HTTP 1.1 vs HTTP 1.0,* April 1998.
6. Hitesh Raigandhi, *Implementation of bitmap based loss-recovery in PGM and Overhead Analysis,* December 1998.
7. Xiuping Lu, *Analysis of remote shaping and rate control techniques on TCP performance,* April 1999.
8. Prasad Bagal, *Comparative study of RED, ECN, TCP rate control and edge-to-edge control techniques,* April 1999.
9. Neelkanth Natu, *Multicast Congestion Control*, MS Thesis, December 1999.
10. Feroz Azeem, *TCP Friendly Traffic Conditioners,* MS Thesis, December 1999.
11. Amit Rao, *Dynamic Provisioning Strategies for Differentiated Services,* MS Thesis, December 1999.
12. Dibyendu Shekhar, *Performance of TCP over ADSL,* MS Thesis, December 1999.

13. Markus Kuhn, *Implementation of PGM on a Linux Testbed,* MS Project (Computer Science), December 1999.
14. Anand Paka, *Distributed NS: a two-machine case,* MS Project (Computer Science), December 1999.
15. Giampiero Lo Monaco, *Implementation of a TCP friendly traffic conditioner in a Linux Testbed,* M Engg Project, April 2000.
16. Hua Qin, *Implementation of Ack-regulation schemes for TCP over ADSL,* MS Thesis, April 2000.
17. Priya Rajagopal, *SBMCC: A Multicast Congestion Control Scheme for Reliable Multicast,* MS Project (Computer Science), April 2000.
18. Ranjeeta Sinha, *Dynamic Capacity Contracting: A New Framework for Congestion-sensitive Pricing in the Internet,* MS Project (Computer Science), April 2000.
19. Shrikrishna Karandikar, *TCP Rate Control: A performance study,* MS Project (Computer Science), April 2000.
20. Muhammed Ali Chaudry, *Packetization Schemes for Compressed Video over the Internet,* MS Thesis, April 2000. Co-advised with John Woods.
21. Darren Challey, *Implementation of Edge-to-Edge Congestion Control on a Linux Testbed,* MS Thesis, April 2000.
22. Ekta Agrawal, *Scalable TCP Flow Generator for a Network Testbed,* M.S. Project (CS), April 2000.
23. Nikolaos Tiligadas, *Experimentation with a Multicast Congestion Control Scheme on a Linux Testbed,* M Engg Project, April 2000.
24. Chetan Ravindra Jog, *Implementation of an edge-to-edge control and pricing scheme on a Linux Testbed,* M.S. Thesis, December 2000.
25. Karan Gupta, *Edge-to-edge Traffic control: architecture and implementation on a Linux Testbed,* M.S. Project, December 2000.
26. Amit Manjunath Shenoy, *Implementation of the EEC scheme on a linux testbed,* M.S. Thesis, December 2000.
27. Sumeet Kumar Singh, *Simple QoS Architecture: Trading off Bandwidth for Architectural Simplicity,* M.S. Thesis, December 2000.
28. Karthik Chandrayana, *Analysis of RED buffer management scalability,* M.S. Thesis, December 2000.
29. Satish Raghunath, *Dynamic Provisioning,* M.S. Thesis, December 2000.
30. Puneet Thapiyal, *Multi-stage Filter Design for Multicast Congestion Control,* M.S. Thesis, April 2001.
31. Sidhartha, *Stochastic and Numerical analysis of a Multicast Congestion Control Scheme,* M.S. Thesis, April 2001.
32. Vijay Kumar Ramani, *Implementation of Edge-to-Edge Congestion Control at the User-Plane,* M.S. Thesis, April 2001.
33. Sthanunathan Ramakrishnan, *Control-theoretic Analysis of AIMD algorithms: Effect of Time-delays,* M.S. Thesis, April 2001.
34. Roopesh Varier, *Edge-to-Edge Control: Riviera Implementation,* M.S. Thesis, December 2001.

35. Josh Hort, *Edge-to-Edge Control: Service Building Blocks,* M.S. Thesis, December 2001.
36. Manoj Mehta, *Implementation of Randomized TCP,* M.S. Thesis, December 2001.
37. Niharika Mateti, *Linux/Zebra/Click Implementation of the BANANAS Traffic Engineering Framework*, M.S. Thesis, April 2002.
38. Kishore Ramachandran, *Simulation-Based Study of Riviera: An Edge-Based Congestion Avoidance Scheme,* M.S. Thesis, April 2002.
39. Mehul Doshi, *Connectionless Inter-Domain Traffic Engineering,* M.S. Thesis, August 2002.
40. Anand Balan, *Integrated Buffer Management and Congestion Control for Video Streaming,* M.S. Thesis, August 2002.
41. Arvind Venkatesh, *Linux/Click Implementation of Edge-to-edge congestion control,* M.S. Thesis, August 2002.
42. Hemang Mukesh Nagar, *Simulation of Dynamic Multi-Area OSPF in SSFnet,* M.S. Thesis, August 2002.
43. Kerry Neil Wood, *BANANAS Traffic Engineering Framework: Implementation on Intel IXA Platform,* M.S. Thesis, December 2002.
44. Ayesha Gandhi, *Explicit Out-bound Load-Balancing in Inter-domain Routing: Implementation in SSFnet,* M.S. Thesis, December 2002.
45. Andreas Weiss, *Intra-Domain Connectionless Traffic Engineering,* M.S. Thesis, December 2002.
46. Rahul Sachdev, *Large-Scale Experimental Realization of QoS and Routing Schemes,* M.S. Thesis, December 2002.
47. Advait Sane, *Transport Issues in Ad-Hoc Wireless Networks,* M.S. Thesis, December 2002.
48. Beau Croteau, *Video Streaming: Systems Issues*, M.S. Thesis, December 2002.
49. Benjamin Lam, *Implementing BGP Models in ROSSnet*, MS Thesis, April 2003.
50. Harshad Bhutada, *Implementing OSPF and BGP Models in ROSSnet*, MS Thesis, April 2003.
51. Shifalika Kanwar, *Efficient Explicit and Multi-path Routing in the Internet,* M.S. Thesis, April 2003.
52. Ranjit Vadakkan, *Virtual Home Agent in Mobile IP* M.S. Thesis, December 2003.
53. Dinesh Bhandare, *Utilizing multi-path capability for streaming video applications* M.S. Thesis, December 2003.
54. Seth Hinze, *Implementing a multi-path transport protocol over Planetlab using the BANANAS Architecture* M.S. Thesis, April 2004.
55. Chang Liu, *Hardware Architectures for Ultra-High-Speed and Low-Cost Free-Space-Optical Ad-Hoc Networks*, M.S. Thesis, Summer 2004.
56. Bow-Nan Cheng, *Community Wireless Network: Architecture*, M.S. Thesis, December 2004.
57. David M. Partyka, *Simulation of Free-Space-Optical Networks*, M.S. Thesis, April 2005.
58. Roopa Venkateswaran, *ns-2 Simulation of WIMAX MAC Layer*, M.S. Thesis, Fall 2006.

59. Sharat Krishnaiyer *Implementing WIMAX OFDMA Abstraction in ns-2*, M.S. Thesis, Fall 2007.
60. Sampad Misra, *Implementing WIMAX MIMO abstractions in ns-2*, M.S. Thesis, Fall 2007.
61. Damodar Banodkar, *Multicast Instant Channel Change in IPTV Systems*, M.S. Thesis, Fall 2007.
62. David Doria, *Implementing WIMAX MIMO abstractions in ns-2*, M.S. Thesis, Spring 2008.

6. Visiting Scholars

1. Prof. Sonia Fahmy, (part of) Fall 2005, Sabbatical visit from Purdue University.
2. Humphrey Cheng, Summer-Fall 2005 (**CURRENT visiting scholar** from Chinese University of Hong Kong).
3. Xin Liu, Summer 2004 (visiting scholar from Northeastern University, Boston, MA). Collaboration with Northeastern University. I also sent a student (Yong Xia) to UC Berkeley as part of another collaboration effort, which will led to a top-conference (ACM SIGCOMM) paper in 2005.
4. Jamel Rouahi, Spring/Summer 2004 (visiting scholar from Ecole Polytechnique, Paris, France). International collaboration with INRIA, Sophia Antipolis, France.
5. Vijay Arya, Summer 2003 (visiting scholar from INRIA, France). International collaboration with INRIA, Sophia Antipolis, France.
6. Yufeng Shan, Fall 2002 - Summer 2003 (visiting scholar from UC Berkeley).

C. Course and Curriculum Development

My teaching contributions are primarily in the Computer Engineering area with a focus in computer networking. My contributions span the undergraduate and graduate levels, using multiple modes of delivery (lecture, lab, studio, seminar, online), and leverages my research program. My online education experiments, book writing project, and teaching workshop activities are aimed at outreach and building Rensselaer's brand in networking education. I have also obtained competitive grants from NSF IGERT, Intel IXA, CAIDA for my teaching innovations and activities. My overall objective is to build a vibrant networking and computer engineering program at Rensselaer that connects to other disciplines and achieves a global reputation. These aspects are elaborated below:

New course development: Fundamentals of Wireless Broadband Networks (ECSE-6961), Internet Protocols (ECSE-6600, graduate course), Experimental Networking (ECSE 4960/6966 undergraduate- and graduate-level lab course), Broadband and Optical Networks (ECSE-6660, graduate course). In Spring 2007, I developed a new course "Fundamentals of Wireless Broadband Networks" which is a graduate wireless communication course but designed for a broader audience. Content for these courses has been drawn from research supported by NSF (eg: NSF NeTS-NR 0435259, NSF-STI 0230787) ARO (NSF-STI 0230787) and DARPA (F30602-00-2-0537). These courses have been popular, often attracting 30+ students at the graduate level (see enrolments in Section III-A). They have been an important factor in winning an NSF-IGERT grant and have influenced my current book writing project (see below). The experimental networking course is a course in a studio format pioneered by RPI, involving mix of short lectures, in-class lab work and a one-month term project. The extensive course material available online (with videos) has also been leveraged by colleagues in other top schools.

Book Writing: Writing a graduate networking textbook with Prof. Jim Kurose, UMass, Amherst. This book project builds upon prior educational initiatives at ACM SIGCOMM (see below) and the new courses developed at RPI. This project will take two years, and is intended to be a sequel to Jim's successful undergraduate textbook (which sold $>$ 100,000 copies) and is intended to influence graduate networking curricula worldwide.

NSF IGERT: Co-PI on an NSF Integrative Graduate Education and Research Traineeship Program (IGERT) award ($3.86 million) to support PhD-level graduate education in the area of Terahertz technology. This award which bridges the Physics and ECSE departments builds upon the NSF grant on free-space-optical networking (NSF-STI 0230787) and the synergistic courses (ECSE 4960 and ECSE 6660). My responsibility is to bridge the knowledge gap between networking, optical communications (wired and wireless), and terahertz free-space-optical technology. See: http://www.rpi.edu/dept/NewsComm/Campus_News/oct_03/oct_27/nsf.html

Educational Funding: Secured funding from CAIDA and Intel (over $150,000 worth of equipment and cash) to support the Experimental Networking studio lab course.

Outreach in Workshops: Led outreach efforts on innovative networking education in top conferences (ACM SIGCOMM 2002 and 2003: Education Workshops) and in Intel. I was a co-organizer of the ACM SIGCOMM 2003 NetEd Workshop in Karlsruhe, Germany (see: http://www.acm.org/sigs/sigcomm/sigcomm2003/workshop/neted/).

Online Education Experiments: Web-based video delivery of networking courses to support regular courses on campus and to support research. The video courses put online with permission of ECSE and RSVP/PDE office are accessed by large off-campus audience

worldwide and has enhanced the research reputation of our group because of the cross-references to research. These sites are the top bandwidth consumers on the ECSE network (see: http://www.ecse.rpi.edu/usage/usage_200511.html#TOPURLS). A google search for "networking lecture video" points to my site as a top URL linked to by several networking courses worldwide. (see: http://www.ecse.rpi.edu/Homepages/shivkuma/teaching/video_index.html)

Broader Teaching Activities: Teaching and enhancing existing computer networking and computer engineering courses at various levels: Computer Systems Architecture (ECSE-4730), Computer Components and Operations (ECSE-2610), and Computer Communications Networks (ECSE-4670).

Involving Undergraduates and Masters Students in Research: Developed a vibrant undergraduate research program (URP) and graduated several masters students: to engage both bachelors and masters students in the research program. NSF REU (research experience for undergraduates) funds linked to my NSF projects helped fund part of this activity. Some undergrads from this program have either joined my research group for their graduate work or gone on to grad school at places like CMU and Stanford. I have also advised a number of BS Senior Design projects and MS thesis projects (see lists in section III-B).

Former PhD and Post-Doc Students in Academia: Though several of my PhD and post-doctoral students have joined industry, three PhD graduates and three former post-docs are in academia as faculty (see student lists in Section III-B). The volume of students graduating from my group (and in progress) underscores my commitment to developing students through my research program.

IV. PUBLICATIONS

A. Books, Monographs and Book Chapters

Give title, co-authors if any, publisher, date. State if a contributing author to an edited compilation.)

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2. Yong Xia, Lakshminarayanan Subramanian, Ion Stoica and Shivkumar Kalyanaraman, "One more bit is enough," *IEEE/ACM Transactions of Networking*, to appear, February 2009.
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53. A. Gupta, L. Zhang, and S. Kalyanaraman, "A Two-component Spot Pricing Framework for Loss-rate Guaranteed Internet Service Contracts," In *Proceedings of ACM/IEEE/SCS Winter Simulation Conference (WSC)*, Volume 1, Pages 372-380, December 2003.

54. David Bauer, Garrett R. Yaun, Christopher D. Carothers, Murat Yuksel, Shivkumar Kalyanaraman, "ROSS.Net: Optimistic Parallel Simulation Framework for Large-Scale Internet Models", In *Proceedings of Winter Simulation Conference (WSC)*, December 2003.

55. Garrett Yaun, Christopher D. Carothers, and Shivkumar Kalyanaraman, "Large-Scale TCP Models Using Optimistic Parallel Simulation", In *Proceedings of the 17th Workshop on Parallel and Distributed Simulation (PADS)*, 2003. **Won the BEST PAPER AWARD for the conference**

56. Yufeng Shan and Shivkumar Kalyanaraman "Hybrid Video Downloading/Streaming Over Peer-to-Peer Networks", *International Conference on Multimedia and Expo (ICME)*, Vol II, pp 665 - 668, Baltimore, MD, July 2003

57. Jiang Li, Shivkumar Kalyanaraman, "Generalized Multicast Congestion Control," In the *Proceedings of 5th COST 264 International Workshop on Network Group Communications (NGC 2003) and ICQT*, Munich, Germany, September 2003.

58. K. Chandrayana and S. Kalyanaraman, "On Impact of Non-Conformant Flows on a Network of DropTail Gateways," In the *Proceedings of IEEE Globecom*, San Francisco, CA, November 2003.

59. H. Tahilramani Kaur, T. Ye, S. Kalyanaraman, "Minimizing Packet Loss by Optimizing OSPF Weights Using On-line Simulation," In the *Proceedings of 11th International IEEE/ACM Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS)*, pp.79 - 86, 2003.
60. Yong Xia, David Harrison, Shivkumar Kalyanaraman, Kishore Ramachandran, Arvind Venkatesan, "Accumulation-based Congestion Control,", In the Proceedings of *IEEE International Conference on Communications (ICC)*, Anchorage, AK, May, 2003.
61. Murat Yuksel, Shivkumar Kalyanaraman, Anuj Goel, "Congestion Pricing Overlaid on Edge-to-Edge Congestion Control", In the *Proceedings of IEEE International Conference on Communications* (ICC'03), Anchorage, AK, May 2003.
62. Anand Balan, Omesh Tickoo, Ivan Bajic, Shivkumar Kalyanaraman, and John Woods, "Integrated end-to-end buffer management and congestion control for scalable video communications," In the *Proceedings of IEEE ICIP*, Barcelona, Spain, September 2003.
63. S. Kalyanaraman, "Overlay Network Services: New QoS and Traffic Engineering Techniques," *17th IEEE Annual Computer Communications Workshop (CCW)*, Santa Fe, New Mexico, October 13-16, 2002.
64. Hema T. Kaur, Shiv Kalyanaraman, "A Connectionless Approach to Intra- and Inter-Domain Traffic Engineering," *Second NY Metro Area Networking Workshop,* Columbia University, New York City, September 3rd, 2002.
65. Mehdi Aboulfadl, Ritesh Pradhan, Aparna Gupta, and, Shivkumar Kalyanaraman, "A Spot Pricing Framework To Enable Pricing And Risk Management Of Inter-Domain Assured Bandwidth Services", *Proceedings of Winter Simulation Conference,* San Diego, December 2002.
66. Tao Ye, Shivkumar Kalyanaraman, "Adaptive Tuning of RED Using On-line Simulation," *Proceedings of IEEE Global Telecommunications Conference (GLOBECOM'2002)*, Taipei, Taiwan, November 2002.
67. Murat Yuksel, Shivkumar Kalyanaraman "A Strategy for Implementing Smart Market Pricing Scheme on Diff-Serv," *Proceedings of IEEE Global Telecommunications Conference (GLOBECOM'2002)*, Communications Quality and Reliability Symposium, Taipei, Taiwan, November 2002.
68. Biplab Sikdar, Karthikeya Chandrayana, K. S. Vastola, S. Kalyanaraman, "On Reducing the degree of Second Order Scaling in Network Traffic,"*Proceedings of IEEE Global Telecommunications Conference (GLOBECOM'2002)*, Taipei, Taiwan, November 2002.
69. Gurjeet S. Arora, Murat Yuksel, Shivkumar Kalyanaraman, Thiagarajan Ravichandran, Aparna Gupta, "Price Discovery at Network Edges," *Proceedings of International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS)*, July 2002.
70. Karthikeya Chandrayana, B. Sikdar and S. Kalyanaraman, "Comparative Study of TCP Compatible Binomial Congestion Control Schemes," *Proceedings of IEEE Workshop on High Performance Switching and Routing (HPSR)*, Kobe, Japan, May 2002.
71. B. Sikdar, K. Chandrayana, K. S. Vastola and S. Kalyanaraman, "Queue Management Algorithms and Network Traffic Self-Similarity," *Proceedings of IEEE Workshop on High Performance Switching and Routing (HPSR)*, Kobe, Japan, May 2002.
72. Murat Yuksel, Shivkumar Kalyanaraman "Distributed Dynamic Capacity Contracting: A congestion pricing framework for Diff-Serv," *Proceedings of IFIP/IEEE International*

Conference on Management of Multimedia Networks and Services (MMNS), Santa Barbara, CA, October 2002.

73. J. Li, S. Kalyanaraman, "MCA: A Rate-based End-to-end Multicast Congestion Avoidance Scheme," Proceedings of *IEEE International Communications Conference* (ICC'2002), New York, NY, April 2002.

74. S. Raghunath, K. Chandrayana, S. Kalyanaraman, "Edge-Based QoS Provisioning for Point-to-Set Assured Services," Proceedings of *IEEE International Communications Conference* (ICC'2002), New York, NY, April 2002.

75. D. Shekhar, H. Qin, S. Kalyanaraman, K. Kidambi, "Performance Optimization of TCP/IP over Asymmetric Wired and Wireless Links," *European Wireless (EW 2002)*, February 2002, Florence, Italy. **Invited Paper**

76. P.F. Quet, S. Ramakrishnan, H. Ozbay, S. Kalyanaraman, "On the H-infinity Controller Design for Congestion Control with a Capacity Predictor," *IEEE Conference on Decision and Control (CDC)*, December 2001, Orlando FL.

77. B. Sikdar, S. Kalyanaraman and K. S. Vastola, "Analytic Models for the Latency and Steady-State Throughput of TCP Tahoe, Reno and SACK," *Proceedings of IEEE Global Telecommunications Conference (GLOBECOM'2001)*, November 2001, San Antonio, TX.

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83. R. Sinha, M. Yuksel, S. Kalyanaraman, T. Ravichandran, "A Comparative Evaluation of Internet Pricing Models: Smart Markets and Dynamic Capacity Contracting," *Proceedings of the 10th Workshop on Information Technologies and Systems (WITS'2000)*, Brisbane, Australia, December 2000.

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99. S. Kalyanaraman, R. Jain, R. Goyal, S. Fahmy and Seong-Cheol Kim, "Performance of TCP/IP Using ATM ABR and UBR Services over Satellite Networks," *IEEE Communication*

Society Workshop on Computer-Aided Modeling, Analysis and Design of Communication Liks and Networks, Mclean, VA, Oct 1996.

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101. S. Fahmy, R. Jain, S. Kalyanaraman, R. Goyal, Fang Lu, "On Source Rules for ABR Service on ATM Networks with Satellite Links" *WOSBIS'96 Workshop on Satellite Based Information Systems*, New York, Nov 1996.
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103. R. Jain, S. Kalyanaraman, R. Viswanathan, "The OSU Scheme for Congestion Avoidance in ATM networks Using Explicit Rate Indication," *Proceedings of WATM'95 First Workshop on ATM Traffic Management*, Paris, Dec 1995.

D. Refereed Conference Abstracts and Short Papers

1. Murat Yuksel, Jayasri Akella, Shiv Kalyanaraman and Partha Dutta, "Optimal Communication Coverage for Free-Space-Optical MANET Building Blocks," *IEEE Upstate New York Communications and Networking Workshop*, Rochester, NY, November, 2005.
2. Murat Yuksel, Ritesh Pradhan, Shivkumar Kalyanaraman, "Trajectory-Based Forwarding Mechanisms Ad-Hoc Sensor Networks," (Extended Abstract) In *IEEE 2nd Upstate Workshop on Sensor Networks*, Syracuse, NY, October, 2002.
3. S. Kalyanaraman, H. Tahilramani, M. Doshi, A. Gandhi, "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.
4. David Harrison, Shivkumar Kalyanaraman, Sthanunathan Ramakrishnan "Congestion Control as a Building Block for QoS," *Student Poster, SIGCOMM 2001*, August 2001. Reprinted in *Computer Communication Review,* Volume 32, Number 1, January 2002.
5. S. Ramakrishnan, S. Kalyanaraman, J. Wen, H. Ozbay, "Effect of Time Delay in Network Traffic Control," Short Paper, *Proceedings of Automatic Controls Conference (ACC)*, 2001.
6. P. Thapliyal, Sidhartha, S. Kalyanaraman, "Source Based Multicast Congestion Control," *NGC'2000*, Stanford, CA, November 2000 (Poster)
7. S. Kalyanaraman, "An Update on ATM Traffic Management," in *IEEE Network Magazine*, May/June 1998.

E. Non-Refereed Conference Articles and Abstracts

I have 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.

Note: ATM Forum Contributions are available at: http://www.cse.wustl.edu/ jain/atmforum.htm

1. N. Natu, P. Rajagopal, S. Kalyanaraman, "Generic Source-based Congestion Control Algorithm for Reliable Multicast," IETF RMT Subgroup on Congestion Control, ACIRI, Berkeley, February 2000.
2. N. Natu, S. Kalyanaraman, P. Stirpe, "Congestion Control for Reliable Multicast," IRTF Reliable Multicast Research Group (RMRG), Pisa, Italy, June 1999.
3. F. Azeem, A. Rao and S. Kalyanaraman. "TCP-Friendly Traffic Conditioners for Differentiated Services," IETF Internet Draft, March 1999.
4. S. Kalyanaraman, D. Harrison, S. Arora, K. Wanglee, G. Guarriello, "A one-bit feedback enhanced differentiated services architecture," Internet Draft, draft-shivkuma-ecn-diffserv-00.txt, March 1998.
5. S. Fahmy, R. Jain, S. Kalyanaraman, R. Goyal, and B. Vandalore, "Determining the number of active ABR sources in switch algorithms," ATM Forum/98-0154, February 1998
6. R. Satyavolu, K. Duvedi, S. Kalyanaraman, "Explicit rate control of TCP applications," ATM Forum/98-0152R1, February 1998.
7. S. Fahmy, R. Jain, R. Goyal, B. Vandalore, and S. Kalyanaraman, Sastri Kota, Pradeep Samudra, "Feedback consolidation algorithms for ABR point-to-multipoint Connections," ATM Forum/97-0615, July 1997.
8. R. Goyal, R. Jain, S. Fahmy, B. Vandalore, Shiv Kalyanaraman, Sastri Kota, Pradeep Samudra, "UBR Buffer Requirements for TCP/IP over Satellite Networks," ATM Forum/97-0616, July 1997.
9. B. Vandalore, S. Kalyanaraman, R. Jain, R. Goyal, S. Fahmy, P. Samudra, "Worst case TCP behaviour over ABR and buffer requirements," ATM Forum/97-0617, July 1997.
10. S. Kalyanaraman, B. Vandalore, R. Jain, R. Goyal, S. Fahmy, S.C. Kim, "Performance of TCP over ABR with self-similar VBR video background traffic over terrestrial and satellite ATM networks," ATM Forum/97-0177r2, April 1997,
11. B. Vandalore, S. Kalyanaraman, R. Jain, R. Goyal, S. Fahmy, X. Cai, S.C. Kim, "Performance of Bursty World Wide Web (WWW) Sources over ABR," ATM Forum/97-0425, April 1997.
12. S. Kalyanaraman, R. Jain, J. Jiang, R. Goyal, S. Fahmy, S.C. Kim, "Virtual Source/Virtual Destination (VS/VD): Design Considerations," ATM Forum/96-1759, (Dec 1996)
13. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, S.C. Kim, D. Kataria, T. V. Lakshman, A. Wong, "Real-Time ABR: Proposal for a New Work Item," ATM Forum/96-1760, (Dec 1996)
14. R. Jain, S. Fahmy, S. Kalyanaraman, and R. Goyal "ABR Switch Algorithm Testing: A Case Study with ERICA," ATM Forum/96-1267, (Oct 1996)
15. R. Jain, S. Kalyanaraman, S. Fahmy, R. Goyal, and R. Viswanathan, "ERICA Switch Algorithm: A Complete Description," ATM Forum/96-1172, (Aug 1996)
16. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, Saragur Srinidhi, "Buffer Requirements for TCP over ABR," ATM Forum/96-0517, (Apr 1996)
17. R. Jain, R. Goyal, S. Kalyanaraman, and S. Fahmy, "Performance of TCP over UBR and buffer requirements," ATM Forum/96-0518, (Apr 1996)
18. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, F. Lu, S. Srinidhi, "TBE and TCP/IP traffic," ATM Forum/96-0177, (Feb 1996)
19. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, F. Lu, S. Srinidhi, "Comments on "Use-it or Lose-it" (Annex E of TM4.0)," ATM Forum/96-0178, (Feb 1996)

20. R. Jain, S. Kalyanaraman, R. Goyal, S. Fahmy, F. Lu, S. Srinidhi, "A Fix for Source End System Rule 5," ATM Forum/95-1660, (Dec 1995)
21. R. Jain, S. Kalyanaraman, F. Lu, and S. Fahmy, "Bursty ABR Sources," ATM Forum/95-1345, (Oct 1995)
22. R. Jain, S. Kalyanaraman, F. Lu, S. Fahmy, S. Srinidhi, "New Source Rules and Satellite links," ATM Forum/95-1344, (Oct 1995)
23. R. Jain, S. Kalyanaraman, S. Fahmy, F. Lu, S. Srinidhi, "Straw-Vote comments on TM 4.0 R8," ATM Forum/95-1343, (Oct 1995)
24. R. Jain, S. Kalyanaraman, S. Fahmy and F. Lu, ATM Forum/95-973R1: Out-of-Rate RM Cell Issues and Effect of Trm, TOF, and TCR (Aug 1995)
25. R. Jain, S. Kalyanaraman, S. Fahmy and F. Lu, "Parameter Values for Satellite Links," ATM Forum/95-972R1, (Aug 1995)
26. R. Jain, S. Kalyanaraman, R. Goyal, V. K. Samalam, "Examples of Switch Mechanisms - Corrected Text for the Appendix," ATM Forum/95-0809, (June 1995)
27. R. Jain, S. Kalyanaraman, R. Viswanathan, and R. Goyal, "A Sample Switch Algorithm," ATM Forum/95-0178R1, (Feb 1995)
28. R. Jain, S. Kalyanaraman and R. Viswanathan, "Current Default Proposal: Unresolved Issues," ATM Forum/94-1175R1, (Nov 94)
29. R. Jain, S. Kalyanaraman and R. Viswanathan, "Transient Performance of EPRCA and EPRCA++," ATM Forum/94-1173, (Nov 94)
30. R. Jain, S. Kalyanaraman and R. Viswanathan, "BECN: Why we need a timestamp or sequence number in the RM Cell," ATM Forum/94-0987, (Oct 1994)
31. R. Jain, S. Kalyanaraman and R. Viswanathan, "Simulation Results: The EPRCA+ Scheme," ATM Forum/94-0988, (Oct 1994)
32. R. Jain, S. Kalyanaraman and R. Viswanathan, "Rate Based Schemes: Mistakes to Avoid," ATM Forum/94-0882, (Sep 1994)
33. R. Jain, S. Kalyanaraman and R. Viswanathan, "The OSU Scheme for Congestion Avoidance using Explicit Rate Indication," ATM Forum/94-0883, (Sep 1994)

V. RESEARCH GRANTS AND CONTRACTS

(Give title of project, other senior investigators, starting and completion dates, amount of funding, sponsoring agency.)

A. Proposals Approved and Funded

1. *NeTS-FIND: Value Flows and Risk Management Architecture for Future Internet,*
co-PI (lead-PIs: Aparna Gupta (RPI-Lally School), Murat Yuksel (UNR)),
Time of award: September 2007 - August 2010 (3 years),
Funds: RPI total funds **$270,000**
Program: National Science Foundation (NSF) Future Internet Design (FIND) Initiative.
My responsibility: 40% of the contract, with support for 0.5 student.

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.
My responsibility: 40% of the contract, with support for 0.5 student.

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, AT&T Sponsor: Dr. K.K. Ramakrishnan and Dr. Chuck Kalmanek
My responsibility: 100% of the gift.

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.
My responsibility: 30% of the contract, with support for 0.75 student.

5. *Proposal for a NS-2 WiMax System Simulator*
co-PI, (co-PI: Biplab Sikdar),
Time of award: August 15, 2006 – December 31, 2007 (renewable, subject to performance)
Funds: RPI total funds **$135,900**,
Program: WIMAX Forum (an international consortium of companies for the next generation broadband wireless standard, Wimax),
My responsibility: 50% of the contract.

6. *Net Neutrality: A Quantitative Model of Key Issues,*
Sole PI

Time of award: May 2006 – April 2007 (1 year),
Funds: RPI total funds **$50,000**
Program: AT&T Foundation, AT&T Sponsor: Helen McGrath
My responsibility: 100% of the gift.

7. *RPI Seed Grant: TeleTouch: Networked Haptics in Shared Virtual Environments,*
co-PI, (lead-PI: Suvranu De),
Time of award: January 2006 – December 2006,
Funds: **$30,000**
Program: RPI VP of Research Office.
My responsibility: 40% of the gift.

8. *Robust TCP for Airborne Networks,*
Sole PI (Dr. K.K. Ramakrishnan at AT&T Research is a non-funded collaborator)
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,
My responsibility: 100% of the contract.

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),
Funds: RPI total funds **$500,000**
Program: Electronics Division, US Army Research Office (ARO)
My responsibility: 50% of the contract, with support for 1 student.

10. *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.
My responsibility: 50% of the contract, with support for 1 student.

11. *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),
Funds: 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.
My responsibility: (one of 5 co-PIs, and about 10 other participants): 1 fellowship per year

12. *Tools and Protocols for Internet Traffic Management,*
lead PI,
Time of award: December 2002 – December 2007 (5 years),
Funds: RPI total funds **$250,000**, (100K first year, and 50K/year thereafter, renewable each

year)
Program: AT&T Labs Joint Research Program, Dr. Robert Calderbank, VP of Research, AT&T Technical Sponsor: Dr. K.K. Ramakrishnan
My responsibility: 100% of the contract.

13. *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),
Funds: RPI total funds **$350,000**
Program: National Science Foundation (NSF) Information Technology Research (ITR) Small Grants.
My responsibility: 50% of the contract, with support for 1 student.

14. *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),
Funds: RPI total funds **$180,000, plus $25,000 worth of PCs and networking equipment**,
Program: Intel Corporation, University Research Program,
My responsibility: 50% of the gift.

15. *Smart Reconfigurable Plasma Antennas for Seamless Sensor Network Communications,*
co-PI (co-PIs: Ted Anderson (Haleakala R&D), Alejandra Mercado),
Time of award: September 2004 – August 2005 (1 year),
Funds: RPI total funds **$30,000**
Program: STTR Program
My responsibility: 33% of the gift.

16. *Performance Evaluation of VoIP in an Educational Setting,*
lead PI (co-authors (participants): Samara Hannah, John Bradley),
Time of award: January 2004 – December 2004 (1 year),
Funds: RPI total funds **$50,000**
Program: AT&T Foundation, AT&T Sponsor: Helen McGrath
My responsibility: 100% of the gift.

17. *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,
Funds: RPI funds **$ 510,000**
Program: National Science Foundation (NSF) Strategic Technologies for the Internet Program
My responsibility: 50% of the contract. Includes **5% chargeout** for me for the duration of the contract and support for one (1) student.

18. *Intel IXA-based Internet Teaching Laboratory (ITL) at Rensselaer (RPI),*
sole PI, Curriculum Development Equipment Gift Award won from Intel IXA Program
Time of award: September 2002 – August 2003 (1 year),
Funds: RPI total funds **$117,600 value equipment: (20) IXP1200 Development Kits, three-year parts and labor warranty.**,
Program: Intel Corporation, IXA Program

My responsibility: 100%. The Equipment has been installed in the JEC 4210 LITEC Studio for the Experimental Networking Lab Course.

19. *Measurement-driven Overlay QoS Control using Closed-loop Techniques,*
sole PI,
Time of award: June 1, 2002 – Jun 1, 2005,
Funds: RPI Total funds **$ 510,000**,
Program: U.S. Defense Advanced Research Projects Agency (DARPA), Network Management and Simulation (NMS), ITO Program (BAA 00-18).
My responsibility: 100% of the contract. Includes **25% chargeout** and support for 2 students.

20. *RPI Seed Grant: Interdisciplinary Research Between Networking, Controls and Wireless Communication Groups,*
co-PI, (John Wen, Murat Arcak, Biplab Sikdar, Babak Al-Salimi, Partha Dutta, Alejandra Mercado),
Time of award: January 1, 2002 – June 1, 2003,
Funds: **$75,000 (2002-2003)**
Program: RPI VP of Research Office.

21. *NSF/ERC Center for Subsurface Sensing and Imaging Systems,*
co-PI. (Lead RPI PI: James Modestino),
Time of award: June 1, 2000 – June 1, 2001,
Funds: RPI Total funds **$2,250,000**,
Program: National Science Foundation (NSF).
My responsibility: **10% chargeout** and support for one student for one year.

22. *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,
Funds: RPI Total funds **$ 950,000**,
Program: U.S. Defense Advanced Research Projects Agency (DARPA), Network Management and Simulation (NMS), ITO Program (BAA 00-18).
My responsibility: **25% chargeout** and support for 1.25 student.

23. *Streaming Video Compression for Heterogeneous Networks,*
co-PI (lead PI: John Woods),
Time of award: July 1, 2000 – June 30, 2003,
Funds: RPI Total funds **$498,506**,
Program: Electronics Division, US Army Research Office (ARO).
My responsibility: **5% chargeout** and support for 1 student.

24. *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),
Funds: RPI Total funds **$ 823,642**
Program: U.S. Defense Advanced Research Projects Agency (DARPA), Next Generation Internet (NGI): Network Engineering.
My responsibility: 35% of the project (lead PI). Includes **35% chargeout** for me for the duration of the contract and support for 1.33 students (four students shared between 3 PIs).

25. *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,
Funds: RPI funds **$383,628**, total funds **$563,725**,
Program: National Science Foundation (NSF) Special Projects in Networking Program (handles inter-disciplinary projects).
My responsibility: 60% of the contract. Includes **10% chargeout** for me for the duration of the contract and support for two (2) students.

26. *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),
Funds: RPI total funds **$455,984**,
Program: National Science Foundation (NSF) Special Projects in Networking Program (handles inter-disciplinary projects).
My responsibility: 50% of the contract. Includes **10% chargeout** for me for the duration of the contract (3 years) and support for one (1) students.

27. *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),
Funds: RPI total funds **$240,000, plus $75,000 worth of PCs and networking equipment**,
Program: Intel Corporation
My responsibility: 100% of the gift.

28. *IBM Shared University Research Grant,*
co-PI (w/ Bolek Szymanski),
Time of award: December, 2000 – November 30, 2001,
Funds: Total RPI funds **$168,000** for equipment purchases
Sponsor: IBM SUR,
My responsibility: 33.33% of the grant. Equipment will be used in network testbed lab.

29. *Cooperative Association for Internet Data Analysis (CAIDA)- Internet Teaching Laboratories grant,*
sole PI,
Time of award: December, 2000 – NA
Equipment: Three high-end Cisco Routers worth **$20,000** for building network teaching labs.
Sponsor: CAIDA-ITL,
My responsibility: 100% of the grant.

30. *A Performance Study of Reliability and Congestion Control for multicast Applications,*
sole PI,
Time of award: October 1, 1998 – September 31, 1999,
Funds: Total RPI funds **$61,186**
Sponsor: Reuters, Inc.
My responsibility: 100% of the contract. Includes **7.5% chargeout** for me for the duration of the project and support for one student.

31. *Next Generation Internet (NGI) Traffic Management: Simulation and Protocol Research*

Issues,
sole PI,
Time of award: June 1st, 1999 – May 31st, 2000,
Total funds: **$50,000**
Sponsor: RPI Provost's Office: Outstanding Young Faculty,
My responsibility: 100% (sole Principal Investigator). Discretionary funds.

32. *Intel IXA-based Internet Teaching Laboratory (ITL) at Rensselaer (RPI),*
sole PI, competitive curriculum development gift award won from Intel IXA Program
Time of award: November 1, 2001 – October 31, 2002 (1 year),
Funds: RPI total funds **$40,000, plus $15,000 worth of PCs and networking equipment**,
Program: Intel Corporation
My responsibility: 100% of the contract. Intended support: support for students

33. *Dynamic Provisioning for Point-to-Anywhere Services on IP networks,*
sole PI,
Time of award: August 1, 2000 – July 31, 2001 (1 years),
Funds: RPI total funds **$39,321**,
Program: Nortel Networks, Ottawa, Canada
My responsibility: 100% of the contract. Includes **3% chargeout** and support for one student.

34. *Evaluation of Scalability and Denial of Service Countering Capabilities of TCP Rate-Control,*
sole PI,
Time of award: March 15, 2000 – December 31st 2000,
Funds: Total RPI funds **$39,365**
Sponsor: Packeteer Inc.
My responsibility: 100% of the contract. Includes **5% chargeout** for me for the duration of the project and support for one student.

35. *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..
My responsibility: 100% (sole Principal Investigator). Support for one half student., **5% AY charge-out**

36. *Comparative Performance Study of TCP Rate Control,* sole PI,
Time of award: August 1, 1998 – December 31, 1998,
Funds: Total RPI funds **$26,338**
Sponsor: Packeteer Inc.
My responsibility: 100% of the contract. Includes **10% chargeout** for me for the duration of the project and support for one student.

37. *Scalable Edge-to-edge Flow Control for Virtual Private Networks (VPNs),*
sole PI,
Time of award: April 15th, 1999 – April 14th, 2000,
Total funds: **$17,782**
Sponsor: Nortel Networks, Inc..

My responsibility: 100% (sole Principal Investigator). Support for one half student.

38. *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,
Funds: 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.
My responsibility: My role is as a participant drawing **10% chargeout** for the duration of the project and no student support

39. *Equipment Gift from Intel Corp.,*
sole PI,
five Pentium III PCs for the Networking Testbed
Estimated Amount: **$ 15,000**

40. *Software Gift from Microsoft Corp.,*
sole PI,
Complementing Intel's Five Pentium III PCs for the Networking Testbed
Estimated Amount: **$ 10,000**

41. *NSF REU Supplement: Rate-Based Flow Control Algorithms for High Speed Networks,*
sole PI,
Time of award: 1999-2000 (1 year).
Funds: RPI funds **$5,000**
Program: National Science Foundation (NSF) Special Projects in Networking Program.
My responsibility: 100% of the contract: support for an undergrad research experience.

42. *Equipment Gift from Pulsecom, Inc.,*
sole PI,
Three personal computers for the networks laboratory
Estimated Amount: **$ 5,000**

43. *Equipment Gift from Packeteer, Inc.,*
sole PI,
A "packetshaper" (bandwidth manager for improved network performance)
Estimated Amount: **$ 3,000**

B. Proposals Pending (Under Review)

NONE.

C. Briefly describe your current research interests

My research interests are 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 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. The breadth of research activities has helped in deepening the content for the 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).

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 atracted interest from AFOSR (for airborne networks), DARPA (cross-layer design for extreme wireles 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: 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). 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 autoconfigurable 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.

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. We now have 5-6 PhD students, 1-2 post-docs and a visiting scholar at any time. 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).

Going forward, in the near future, I anticipate our group deepening our focus in the tetherless networking area, with topics such as airborne networks, cross-layer design, opportunistic/delay-tolerant networks, FSO MANETs and programmable wireless becoming prominent. Indeed we have already obtained several grants in these areas. We will also explore new applications such as Haptics and virtual reality, and interdisciplinary collaborations with nanotechnology. Our large-scale performance analysis efforts will likely have niche applications in biotechnology (eg: protein folding).

In summary, I have developed my research program modeled around my core aspirations: working with large and diverse student teams, developing theoretical, simulation and experimental groups, and working with colleagues and students on inter-disciplinary areas. It has been my honor to work with such a distinguished set of colleagues and participate in the intellectual development of fine students.

VI. EDITORSHIP OF JOURNALS, REVIEWS OF MANUSCRIPTS, BOOKS, AND RESEARCH PROPOSALS

(Give organization of journals, significant items reviewed, date.)

TPC Co-Chair, Technical Program Committee (TPC) Chair of IEEE/Create-Net/ICST International Conference on COMmunication System softWAre and MiddlewaRE (COMSWARE), 2009.

TPC Co-Chair, Technical Program Committee (TPC) Chair of IEEE INFOCOM 2008 (the premier networking conference with over 1200 paper submissions).

Editor, **ACM/Springer Journal on Wireless Networks**, June 2005 - present.

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.

Reviewer of books for Macmillan Technical Publishing.

"Differentiated Services" by Kalevi Killki (review acknowledged in published version of the book)

Reviewer of over 100 full papers for conferences such as

ACM SIGCOMM: The Conference of the ACM Special Interest Group (SIG) in Communications.

IEEE INFOCOM: The Conference on Computer Communications.

IEEE Conference on Communications (ICC).

IEEE Global Telecommunications Conference (GLOBECOM).

VII. SERVICE

A. Service to University

1. University, school, and departmental committees and dates for each.

Member, Institute Graduate Education Committee, convened by President Shirley Ann Jackson, April 2007-present.

Member, Graduate Student Recruitment Committee, ECSE Dept. Fall 2005 onwards.

Member, Graduate Student Recruitment Committee, CS Dept. Fall 2005 onwards.

Member, Vice President of Research Search Committee, Institute Committee convened by President Shirley Ann Jackson, April 2004 - April 2005. Met once/2 weeks. Led to the hire of Om Nalamasu.

Member, Institute Committee for the review of William A Baeslack, III, Dean of SoE. Spring 2004. Met once a week.

Member of Executive Committee, Center for Pervasive Computing and Networking (CPCN).

Member, Graduate Admission and Recruitment Committee, ECSE. Meets once a semester. Active in marketing RPI-ECSE and recruiting graduate students worldwide. The online networking videos help in this process.

Member, ECSE (Comp engg) Faculty Search Committee, Jan 2001– 2003. Very active in search and recruitment of Computer Engineering candidates. Played a **central role in attracting Koushik Kar and Biplab Sikdar** to ECSE.

Member, Institute IT Constellation Chair Search Committee, 2000 – Spring 2004. Met every week for two hours/week. Convened by Bud Peterson and charged by President Jackson. Played a pivotal role in interviews with key candidates.

Member, ECSE Chair Search Committee, Dec 2000– summer 2001. Met every week for 2 hours.

Member, CS New Staff Committee, 2000– present. Meets every week. Played a key role in the hire of Prof. Bulent Yener to Computer Science.

Member, CS Executive Committee, 2000– current. Meets once amonth.

Member, University IT Strategic Committee (convened by Art Sanderson), 1999-2000. Met once a month. Completed.

Member, ECSE Graduate Committee, 1998 – 2001.

Member, ECSE Computing Committee, 1999 – 2001. Thrice a semester meetings for 2 hours each.

Member, ECSE Department Executive Committee, 1999 – present. Once a semester meeting for 2 hours.

Member, PDE, Interactive Distance Learning Committee. 1999 – late 2000. Met once a month (4 times a semester) meeting for 2 hours each to discuss future IDE issues and solutions.

Member, IT Strategy Committee, Chaired by Prof. Art Sanderson, Met once a week for 2 hours to discuss IT strategy issues for the Institute.

Industry relations committees with Beth Wales and Nancy Preston. Key contributions in developing relationships with companies including Cisco, Intel and Telcordia (SAIC) and Microsoft.

Rensselaer at Hartford internal evaluation committee (Spring 1999). Two full days of work (including site visit to Hartford) and a detailed report with Prof. Dave Musser, CS.

2. Other RPI service and administration activities

Tenure Appeal Advocate, Costas Busch (CS), 2006-2007.

Co-Founder and first deputy director, Center for Pervasive Computing and Networking (CPCN). Part of leadership team led by Bolek Szymanski that articulated the vision for and shepherded the formation of the center as part of the Rensselaer Plan.

Leadership of the networking group within the ECSE department along with Prof. Ken Vastola.

Mentorship of New ECSE Faculty: Biplab Sikdar, Alhussein Abouzeid and Koushik Kar. Activities involve frequent detailed discussions, review of proposal submissions, co-advising students, co-authoring of proposals, and informal activities. This has led to increasing success rate in proposals (especially NSF SENSORS and NSF CAREER program) and in joint proposals.

Lab Development: Instrumental in getting large equipment donations (over $250,000 cumulative) for the networking laboratory and networking education. These funds also help ongoing maintainence of the lab.

Judge, 4th Annual Walter L. Hawkins '32 Minority Graduate Research Conference, Rensselaer Biotech Auditorium, 16th Nov 2005.

Co-organizer, Center for Pervasive Computing and Networking (CPCN) Workshop, RPI, Summer 2004.

Co-organizer of the Center for Pervasive Computing and Networking (CPCN) retreat on 5/5/03, Heffner Alumni Hall.

Co-organizer, Mini-symposium on "Tetherless World," October 1st 2001.

Pivotal role in the hire of Dr. Robert Bonneau, who was a DARPA program manager. Continuing to maintain relationship with him at AFRL after he left RPI.

Brought in a number of visitors for seminars: Sonia Fahmy (Purdue), Ravi Sundaram (Northeastern), Dah-Ming Chiu (Chinese University of Hong Kong), Srinivasan Keshav (Ensim), P.R. Kumar (UIUC), Ravi Sundaram (Northeastern), Dan Rubenstein (Columbia), Steven Low (Caltech), Rayadurgam Srikant (UIUC), Don Towsley (UMass), Henning Schulzrinne (Columbia). I view this as part of prominence development both for RPI and my networking group.

Trip to Islip, Long Island to interview with prospective ECSE Chair candidate.

Worked closely with the RPI Corporate relations office and Institute Advancement Office in developing relationships with Intel, Microsoft, Sun Microsystems, Cisco, AT&T, Motorola, and IBM. I regularly participate in upto 2 meetings every month to develop relations with prospective companies.

Worked with RPI public relations and marketing teams on PR articles and advertisements. These articles/ads appeared in high profile newspapers like: The Wall Street Journal, Washington Post, Rensselaer Alumni Magazine, Engineering School Magazine, Campus News, and the Review.

Worked with Chuck Rancourt, Prof. Gina O'Connor (Lally School) and others from the Severino Center for Technological Entrepreneurship on patent and technology commercialization directions.

Co-chair of Annual Trustees/Faculty Meeting: Discussion Group: "Scenarios for 2050: After the BT/IT Revolution."

Talk on "Increasing Interactivity with IT" along with Don Millard on June 2nd 2000: Rensselaer Reunion'2000. This exposed our networking programs and IT efforts to RPI Alumni.

Presented on "Future of networking research at RPI" to a high-profile IT external panel of visitors. May 25/26th 2000.

Worked in collaboration with Prof. Mark Goldberg on a LINKS project to develop graph theory modules for networking and mathematical instruction.

3. Undergraduate student advising and counseling (number and year)

Approximately 30 students of the class of 2010, Fall 2006 – present. (Individual sessions and three (3) Meet-Your-Advisor Day Presentations each semester).

Approximately 25 students of the class of 2006, Fall 2002 – 2006.

Approximately 30 members of the class of '02, 1999 – present.

Advising a part of Howard Kauffman's undergraduate class.

B. Professional Societies

(Give memberships, positions held, dates.)

Senior Member, IEEE and IEEE Communications Society, 2007-present.

Senior Member, ACM, 2007-present.

Member, IEEE and IEEE Communications Society, 1993-2007.

Associate Member, ACM, 1993-present.

Member, ASEE (American Society of Engineering Education), 2004-present.

Member, Marquis Who's Who in the World, 2001.

Honored member, International Who's Who of Information Technology. 1998-1999.

C. Community and Public Service

(Give national, state, and local organizations; positions held; dates.)

President, India Students Association, OSU, 1995 – 96.

Indian Classical Music Workshops, SPIC-MACAY, RPI, 1999– present.

Indian Classical Music Classes, RPI, 1999 – present, conducted twice a week (6 hours/week) throughout the year.

Operate a popular web page with audio classes on Indian Classical Music, 1999–present.

Operate a popular web site with Networking Education Videos, 2003–present.

VIII. PROFESSIONAL AND PUBLIC LECTURES

(List invited and contributed papers and lectures, giving title, organization, and dates.)

1. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group**, MITRE, McLean, VA, November 2007.
2. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group**, AT&T, San Jose, CA, September 2007.
3. *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.

4. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group**, Sprint Campus, Vienna VA, June 2007.
5. *Large-Scale Network Parameter Configuration Using An On-line Meta-Simulation Framework,* **Invited Talk, IBM India Research Labs**, Bangalore, India, June 2007.
6. *Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks,* **Invited Talk, Microsoft Research**, Bangalore, India, June 2007.
7. *Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks,* **Invited Talk, Tata Research Development and Design Centre (TRDDC)**, Pune, India, June 2007.
8. *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.
9. *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.
10. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum F2F Meeting, AATG Working Group**, NIST, Gaithersburg, MD, March 2007.
11. *Free-Space-Optical (FSO) & Opportunistic Networks: Hardware and Protocol Building Blocks,* **Invited Talk, University of Nebraska, Lincoln**, Lincoln, NE, March 8th, 2007.
12. *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.
13. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum Members Conference, AATG Working Group**, Waikaloa, Hawaii, January 29, 2007.
14. *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.
15. *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.
16. *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.
17. *Tetherless Networking: Towards Ultra-High-Speeds, Disruption-Tolerance*, Upstate New York Electronic Crimes Coalition Conference, Troy NY, November 2, 2006.
18. *WiMax NS-2 SLS Simulator: RPI Modeling Update*, **Invited Talk, WIMAX Forum Members Conference, AATG Working Group**, Seoul, South Korea, October 18, 2006.
19. *Tetherless Networking at RPI: Towards Ultra-High-Speeds and Disruption-Tolerance*, RPI ACM Student Chapter, Troy NY, October 10, 2006.
20. *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.
21. *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.

22. *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.
23. *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.
24. *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.
25. *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.
26. *Evolution path for WiMax NS-2 Simulator*, **Invited Talk, WIMAX Forum Members Conference, AATG Working Group**, San Diego, CA, July 12, 2006.
27. *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.
28. *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.
29. *Baseline NS-2 WiMax System Simulator*, **Invited Talk, WIMAX Forum AATG Working Group, F2F Meeting**, AT&T Labs, Middletown, NJ, June 1, 2006.
30. *Information Technology: Trends and Implications*, Invited Seminar, EMBA Program, RPI, Troy, NY, April 22nd, 2006.
31. *Experimental Networking Education at RPI*, Key Executive Conference: Academic Subcommittee, Troy, NY, April 7, 2006.
32. *Proposal for a Baseline NS-2 WiMax System Simulator*, **Invited Talk, WIMAX Forum Members Conference, AATG Working Group**, Orlando, FL, April 4, 2006.
33. *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.
34. *WiMax Simulation Framework*, **Invited Talk, WIMAX Forum Members Conference, AATG Working Group**, Paris, France (by phone), February 7, 2006.
35. *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
36. *Error Control and Traffic Control*, Faculty Opponent Presentation, KTH Royal Institute of Technology, Stockholm, Sweden, November 11th, 2005.
37. *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.
38. *A Sampling of RPI Research in Tetherless Networking Technologies*, RPI ECSE Advisory Committee Talk, Troy NY, October 18th, 2005.
39. *A Sampling of RPI Research in Tetherless Networking Technologies*, RPI FundRaising Talk to Lou Bellardo (Cisco Systems), Troy NY, September 28, 2005.

40. *Free-Space-Optical Mobile Ad-Hoc Networks (FSO-MANETS)*, Presentation to Lockheed Martin, Troy NY, September 27, 2005.
41. *Free-Space-Optical Mobile Ad-Hoc Networks (FSO-MANETS)*, DARPA CBMANETs Proposers Day Conference, Arlington, VA, August 30th, 2005.
42. *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.
43. *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.
44. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Seminar, Bell Labs, Lucent Technologies, Bangalore, India**, June 15th, 2005.
45. *Quality-of-Service (QoS) over Best-Effort Networks*, **Keynote Lecture, Technology Day, Tata Consulting Services (TCS) Reseach, New Delhi (Gurgaon), India**, June 8th, 2005.
46. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Talk, Indian Institute of Technology (IIT), Mumbai, India**, June 6th, 2005.
47. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Talk, Microsoft Research, Bangalore, India**, June 3rd 2005.
48. *High Speed Router Design*, **Invited Full-Day Tutorial, HCL Technologies, Chennai, India**, May 20th 2005.
49. *Voice-over-IP, SIP and Quality-of-Service (QoS)*, **Invited Full-Day Tutorials, Tata Elxsi, Bangalore, India**, May 4-5th 2005.
50. *Transport-Level (TCP) Hybrid ARQ and MAC Scheduling Policies For WiMax Mesh Networks*, **Invited Seminar, Intel Corporation, Hillsboro, OR**, March 31st, 2005.
51. *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.
52. *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.
53. *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.
54. *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.
55. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Talk, IEEE-ComSOC, Rochester Institute of Technology (RIT)**, December 7, 2004.
56. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Talk, Northeastern University**, December 2, 2004.
57. *Building Blocks for Engineering QoS Expectations over Best-Effort Networks*, **Invited Talk, Boston University**, December 1, 2004.

58. *Overlay Multi-hop FEC scheme for Video Streaming over Peer-to-Peer Networks*, **International Conference on Image Processing (ICIP)**, Singapore, October 2004.
59. *Efficient Path Aggregation and Error Control for Video Streaming*, **International Conference on Image Processing (ICIP)**, Singapore, October 2004.
60. *Intel IXA and Experimental Networking Education at Rensselaer*,**Intel IXA Workshop**, Hudson, MA, September, 2004.
61. *Infrastructure Mesh Wireless Networks (IWMNs)* **Intel Research Workshop**, Portland, OR, April 2004.
62. *Overlay QoS using Closed-Loop Control and Multi-Paths*, **DARPA PI Meeting**, January 2004.
63. *Ultra-High-Speed Wireless Last-Mile Networks*, **NSF Broadband Workshop**, Chicago, IL, Oct 25, 2003.
64. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **UC Riverside**, Riverside, CA, 2003.
65. *Generalized Multicast Congestion Control*, **International Workshop on Network Group Communications (NGC 2003)**, Munich, Germany, September 2003.
66. *Integrated end-to-end buffer management and congestion control for scalable video communications*, **IEEE ICIP'03**, Barcelona, Spain, September 2003.
67. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **SIGCOMM Future Directions on Network Architectures (FDNA) Workshop**, Karlsruhe, Germany, August 2003.
68. *Online and Distance Educational Intiatives at Rensselaer*, **SIGCOMM NetEd03 Workshop**, Karlsruhe, Germany, August 2003.
69. *BANANAS Traffic Engineering and Ultra-High-Speed Wireless Networking*, **Telcordia Technologies**, Morristown, NJ, July 2003.
70. *Traffic Management: Protocols and Tools*, **AT&T Labs Research**, Basking Ridge, NJ, June 2003.
71. *Overlay QoS*, **DARPA PI Meeting**, San Diego, CA, May 2003.
72. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **France Telecom**, Paris, France, March 2003.
73. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **Institut Eurecom**, Sophia Antipolis, France, March 2003.
74. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **Politechnico di Torino**, Torino, Italy, March 2003.
75. *Overlay QoS using Closed-Loop Control*, **INRIA**, Sophia Antipolis, France, March, 2003.
76. *BANANAS: A Connectionless Framework for Traffic Engineering in the Internet*, **UC Berkeley**, Berkeley, CA, 2003.
77. *Overlay QoS using Closed-Loop Control: Expected Minimum Rate Service*, **DARPA NMS PI Meeting**, Chicago, IL, November 13th, 2002.
78. *Overlay Network Services: New QoS and Traffic Engineering Techniques*, **IEEE Computer Communications Workshop (CCW)**, Santa Fe, NM, October 17th 2002.
79. *Low-Power Low-Cost Multi-Hop Hybrid Optical/RF Sensor Networks*, **First IEEE Upstate NY Workshop on Sensor Networks**, Syracuse NY, October 11th, 2002.

80. *A Closed-Loop Scheme for Expected Minimum Rate (QoS) Service*, **University of Illinois at Urbana Champaign (UIUC)**, Champaign, IL, October 7th, 2002.
81. *A Connectionless Approach to Intra- and Inter-Domain Traffic Engineering*, **Second NY Metro Area Networking Workshop,** Columbia University, New York City, September 3rd, 2002.
82. *ACM SIGCOMM Workshop on Computer Networking Curriculum Designs and Educational Challenges, Chair of Breakout Session on Lab Courses*, Pittsburgh, August 20th, 2002.
83. *Connectionless Traffic Engineering: Towards Better Building Blocks*, **AT&T Labs Research**, Murray Hill, NJ, August 15th, 2002.
84. *Ultra-High-Speed (100 Mbps - 100 Gbps) Wireless Distribution Networks*, **Intel Architecture Lab**, Portland, OR, June 5th, 2002.
85. *Overlay Network Services: New QoS and Traffic Engineering Techniques*, **Intel Architecture Lab**, Portland, OR, May 30th, 2002.
86. *Ultra-High-Speed (100 Mbps - 100 Gbps) Wireless Distribution Networks*, **DARPA Director (Tony Tether) Visit**, Troy, NY, May 16th, 2002.
87. *Connectionless Traffic Engineering: Towards Better Building Blocks*, **Lucent Bell Labs**, Murray Hill, NJ, May 9th, 2002.
88. *Edge-based Traffic Management Building Blocks for Overlay QoS*, **DARPA NMS PI Meeting**, Baltimore, MD, April 19th, 2002.
89. *Edge-based Traffic Management Building Blocks for The Internet*, **University of Massachussets at Amherst**, Amherst, MA, March 27th 2002.
90. *Performance Optimization of TCP/IP over Asymmetric Wired and Wireless Links*, **European Wireless (EW 2002)**, February 27th, 2002, Florence, Italy.
91. *Edge-based Traffic Management Building Blocks for The Internet*, **Politecnico Di Milano**, February 25th, 2002, Milan, Italy.
92. *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.
93. *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.
94. *Scalable Online Simulation for Network Management*, **DARPA NMS PI meeting**, Atlanta, GA, 22nd October, 2001.
95. *Edge-based Traffic Management Building Blocks for The Internet*, **Intel**, Chandler, AZ, 5th October, 2001.
96. *Congestion-control as a building block for QoS*, **ACM SIGCOMM Poster Session**, San Diego, CA, 28th August, 2001.
97. *Edge-based Traffic Management Building Blocks for The Internet*, **Microsoft Research**, Redmond, WA, 17th August 2001.
98. *Edge-based Traffic Management Building Blocks for The Internet*, **California Institute of Technology, Pasadena (Caltech)**, Lee Center Seminar Series, 17th June 2001.
99. *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)

100. *Edge-based Traffic Management Building Blocks for The Internet*, **University of California, Los Angeles (UCLA)**, 5th April 2001.

101. *QoS and Overlay Networks*, DARPA NMS PI meeting, San Diego, CA, April 4th 2001.

102. *Edge-based Traffic Management Building Blocks for The Internet*, **Massachussetts Institute of Technology (MIT) Laboratory for Computer Science (LCS)**, Cambridge, MA, 15th March 2001.

103. *Edge-based Traffic Management Building Blocks for The Internet*, **Intel Architecture Labs**, Portland, OR, 7th March 2001.

104. *Edge-based Traffic Management Building Blocks for The Internet*, **Carnegie Mellon University (CMU)**, Pittsburg, PA, 1st March 2001.

105. *Edge-based Traffic Management Building Blocks for The Internet*, **Univ of Pennsylvania, Center for Telecommunications**, Philadelphia, PA, 7th Feb 2001.

106. *Edge-based Traffic Management Building Blocks for The Internet*, **University of California, Berkeley, CA**, 19th Jan 2001.

107. *Edge-based Traffic Management Building Blocks for The Internet*, Cisco Systems, San Jose, CA, 25th Jan 2001. (talk given in proxy by Bolek Szymanski)

108. *Edge-based Traffic Management Building Blocks for The Internet*, Nortel Networks, Ottawa, Canada (by teleconference), 24th Jan 2001.

109. *Traffic Management for the Next Generation Internet*, IBM Site Visit, 11th Jan 2001.

110. *Edge-based Traffic Management Building Blocks for The Internet*, RPI, CS Colloquim, Troy, NY, 10th Jan 2001.

111. *Edge-based Traffic Management (TM) Building Blocks for The Internet*, **Purdue University**, Lafayette, IN, 20th Dec 2000.

112. *Edge-based Traffic Management (TM) Building Blocks for The Internet*, **Columbia University**, New York, NY, 6th December 2000.

113. *Hierarchical Packet Shaping Technology*, Talk at Packeteer, Inc., San Jose, CA, 1 Dec 2000.

114. *Scenarios for 2050: After the BT/IT Revolution*, Trustee/Faculty Dinner: Panelist with Paul Severino and other trustees, 30 Nov 2000.

115. *Source-based Multicast Congestion Control*, Invited Poster/Presentation at NGC'2000, Stanford, CA, 9th Nov 2000.

116. *Traffic Management Building Blocks for the next generation Internet*, **Motorola Research**, Arlington, IL, 11th August, 2000.

117. *Source Multicast CC for NAK-based transport protocols*, IETF Pittsburg, Pittsburg, PA, 1st August 2000.

118. *Generic Source-based Multicast Congestion Control (GSC)*, ISI East/RMRG, Arlington, VA, 28th July 2000.

119. *Edge-based services for VPNs*, Global Crossing, Sunnyvale, CA, 20th July 2000.

120. *Online Simulation for Network Management: Closing Report*, DARPA, Arlington, VA, 18th July 2000.

121. *Traffic Management Building Blocks for the next generation Internet*, **Invited Talk at Telcordia Technologies (Bellcore Labs)**, Morristown, NJ, 14th July 2000.

122. *Traffic Management Building Blocks for the next generation Internet*, Invited Talk at **IBM TJ Watson Labs**, Hawthorne, NY, 13th July 2000.

123. *TCP-Friendly Traffic Marker for IP Differentiated Services,* International Workshop on Quality of Service (IwQoS'2000), Pittsburg, PA, June 2000.

124. *Generic Source-based Congestion Control Algorithm for Reliable Multicast*, **Invited presentation to IETF RMT Working Group**, Berkeley CA, February 10th, 2000.

125. *Network Management and Control using Collaborative Online Simulation*, **DARPA PI meeting**, Washington DC, December 16th.

126. *TCP/IP over ADSL*, Invited talk at Pulsecom, Herndon, VA, December 14th.

127. *Networking Research at Rensselaer*, Invited presentation to Telcordia Technologies, November 19th, 1999.

128. *Edge-to-edge Congestion Control*, **Invited Talk at Nortel Networks Research Conference**, Ottawa, Canada, October 28th, 1999

129. *Traffic Management for the Next Generation Internet*, Invited Talk at **SUNY Albany**, Dept of CS, October 19th 1999.

130. *Feedback-based Congestion Control for the Next-Generation Internet*, Invited Talk at **Ohio State University**, Dept of EE, September 30th, 1999.

131. *Protocol Issues for 10Gb/s Ethernet LANs*, Invited Talk at Cisco Systems, Optical Internetworking Group, Ottawa, Ontario, Canada, Sept 14th, 1999.

132. *Content-customization for Broadband End-users through Server-side Enhancements* , **Invited Talk at Amazon.com**, Seattle, WA, July 23rd, 1999.

133. *Congestion Control for the Next-Generation Internet*, **Invited Talk at Motorola Research**, Schaumberg, IL, July 22nd, 1999.

134. *QoS building blocks in Internet and ATM Standards*, **Invited Talk at xDSL Comforum**, Chicago, IL, July 21st, 1999

135. *Traffic Management for the Next Generation Internet*, **Invited Talk at Tata Consultancy Services Research Division (TRDDC)**, Pune, India, June 24th, 1999.

136. *Hot Topics in Internetworking*, Invited Talk at Infosys Ltd, Bangalore, India, June 17th, 1999.

137. *IP Telephony*, Invited Talk at BPL Telecom Ltd, Bangalore, India, June 16th, 1999.

138. *Hot topics in Internetworking*, Invited Talk at Tata Elxsi Ltd, Bangalore, India, June 14-15th, 1999.

139. *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.

140. *Internet Protocols*, Short Course at Indian Institute of Science, Bangalore, India, May 17-28th, 1999.

141. *Virtual Private Networks based upon Packeteer TCP Rate Control*, Invited Talk at Packeteer, Inc., March 9th 1999.

142. *Problems in Feedback-based Congestion Control for the Next Generation Internet*, **Invited Talk at Intel**, Portland, Oregon, March 3rd 1999.

143. *Differentiated Services and Multi-protocol Label Switching (MPLS)*, Invited Talk at Tellabs, Inc., March 1st 1999.

144. *Virtual Private Networks: Building Blocks*, Invited Talk at Sprint, Herndon, VA, 14th February 1999

145. *TCP Friendly Traffic Conditioners*, Talk at IETF, March 1999, Minneapolis, MN.

146. *Internet performance on a variable capacity channel with millions of flows*, Talk at IETF, Dec/Jan 1998, Orlando, FL.

147. *Internet Traffic Management*, Invited Seminar in Nokia, Cisco Systems, Bay Networks, Reuters, Torrent Network Technologies, NIST, Summer 1998.

148. *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.

149. *Introduction to ATM Networks*, Invited presentation at Infosys Co., Bangalore, India (Dec 1994) and at NRSA, Hyderabad, India (Dec 1996).

IX. HONORS AND AWARDS

Patents:

1. R. Jain, S. Kalyanaraman and R. Viswanathan, "Method and Apparatus for Congestion Management in Computer Networks Using Explicit Rate Indication," U. S. Patent Number 5,633,859, granted May 27, 1997. http://www.cis.ohio-state.edu/ jain/patents/patenta.htm
2. R. Jain, S. Kalyanaraman, R. Goyal, R. Viswanathan, and S. Fahmy, "ERICA: Explicit Rate Indication for Congestion Avoidance in ATM Networks," U.S. Patent No. 5,805,577, Issued September 8, 1998. http://www.cis.ohio-state.edu/ jain/patents/patente.htm
3. K.R. Kidambi, S. Kalyanaraman, D. Shekhar, "Method and System for Discarding and Regenerating Acknowledgement Packets in ADSL Communications," U.S. Patent S/N 09/409,035, Filed on October 29, 1999. Granted U.S. Patent Number 6,424,626,: July 23, 2002.
4. S. Kalyanaraman, B. Szymanski, K. Vastola, Y. Tao, D. Harrison, B. Mo, B. Sikdar, H.T. Kaur, and J. Jiang, "Network Management and Control using Collaborative On-Line Simulation," U.S. Provisional Patent S/N 60/170,896, December 15, 1999. (RPI Case 581). U.S. patent application is filed and pending. Appl # 10/149,207.
5. D. Harrison, S. Kalyanaraman, P. Bagal, "Edge-to-edge Traffic Control for the Internet," U.S. Provisional Patent S/N 60/185,795, February 29th 2000. (RPI Case 582) U.S. patent application is filed and pending. Appl # 10/204,222
6. S. Kalyanaraman, N. Natu, P. Rajagopal, "System and Method of Source-Based Multicast Congestion Control," (RPI Case 583), Granted. U.S. patent number: 7,020,714. Grant Date: March 28, 2006
7. S. Kalyanaraman, F. Azeem, A. Rao, "A TCP-Friendly Traffic Marker for IP Differentiated Services,' U.S. Provisional Patent S/N 60/195,511, April 6th 2000. (RPI Case 584). U.S. patent application is filed and pending. Appl # 10/240,416
8. S. Kalyanaraman, F. Azeem, G.L. Monaco, "TCP-Friendly Traffic Marking for Scalable and "better" best-effort services on the Internet,' U.S. Provisional Patent S/N 60/204,906, May 16th 2000. (RPI Case 614). Combined with case 584 as one patent application.

9. Shivkumar Kalyanaraman, Hema Tahilramani Kaur, Jayasri Akella, Satish Raghunath, Karthikeya Chandrayana and Hemang Nagar, "BANANAS: a framework for connectionless traffic engineering in the Internet," Provisional Patent Number: 60/356,032. Filed February 11, 2002. (RPI Case 700). U.S. patent application is filed and pending. Appl # 10/361,359
10. S. Kalyanaraman, Partha Dutta, "Multi-Hop Free Space Optics Last-Mile Networks Using Very Low-Cost Components", disclosed 1/29/2003 (RPI Case 797).
11. S. Kalyanaraman, Ye Tao, "Large-Scale Network Parameter Configuration Using On-Line Simulation Framework", disclosed 7/30/2003. (RPI Case 832)
12. O. Tickoo, V. Subramanian, S. Kalyanaraman, K.K. Ramakrishnan, "Loss Tolerant Transmission Control Protocol," Provisional Patent Number: 60/666,398, filed March 30, 2005. U.S. patent application is filed and pending (1 December 2005), Application nos. 20060251011 /20060251010 /20060250949 .

Other Awards:

- Selected as **ACM Senior Member**, 2007.
- Selected as **IEEE Senior Member**, 2007.
- Our paper rated among the top 10 % of the accepted papers in IEEE International Conference on Image Processing (ICIP) 2005 (the top image processing conference), Genova, Italy, September 11-14, 2005.
- Recepient of **School of Engineering Research Award in Rensselaer** in May 2003 in recognition of outstanding research contributions.
- **Best Paper Award**, ACM Parallel and Distributed Systems (PADS) Conference, June 2003.
- Recepient of **Faculty Early Career Award by Rensselaer** in May 2001. The award is given to one young faculty member per year who has at least three years of service to RPI (and less than 10 years of service), in recognition of exceptional contributions.
- Selected as one of the **top 100 visionaries (TR 100) for the next millenium by MIT's Technology Review** (and alumni) magazine. Honored in a ceremony at MIT on November 4th, 1999. Received recognition from the elite of the technology community.
- Internally recognized by the Provost as an **"Outstanding Young Faculty Member"** in combination with an anonymous award towards my research program.
- Member, technical advisory board of Expeditrix.com, Inc.
- Member of the **Marquis Who's Who in the World**, 2000-2001.
- Honorary member of the **International Who's Who of Information Technology**, 1999.
- Member, Technical Advisory Board of Packeteer, Inc.
- Ameritech **Presidential Dissertation Fellowship award**, The Ohio State University, 1997, for outstanding graduate research work.
- SIGCOMM Student Travel Grant, 1995. Annually awarded to about 10 students in the world.
- Indian Institute of Technology Merit Award, 1989 (for being 3rd out of nearly 100,000 students)
- National Talent Search Scholar, India, 1987-1993 (financed entire undergraduate education)

X. SABBATICAL LEAVES, OFF-CAMPUS STUDY PROGRAMS, FOREIGN PROFESSIONAL TRAVEL

(Dates and topics.)

A. Sabbatical Leave: Fall 2004, Visiting Jim Kurose, Distinguished Professor, Department of Computer Science, University of Massachussetts, Amherst. Writing a graduate textbook on computer networking.

B. Off-Campus Study Programs

None.

C. Foreign Professional Travel

Travel to Japan (SIGCOMM'07), India (COMSWARE'07), Spain (Apr 2006: INFOCOM), Japan/Singapore/Hong Kong/China (July-August 2006), Italy (Sep 2006: SIGCOMM), South Korea (Oct 2006: WIMAX Forum). Travel to Sweden in Nov 2005 (PhD faculty opponent in KTH, Stockholm), India (June 2005), Dubai/UAE (Mar 2005), Italy (Feb 2005). Travel to Singapore in October 2004 (ICIP 2004), Travel to France, Italy, Germany and Spain in March and August/September 2003: conference and university visits. Travel to India in Summer 1999 and Summer 2001. Gave a short course at Indian Institute of Science (IISc), Bangalore, and talks at about 10 Indian networking companies.

XI. ALL OTHER ACTIVITIES

(List other relevant activities such as consulting (include name of company and days per year), expert witness, or significant activities not included in previous categories.)

ENTREPRENEURSHIP: Executive MBA (EMBA), Lally School of Management and Technology, Rensselaer Polytechnic Institute, Troy, NY, U.S.A., 2005.

ENTREPRENEURSHIP: Co-Founder, Premonitia Inc, 2001, based upon Network Management technology developed w/ Chuanyi Ji, Kenneth Vastola and Bolek Szymanski. Worked with Paul Severino (RPI Trustee and former CEO, Bay Networks) and Martin Schoffstall (founder and former CEO of PSINet). Seed round of funded with Venture Capitalists, Lazard Technology Partners, Castile Ventures and TL Ventures. The company closed in 2003.

Packeteer, Inc. Professional visits to IETF as a consulting assignment. 5 days/year, ended 2002.

Nortel Networks, Inc. Consulting and advising. 3 days/year, ended 2001.

Cisco Systems, Inc. Consulting and advising. 3 days/year, ended 2000.

Qwest Communications, Inc. Consulting and advising. 3 days/year, ended 2001.

Pulsecom, Inc. Consulting and advising. 3 days/year, ended 2001.

Amazon.com, Inc. Consulting and advising. 10 days in summer 1999 (one time).

Tellabs, Inc. Consulting. 1 day in 1999 (one time).

XII. In addition to the above information include, if pertinent, concrete evidence of teaching ability and any unusual contributions to university affairs, such as curriculum advising or development, continuing education participation, etc.

See earlier sections.

Date: _____ **Signature:** _____