

# Nihar Jindal

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**Education**      **Stanford University**      *1999-2004*  
PHD. ELECTRICAL ENGINEERING, July 2004  
M.S. ELECTRICAL ENGINEERING, June 2001  
*Thesis:* Multi-User Communication Channels: Capacity, Duality, and Cooperation  
*Advisor:* Prof. Andrea Goldsmith  
*Associate Advisor:* Prof. Thomas Cover

**University of California, Berkeley**      *1995-1999*  
B.S. ELECTRICAL ENGINEERING/COMPUTER SCIENCE, May 1999

## Work Experience

**University of Minnesota**, Minneapolis, MN      *2004 - Present*  
*Assistant Professor*

### Research

- Multi-user/multi-antenna communication systems
- Ad-hoc networks
- Cross-layer design of communication networks
- Dynamic resource allocation for fading channels
- Multi-user information theory

### Teaching

- Advanced Topics in Wireless Communication (EE 8950), Spring 2008
- Information Theory and Coding (EE 5581), Fall 2007, Fall 2005
- Wireless Communication (EE 5505), Spring 2007, Spring 2006
- Statistical Methods in Electrical and Computer Engineering (EE 3025), Fall 2006
- Multi-User Information Theory (EE 8510), Spring 2005
- Participant in Early Career Faculty Teaching Program, 2005-2006

**Bell Labs, Lucent Technologies**, Crawford Hill, NJ      *June - August 2002*  
*Summer Intern, Wireless Research Lab*  
Mentor: Dr. Gerald Foschini

- Analyzed performance of pre-coding techniques for multiple-antenna downlink cellular systems.
- Evaluated potential gain due to multiple base station cooperation in a cellular environment.

**Intel Corporation**, Santa Clara, CA      *June - Sept 2000*  
*Summer Intern, Microprocessor Research Lab*  
Mentor: Dr. Leslie Rusch

- Evaluated performance of advanced signal processing techniques in wireless LAN receivers.

## Honors

- NSF CAREER Award, 2008.
- McKnight Land-Grant Professor, University of Minnesota, 2007-2009
- Recipient of 2005 IEEE Communications Society and Information Theory Society Joint Paper Award, “On the Duality of Gaussian Multiple-Access and Broadcast Channels” (co-authored with Sriram Vishwanath and Andrea Goldsmith)
- Ezra Frederick Scattergood Fellowship, Stanford University
- Electrical Engineering Honors Program, UC-Berkeley
- Member Eta Kappa Nu, National Electrical and Computer Engineering Honor Society

## Professional Affiliations

- IEEE Information Theory Society
- IEEE Communications Society

## Professional Service

- Editor, IEEE Transactions on Communications (Wireless Communications), 2007-Present
- Guest Editor, EURASIP Journal on Advances in Signal Processing, Special Issue on “Multiuser MIMO Transmission with Limited Feedback, Cooperation, and Coordination”, 2008
- Guest Editor, EURASIP Journal on Wireless Communications and Networking, Special Issue on “Theory and Applications in Multiuser/Multiterminal Communications”, 2008
- Technical Program Co-Chair, Multiple Antennas and Space-Time Processing Track, IEEE Vehicular Technology Conference, Fall 2007
- Treasurer, IEEE Communication Theory Workshop 2009.
- President, IEEE Twin Cities Chapter of Signal Processing and Communication Societies, 2005 - Present
- Technical Program Committee Member: IEEE Int. Symp. on Information Theory (ISIT) 2007, 2008, 2009, IEEE Int. Conf. of Communications (ICC) 2006, 2008, 2009, IEEE Global Telecommunications Conf.(Globecom) 2006, 2007, 2008, 2009, WiOpt 2008, Information Processing in Sensor Networks (IPSN) 2006, RAWNET 2006, Int. Wireless Commun. and Mobile Comput. Conf. (IWCMC) 2006, IEEE WirelessComm 2005, IEEE VTC 2005
- Reviewer for IEEE Transactions on Information Theory, IEEE Transactions on Communications, IEEE Communications Letters, IEEE Transactions on Wireless Communications, IEEE Journal on Selected Areas in Communications, IEEE Transactions on Signal Processing, IEEE Globecom, IEEE International Conference on Communications, IEEE International Symposium on Information Theory

## Book Chapters

1. Andrea Goldsmith, Syed Ali Jafar, Nihar Jindal, and Sriram Vishwanath, Chapter Title: “Capacity Limits of MIMO Systems”, Book Title: “MIMO Wireless Communications”, Cambridge University Press, 2007.

## Journal Publications - Submitted

1. Giuseppe Caire, Nihar Jindal, Mari Kobayashi, and Niranjay Ravindran, "Multiuser MIMO Downlink Made Practical: Achievable Rates with Simple Channel State Estimation and Feedback Schemes," Submitted: *IEEE Trans. Information Theory*, Nov. 2007.
2. Steven Weber, Jeffrey Andrews, and Nihar Jindal, "Transmission Capacity: Applying Stochastic Geometry to Uncoordinated Ad Hoc Networks," Submitted: *IEEE Journal Sel. Areas in Communications* (Special Issue on Stochastic Geometry and Random Graphs for Wireless Networks), Aug. 2008.

## Journal Publications - Accepted/Appeared

1. J. Andrews, N. Jindal, M. Haenggi, R. Berry, S. Jafar, D. Guo, S. Shakkottai, R. Heath, M. Neely, S. Weber, and A. Yener, "Rethinking Information Theory for Mobile Ad Hoc Networks," To Appear: *IEEE Communications Magazine*.
2. Juyul Lee and Nihar Jindal, "Energy-efficient Scheduling of Delay Constrained Traffic over Fading Channels," To Appear: *IEEE Trans. Wireless Communications*.
3. Nihar Jindal, Jeffrey Andrews, and Steven Weber, "Bandwidth Partitioning in Decentralized Wireless Networks," To Appear: *IEEE Trans. Wireless Communications*.
4. Nihar Jindal, S. Weber, and Jeffrey Andrews, "Fractional Power Control for Decentralized Wireless Networks," To Appear: *IEEE Trans. Wireless Communications*.
5. Chan-Byoung. Chae, David Mazzarese, Nihar Jindal and Robert W. Heath, Jr., "Coordinated Beamforming with Limited Feedback in the MIMO Broadcast Channel", To Appear: *IEEE Journal Sel. Areas in Communications*, 2008.
6. Niranjay Ravindran and Nihar Jindal, "Limited Feedback-based Block Diagonalization for the MIMO Broadcast Channel," To Appear: *IEEE Journal Sel. Areas in Communications*, 2008.
7. Nihar Jindal, "Antenna Combining for the MIMO Downlink Channel", To Appear: *IEEE Trans. Wireless Communications*, 2008.
8. Ioannis Schizas, Georgios Giannakis and Nihar Jindal, "Distortion-Rate Analysis for Distributed Estimation with Wireless Sensor Networks," *EURASIP Journal on Advances in Signal Processing*, Special Issue on Distributed Signal Processing Techniques for Wireless Sensor Networks, 2008.
9. Juyul Lee and Nihar Jindal, "High SNR Analysis for MIMO Broadcast Channels: Dirty Paper Coding vs. Linear Precoding," *IEEE Trans. Information Theory*, Vol. 53, No. 12, pp. 4787-4792, Dec. 2007.
10. Steven Weber, Jeff Andrews, and Nihar Jindal, "The Effect of Fading, Channel Inversion, and Threshold Scheduling on Ad Hoc Networks," *IEEE Trans. Information Theory*, Vol. 53, No. 11, pp. 4127-4149, Nov. 2007.
11. Chris Ng, Nihar Jindal, Andrea Goldsmith, and Urbashi Mitra, "Capacity Gain from Two-Transmitter and Two-Receiver Cooperation," *IEEE Trans. Information Theory*, Vol. 53, No. 10, pp. 3822-3827, Oct. 2007.
12. Taesang Yoo, Nihar Jindal, and Andrea Goldsmith, "Multi-Antenna Broadcast Channels with Limited Feedback and User Selection," *IEEE Journal Sel. Areas in Communications*, Vol. 25, No. 7, pp. 1478-1491, Sept. 2007.
13. Yingqun Yu, Georgios Giannakis, and Nihar Jindal, "Noncoherent Modulation for MIMO Training and Related Capacity Analysis," *IEEE Transactions on Information Theory*, Vol. 53, No. 3, pp. 1160-1167, March 2007.
14. Nihar Jindal, "MIMO Broadcast Channels with Finite Rate Feedback," *IEEE Transactions on Information Theory*, Vol. 52, No. 11, pp. 5045-5059, Nov. 2006.

15. Nihar Jindal and Andrea Goldsmith, "Dirty Paper Coding vs. TDMA for MIMO Broadcast Channels", *IEEE Transactions on Information Theory*, Vol. 51, No. 5, pp. 1783-1794, May 2005.
16. Nihar Jindal, Wonjong Rhee, Sriram Vishwanath, Syed Ali Jafar, and Andrea Goldsmith, "Sum Power Iterative Water-filling for Multi-Antenna Gaussian Broadcast Channels," *IEEE Transactions on Information Theory*, Vol. 51, No. 4, pp. 1570-1580, April 2005.
17. Lifang Li, Nihar Jindal, and Andrea Goldsmith, "Outage Capacities and Optimal Power Allocation for Fading Multiple-Access Channels," *IEEE Transactions on Information Theory*, Vol. 51, No. 4, pp. 1326-1347, April 2005.
18. Nihar Jindal, Sriram Vishwanath, and Andrea Goldsmith, "On the Duality of Gaussian Multiple-Access and Broadcast Channels," *IEEE Transactions on Information Theory*, Vol. 50, No. 5, pp. 768-783, May 2004. (Recipient of 2005 IEEE ComSoc/IT Society Joint Paper Award)
19. Nihar Jindal and Andrea Goldsmith, "Capacity and Optimal Power Allocation for Fading Broadcast Channels with Minimum Rates," *IEEE Transactions on Information Theory*, Vol. 49, No. 11, pp. 2895-2909, Nov. 2003.
20. Sriram Vishwanath, Nihar Jindal, and Andrea Goldsmith, "Duality, Achievable Rates, and Sum-Rate Capacity of Gaussian MIMO Broadcast Channels," *IEEE Transactions on Information Theory*, Vol. 49, No. 10, pp. 2658-2668, Oct. 2003.
21. Andrea Goldsmith, Syed Ali Jafar, Nihar Jindal, and Sriram Vishwanath, "Capacity Limits of MIMO Channels," *IEEE Journal on Selected Areas in Communications*, Vol. 21, No. 5, pp. 684 -702, June 2003 (Invited Paper).

## Conference Publications

1. Nihar Jindal, Jeffrey Andrews, and Steven Weber, "Rethinking MIMO for Wireless Networks: Linear Throughput Increases with Multiple Receive Antennas," Submitted: *IEEE Int. Conf. on Communications*, Sept. 2008.
2. Juyul Lee and N. Jindal, "Delay Constrained Scheduling over Fading Channels: Optimal Policies for Monomial Energy-Cost Functions," Submitted: *IEEE Int. Conf. on Communications*, Sept. 2008.
3. Joseph Blomer and Nihar Jindal, "Transmission Capacity of Wireless Ad Hoc Networks: Successive Interference Cancellation vs. Joint Detection," Submitted: *IEEE Int. Conf. on Communications*, Sept. 2008.
4. Steven Weber, Nihar Jindal, Radha Krishna Ganti, and Martin Haenggi, "Longest Edge Routing on the Spatial Aloha Graph," *IEEE Globecom*, Nov. 2008.
5. Mari Kobayashi, Giuseppe Caire, and Nihar Jindal, "How Much Training and Feedback is Required in MIMO Broadcast Channels?," *IEEE Int. Symp. on Information Theory*, July 2008.
6. Juyul Lee and Nihar Jindal, "Energy-efficient Scheduling of Delay Constrained Traffic over Fading Channels," *IEEE Int. Symp. on Information Theory*, July 2008.
7. Niranjay Ravindran and Nihar Jindal, "Multi-User Diversity vs. Accurate Channel Feedback for MIMO Broadcast Channels," *IEEE International Conference on Communications*, May 2008.
8. Peng Wu and Nihar Jindal, "Analysis of Fixed Outage Transmission Schemes: A Finer Look at the Full Multiplexing Point," *IEEE International Conference on Communications*, May 2008.
9. Mariam Kaynia and Nihar Jindal, "Performance of ALOHA and CSMA in Spatially Distributed Wireless Networks," *IEEE International Conference on Communications*, May 2008.

10. Chris Ng, Nihar Jindal, Ubli Mitra, and Andrea Goldsmith "Power and Bandwidth Allocation in Cooperative Dirty Paper Coding," *IEEE International Conference on Communications*, May 2008.
11. Niranjay Ravindran, Nihar Jindal, and Howard Huang, "Beamforming with Finite Rate Feedback for LOS MIMO Downlink Channels", *IEEE Global Communications Conference*, November 2007.
12. Nihar Jindal, Steven Weber, and Jeff Andrews, "Fractional Power Control for Decentralized Wireless Networks", *Allerton Conf. on Communication, Control, and Computing*, Sept. 2007.
13. Giuseppe Caire, Nihar Jindal, Mari Kobayashi, and Niranjay Ravindran, "Achievable Throughput of MIMO Downlink Beamforming with Limited Channel Information," *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)*, Aug. 2007. (Invited Paper)
14. Nihar Jindal, Jeff Andrews, and Steven Weber, "Bandwidth-SINR Tradeoffs in Spatial Networks", *IEEE International Symposium on Information Theory*, June 2007.
15. Giuseppe Caire, Nihar Jindal, Mari Kobayashi, and Niranjay Ravindran, "Quantized vs. Analog Feedback for the MIMO Downlink: A Comparison between Zero-Forcing Based Achievable Rates", *IEEE International Symposium on Information Theory*, June 2007.
16. Niranjay Ravindran and Nihar Jindal, "MIMO Broadcast Channels with Block Diagonalization and Finite Rate Feedback", *IEEE ICASSP*, April 2007.
17. Nihar Jindal, Jeffrey Andrews, and Steven Weber, "Optimizing the SINR Operating Point of Spatial Networks", *Workshop on Information Theory and its Applications*, UC San Diego, Jan. 2007 (Invited Paper).
18. Jin-Jun Xiao, Zhi-Quan (Tom) Luo, and Nihar Jindal, "Linear Coding for Fading Channels", *IEEE Global Communications Conference*, San Francisco, CA, Nov. 2006.
19. Giuseppe Caire, Nihar Jindal, and Mari Kobayashi, "Achievable Rates of MIMO Downlink Beamforming with Non-Perfect CSI: A Comparison Between Quantized and Analog Feedback", *Asilomar Conference on Signals, Systems, and Computers*, Asilomar, CA, Oct. 2006. (Invited Paper)
20. Juyul Lee and Nihar Jindal, "Dirty Paper Coding vs. Linear Precoding for MIMO Broadcast Channels", *Asilomar Conference on Signals, Systems, and Computers*, Asilomar, CA, Oct. 2006. (Invited Paper)
21. Nihar Jindal, "MIMO Broadcast Channels with Digital Channel Feedback", *Asilomar Conference on Signals, Systems, and Computers*, Asilomar, CA, Oct. 2006. (Invited Paper)
22. Steven Weber, Jeff Andrews, and Nihar Jindal, "Throughput and Transmission Capacity of Ad Hoc Networks with Channel State Information", *Allerton Conference on Communication, Control, and Computing*, Monticello, IL, Sept. 2006.
23. Juyul Lee and Nihar Jindal, "Symmetric Capacity of MIMO Broadcast Channels", *IEEE International Symposium on Information Theory*, Seattle, WA, July 2006.
24. Nihar Jindal, "A Feedback Reduction Technique for MIMO Broadcast Channels", *IEEE International Symposium on Information Theory*, Seattle, WA, July 2006.
25. Nihar Jindal and Zhi Quan (Tom) Luo, "Capacity Limits of Multiple Antenna Multicast", *IEEE International Symposium on Information Theory*, Seattle, WA, July 2006.
26. Taesang Yoo, Nihar Jindal, and Andrea Goldsmith, "Finite-Rate Feedback MIMO Broadcast Channels with a Large Number of Users", *IEEE International Symposium on Information Theory*, Seattle, WA, July 2006.
27. Sudhir Srinivasa, Syed Ali Jafar, and Nihar Jindal, "On the Capacity of the Cognitive Tracking Channel," *IEEE International Symposium on Information Theory*, Seattle, WA, July 2006.

28. Nihar Jindal, "Finite Rate Feedback MIMO Broadcast Channels", *Workshop on Information Theory and its Applications*, UC San Diego, Feb. 2006. (Invited Paper)
29. Nihar Jindal, "MIMO Broadcast Channels with Finite Rate Feedback", *IEEE Global Communications Conference*, St. Louis, MO, Oct. 2005.
30. Ioannis Schizas, Georgios Giannakis, and Nihar Jindal, "Distortion-Rate Analysis for Distributed Estimation with Wireless Sensor Networks," *Allerton Conference on Communication, Control, and Computing*, Monticello, IL, Sept. 2005.
31. Nihar Jindal, "High SNR Analysis of MIMO Broadcast Channels", *IEEE International Symposium on Information Theory*, Adelaide, Australia, Sept. 2005.
32. Nihar Jindal, Urbashi Mitra, and Andrea Goldsmith, "Capacity of Ad-Hoc Networks with Node Cooperation," *IEEE International Symposium on Information Theory*, Chicago, IL, pp. 271, June 2004.
33. Nihar Jindal and Andrea Goldsmith, "Optimal Power Allocation for Parallel Broadcast Channels with Independent and Common Information," *IEEE International Symposium on Information Theory*, Chicago, IL, pp. 215, June 2004.
34. Nihar Jindal and Andrea Goldsmith, "Dirty Paper Coding vs. TDMA for MIMO Broadcast Channels," *IEEE International Conference on Communications*, Paris, France, Vol. 2, pp. 682-686, June 2004.
35. Sriram Vishwanath, Nihar Jindal, and Andrea Goldsmith, "The "Z" channel," *IEEE Global Communications Conference*, San Francisco, CA, Vol. 3, pp. 1726-1730, Dec. 2003.
36. Sriram Vishwanath, Wonjong Rhee, Nihar Jindal, Syed Ali Jafar, and Andrea Goldsmith, "Sum Power Iterative Water-filling for Gaussian Vector Broadcast Channels," *IEEE International Symposium on Information Theory*, Yokohama, Japan, pp. 467, July 2003.
37. Nihar Jindal, Sriram Vishwanath, and Andrea Goldsmith, "On the Duality Between General Multiple-Access/Broadcast Channels," *IEEE International Symposium on Information Theory*, Yokohama, Japan, pp. 313, July 2003.
38. Nihar Jindal, Syed Ali Jafar, Sriram Vishwanath, and Andrea Goldsmith, "Sum Power Iterative Water-filling for Multi-Antenna Gaussian Broadcast Channels," *Asilomar Conference on Signals, Systems, and Computers*, Asilomar, CA, pp. 1518-1522, Nov. 2002.
39. Nihar Jindal, Sriram Vishwanath, Syed Ali Jafar, and Andrea Goldsmith, "Duality, Dirty Paper Coding, and Capacity for Multiuser Wireless Channels," *DIMACS Workshop on Signal Processing for Wireless Transmission*, Rutgers, NJ, Oct. 2002 (Invited Paper).
40. Nihar Jindal, Sriram Vishwanath, and Andrea Goldsmith, "On the Duality of Gaussian Multiple-Access and Broadcast Channels," *IEEE International Symposium on Information Theory*, Lausanne, Switzerland, pp. 500, July 2002.
41. Sriram Vishwanath, Nihar Jindal, and Andrea Goldsmith, "On the Capacity of Multiple Input Multiple Output Broadcast Channels," *IEEE International Conference on Communications*, New York, NY, Vol. 3, pp. 1444-1450, April 2002.
42. Nihar Jindal and Andrea Goldsmith, "Capacity and Optimal Power Allocation for Fading Broadcast Channels with Minimum Rates," *IEEE Global Communications Conference*, San Antonio, TX, Vol. 2, pp. 1292-1296, Nov. 2001.
43. Nihar Jindal, Sriram Vishwanath, and Andrea Goldsmith, "On the Duality of Multiple-Access and Broadcast Channels," *Allerton Conference on Communication, Control, and Computing*, Monticello, IL, Oct. 2001.

## Tutorials

1. Andrea Goldsmith, Syed Ali Jafar, Nihar Jindal, and Sriram Vishwanath, "Capacity Limits of MIMO Systems", *IEEE Globecom 2005*, St. Louis, MO.

2. Andrea Goldsmith, Syed Ali Jafar, Nihar Jindal, and Sriram Vishwanath, "Capacity Limits of MIMO Systems", IEEE International Symposium on Information Theory, 2005, Adelaide, Australia.
3. Ali Ghrayeb, Georgios Giannakis, Andrea Goldsmith, Syed Ali Jafar, Nihar Jindal, Reinaldo Valenzuela, Sriram Vishwanath, and Shengli Zhou, "Theory and Practice of MIMO: Promises and Realities", IEEE Globecom 2004, Dallas, TX.

### Invited Presentations

1. IEEE Communication Theory Workshop, "Channel Feedback for Multiuser MIMO Downlink Channels", US Virgin Islands, May 2008.
2. Technical University-Berlin, "Performance of Hybrid ARQ in Fixed Outage Settings," Berlin, Germany, April 2008.
3. Northwestern University, "Multiuser MIMO Downlink Made Practical: Achievable Rates with Simple Channel State Estimation and Feedback Schemes," Evanston, IL, April 2008.
4. University of Colorado, Boulder, "Multi-user diversity vs. channel feedback: Is accurate channel feedback from a few users preferable to coarse feedback from many users?" Feb. 2008.
5. University of California, Berkeley, "Bandwidth Partitioning in Decentralized Wireless Networks," Berkeley, CA, Oct. 2007.
6. Princeton University, "Achievable Throughput of MIMO Downlink Beamforming with Limited Channel Information", Princeton, NJ, Oct. 2007.
7. Penn State University, "Achievable Throughput of MIMO Downlink Beamforming with Limited Channel Information", College Station, PA, Oct. 2007.
8. Seoul National University, "MIMO Downlink Channels with Imperfect Channel Information", Seoul, Korea, Aug. 2007.
9. Yonsei University, "MIMO Downlink Channels with Imperfect Channel Information", Seoul, Korea, Aug. 2007.
10. University of California, Los Angeles, "Optimizing Frequency Reuse in Ad-Hoc Networks", Los Angeles, CA, May 2007.
11. University of Southern California, "Optimizing Frequency Reuse in Ad-Hoc Networks", Los Angeles, CA, May 2007.
12. Workshop on Resource Allocation in Wireless Networks (associated with WiOpt), "Multiple Antenna Downlink Channels: From Theory to Practice", Limassol, Cyprus, April 2007.
13. Purdue University, "MIMO Downlink Channels: From Theory to Practice", West Lafayette, IA, March. 2007.
14. Rice University, "Optimizing Frequency Reuse in Ad-Hoc Networks", Houston, TX, Feb. 2007.
15. Hughes Network Systems, "Multi-User MIMO: The Next Frontier in Wireless Networks", Germantown, MD, Sept. 2006.
16. Bell Labs, "Finite Rate Feedback MIMO Downlink Channels", Crawford Hill, NJ, May 2006.
17. Bell Labs, "Finite Rate Feedback MIMO Downlink Channels", Murray Hill, NJ, May 2006.
18. Motorola Research Labs, "Multi-User MIMO: The Next Frontier in Wireless Networks", Schaumburg, IL, Feb. 2006.
19. Ohio State University, Information Processing Systems Laboratory Seminar Series, "MIMO Broadcast Channels with Finite Rate Feedback", Jan. 2006

20. Melbourne Information Theory Workshop, "MIMO Broadcast Channels with Finite Rate Feedback", Melbourne, Australia, Aug. 2005.
21. Swiss Federal Institute of Technology (ETH), "MIMO Broadcast Channels at High SNR", Zurich, Switzerland, May 2005.
22. Telecommunications Research Center Vienna (ftw), "MIMO Broadcast Channels with Finite Rate Feedback", Vienna, Austria, May 2005.
23. Adventium Labs, "Multiple Antenna Communication", Minneapolis, MN, February 2005.
24. University of Maryland, "Capacity Results for Multiple Antenna Multi-User Systems", College Park, MD, December 2004.
25. Army Research Laboratory, "Multi-user MIMO & Sensor Networks", Adelphi, MD, December 2004.

### **Funded Research Projects**

1. "CAREER: Exploring the Design and Fundamental Limits of Wireless Spatial Networks", PI, National Science Foundation (CAREER program), Feb. 2008 - Jan 2013
2. "Rethinking Mobile Ad Hoc Networks: A Non-Equilibrium Information Theory", co-PI, Defense Advanced Research Projects Agency (Information Processing Technology Office), Oct. 2006 - May 2011
3. "Collaborative Research: Cognitive Ad Hoc Networks: Capacity Optimization Through Local Adaptation", co-PI, National Science Foundation (CISE - Computing & Communications Foundations - Theoretical Foundations Cluster), Sept. 2006 - Aug. 2009
4. "Integrated Scheduling and Broadband SDMA", PI, Motorola Corporation (University Partnership in Research), Sept. 2006 - May 2009
5. "Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management", co-PI, National Science Foundation (Geosciences - Earth Sciences - Hydrologic Sciences Program), Sept. 2006 - Aug 2008
6. "IGERT: Non-Equilibrium Dynamics Across Space and Time: A Common Approach for Engineers, Earth Scientists, and Ecologists", senior personnel, National Science Foundation, CISE, Aug. 2005 - July 2010
7. "Multiple Antenna Downlink Channels with Imperfect Transmitter Channel Knowledge", PI, Grant-in-Aid of Research, Artistry, and Scholarship, University of Minnesota Graduate School, Jan. 2005 - June 2006