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## RESEARCH INTERESTS

- Wireless Communications; Communication and Sensor Networks; Signal Processing

## WORK EXPERIENCE

- Professor, Department of Electrical and Computer Engineering, University of California, Santa Barbara, July 2003 to present.
- Associate Professor, Department of Electrical and Computer Engineering, University of California, Santa Barbara, November 1999 to June 2003.
- Associate Professor, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, August 1998 to November 1999.
- Assistant Professor, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, August 1994 to August 1998
- Research Scientist, Bell Communications Research (Bellcore), August 1991 to July 1994
- Visiting Assistant Professor, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, August 1990 to July 1991
- Research Assistant, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, September 1985 to August 1990

## EDUCATION

- Ph. D. (Electrical Engineering) University of Illinois at Urbana-Champaign, 1990
- M.S. (Electrical Engineering) University of Illinois at Urbana-Champaign, 1987
- B. Tech. (Bachelor of Technology) Indian Institute of Technology, Kanpur, 1985

## RESEARCH IMPACT

- h-index of 49 (49 papers with at least 49 citations)
- Top three cited papers have more than 4900 citations
- In the ISI list of **highly cited** researchers in “computer science” (<http://isihighlycited.com>)
- Co-founder and Interim CEO, ShadowMaps, Inc., a start-up on urban localization and 3D mapping. ShadowMaps has developed a cloud-based software solution that delivers up to 10X improvements in localization in built-up environments, where GPS can produce errors as large as 50 meters due to blockage of satellite signals.
- Co-founder and Chief Scientist, Wirama, Inc., a radio frequency identification (RFID) company founded in 2006. Wirama successfully developed technology for fine-grained tag localization, and was acquired by Checkpoint Systems in 2009, whose “Wirama Radar” product is based on Wirama’s technology.
- Co-founder, Bytemobile, Inc., a wireless infrastructure company (now part of Citrix). Participated in fundraising and consulted as Chief Architect, Transport (July 2000-December 2001) on protocol optimization. Bytemobile’s network infrastructure node is now deployed in 125 wireless carriers in 60 countries, including major carriers such as Orange, T-Mobile, Sprint, and Vodafone.
- 14 US patents

## HONORS AND AWARDS

- Co-recipient, 2012 IEEE Marconi Prize Paper award in Wireless Communications
- Fellow of the IEEE
- Plenary lecture at SPAWC 2014 (15th IEEE International Workshop on Signal Processing Advances in Wireless Communications), Toronto, Canada, June 2014.
- Best paper award at S3 workshop, Mobicom 2014
- Runner up, best demo award, Mobicom 2014
- Advisor for Dr. Sriram Venkateswaran, who received 2012 Best CCDC (Center for Control, Dynamical Systems and Computation, UCSB) PhD thesis award
- PhD student Sriram Venkateswaran was awarded 2012 CCDC best thesis award.
- Plenary at IEEE CODEC 2012 (5th International Conf. on Computers and Devices for Communication), Kolkata, India.
- Co-advisor for Dr. Munkyo Seo, who received the Lancaster award for best Ph. D. dissertation in engineering and sciences at UCSB, 2008.
- Advisor and co-author for Best Student Paper award, ICIP 2004
- NSF CAREER award, 1996
- President of India Gold Medal awarded by the Senate, Indian Institute of Technology, Kanpur, for the best outgoing undergraduate in 1985
- University Fellowship, awarded by the University of Illinois for the academic year 1985-86, and Schlumberger Fellowship, awarded for the academic year 1987-88

## TEACHING CONTRIBUTIONS

**Graduate textbook:** *Fundamentals of Digital Communication*, Cambridge University Press, 2008. Outgrowth of courses in digital communication taught at UCSB and Illinois.

**Undergraduate textbook:** *Introduction to Communication Systems*, Cambridge University Press, 2014. Outgrowth of courses in communications taught at UCSB.

### Course development at UCSB

- Redesigned undergraduate elective sequence in communications and developed an extensive series of lecture notes which have evolved into a book.
- Designed and conducted a graduate level course on machine learning from a signal processing perspective, including inference in nonlinear dynamical systems.
- Designed and conducted an interdisciplinary graduate course on "Advanced Signal Processing for Neuroscience," in which ECE and Psychology students teamed up to explore new approaches for analyzing neuroimaging data.
- Introduced new graduate course in advanced digital communication, covering recent advances in turbo-like coding and space-time communication.
- Introduced new graduate course on networking.

### Course development at University of Illinois, Urbana-Champaign

- Developed new graduate course on advanced digital communications.
- Redesigned junior/senior level course on communications
- Helped modernize the senior/graduate digital communications course
- Updated graduate course on signal detection and estimation

## SELECTED RESEARCH ACCOMPLISHMENTS

(approximately reverse chronological)

**Shadowmaps:** GPS is notoriously imprecise in urban environments due to blockage of satellite signals by tall structures. However, the SNRs to satellites (already available in current GPS receivers) provides information regarding whether or not the receiver is in the shadow of a structure. Since the azimuth and elevation of the satellites are known, this shadow information can be used in conjunction with 3D maps to enhance localization accuracy. We have developed a novel Bayesian framework for utilizing this very noisy information to obtain up to 10X improvement in localization performance in urban environments when 3D maps are available. The framework also provides a means of generating crowdsourced 3D maps via SLAM (simultaneous localization and mapping). These ideas have been demonstrated via prototypes, and are now being commercialized via a start-up.

**Millimeter wave communication:** Sustained intellectual leadership in the emerging area of multiGigabit millimeter wave communication, building interdisciplinary collaborations with hardware designers and computer scientists. Research thrusts, some of which are ongoing, include:

- *LoS MIMO:* In collaboration with hardware designers, developed 60 GHz prototypes demonstrating that, at high carrier frequencies, nodes with compact form factors can provide spatial multiplexing even over line of sight (LoS) links, unlike the “rich scattering” environment required at lower carrier frequencies. Provided information-theoretic analysis showing that node form factor plays a role analogous to bandwidth, in terms of determining the number of spatial degrees of freedom in a LoS environment, via Slepian-Landau-Pollak style reasoning. Leads to design prescription for array of subarrays architecture.

- *Millimeter wave mesh networks:* Recognized that medium access control (MAC) for networks with highly directional links operating at millimeter wave carrier frequencies (e.g., the 60 GHz unlicensed band) must follow drastically different design prescriptions from existing protocols at lower frequencies: the bottleneck now is coordination in the face of deafness rather than interference. Provided comprehensive interference analysis justifying design prescriptions, and developed a novel MAC using memory and learning to combat deafness.

- *Millimeter wave to the mobile:* Proposed a seamless extension of 60 GHz indoor networking to outdoor picocells, providing the 1000X capacity increase required to meet the exponential growth in demand for cellular data. Published initial experiments, simulations and analysis showing that challenges such as interference across closely spaced cells, and adaptation to mobility and blockage, are difficult, but feasible in principle. This sets up an ambitious multi-year research agenda for next generation cellular design, centered around a novel compressive architecture for coordinating antenna arrays with a large number of elements (which can be accommodated in a compact form factor in small picocellular base stations).

- *Indoor mm wave networking:* Early analysis of blockage in mm wave networks using physics-based cross-layer models. Now working on seamless indoor-outdoor networking.

**Compressive estimation:** Developed a framework for compressive estimation for continuous-valued parameters, including fundamental estimation-theoretic limits as well as algorithms that attain them. Existing compressive sensing approaches are in an inherently discrete framework, and lead to error floors when naively applied to estimation of continuous-valued parameters. The development of this theory was motivated by need for an in-depth understanding of compressive techniques invented for RF beamforming for mm wave antenna arrays with a very large number of elements.

**Distributed MIMO:** Pioneered research in the general area of distributed MIMO, where multiple cooperating nodes act as a virtual antenna array to sidestep form factor constraints in synthesizing large arrays at low to moderate carrier frequencies. Achievements include theory and prototyping (using off-the-shelf software defined radios) of scalable feedback-based distributed transmit and receive beamforming schemes, fundamental advances in synchronization algorithms, and technical contributions to DARPA-funded programs such as PREW and CLASS.

**Addressing the ADC Bottleneck in multiGigabit communication:** Recognized that the cost and power consumption of analog-to-digital conversion (ADC) represents a fundamental bottleneck in mostly digital implementation of multiGigabit transceivers, and initiated a comprehensive

research program for transceiver design with sloppy ADC. Both low-precision ADC (where the bottleneck is the nonlinearity due to drastic quantization) and time-interleaved ADC (where the bottleneck is the mismatch between slower ADCs running in parallel) are considered, with research ranging from Shannon theory to algorithms.

**Minimalism and scale in sensor networks:** Developed novel system concepts based on the realization that sensor networks can only scale if individual sensor nodes are “dumbed down.” In terms of applications, an example is the development of fundamental limits and algorithms for target tracking using binary proximity sensors, showing that it is possible to realize sophisticated functionalities such as multiple target tracking with a network of extremely simple sensors. In terms of architecture, an example is the development of a massively scalable “imaging sensor net” architecture for localization and data collection, with “dumb” sensor nodes act as pixels being imaged by one or more “smart” collector nodes to achieve both localization and collection of sensor data. This concept was prototyped at millimeter wave frequencies.

**Wideband Space-Time Communication:** First to relate literature on *outdoor* channel propagation measurements to information-theoretic design prescriptions, ranging from code rate to antenna spacing, for wideband space-time communication. The designs target 4G OFDM-based systems such as IEEE 802.16 and 802.20, Prior work on space-time communication had focused mainly on narrowband indoor applications.

**Communication over Time-Varying Channels:** Systematic investigation for identifying and approaching the fundamental limits of time-varying wireless channels using *efficient* noncoherent communication, broadly interpreted as joint channel and data estimation. Results include signal space concepts, turbo noncoherent modulation, and noncoherent eigenbeamforming for wireless uplinks.

**Robust, Adaptive Data Hiding:** Design and implementation of image data hiding system that represents the “state of the art” in high-volume, robust data hiding (thousands of bits robust to compression attacks, and worse, hundreds of bits robust to printing). Leverages novel application of turbo-like codes with “erasures at the encoder,” and “just-enough-detail” characterization of the data hiding channel.

**Steganalysis:** Developed systematic approach to steganalysis, or the detection of the presence of hidden data, based on detection and learning theory. Used the insights to develop data hiding schemes robust to steganalysis.

**TCP Performance Analysis and Design:** First detailed performance analysis of TCP/IP, the Internet data transport protocol, leading to design prescriptions for its support over high-speed networks, wireless networks, and asymmetric networks. Technology transfer into Bytemobile, Inc., a networking infrastructure start-up, now part of Citrix.

**Adaptive Interference Suppression:** First to show that *near-far* problem can be solved *adaptively*, without knowledge of interference parameters, using MMSE and blind interference suppression schemes for direct-sequence CDMA demodulation. This work stimulated a huge literature on application of adaptive signal processing to multiuser communications. Other results include development of timing acquisition methods including adaptive interference suppression, and Differential MMSE adaptation for time-varying channels.

## TECHNOLOGY TRANSFER VIA CONSULTING

- Consultant for Raytheon (BBN Technologies) on a sequence of DARPA programs on distributed MIMO.
- Consultant for Silvus Technologies on DARPA program on LoS MIMO influenced by our research.
- Consultant for Denali Software on flash memory reliability.
- Consulting and collaboration with Motorola on wireless communication systems, resulting in patent on adaptive interference suppression for CDMA downlinks
- Consulting and collaboration with Bell Labs, Lucent Technologies, in wireless and high-speed networking, resulting in patent on design for TCP support on asymmetric networks
- Consultant for Meru Networks (now a public company) during its formation

## PUBLIC SERVICE

Founder and President of GLEN World ([www.glenworld.org](http://www.glenworld.org)), a non-profit for digital English learning based on games and stories, targeting disadvantaged children worldwide.

- Raised initial seed funding and built up a team including a former Disney animator, Second Language Acquisition and ESL experts, artists, teachers, and engineers.
- Now leading GLEN World's team competing in the Global Learning Xprize ([learning.xprize.org](http://learning.xprize.org)) for developing software to enable children to teach themselves to read, a vision that is closely aligned with the founding vision for GLEN World.

## PROFESSIONAL ACTIVITIES

- 2011-2012: Chair, Faculty Search Committee, ECE Department, UCSB
- Served on campus-level Graduate Council and Undergraduate Councils at UCSB.
- Served on (including as chair) ECE long range planning committee.
- Served as Associate Editor for *IEEE Trans. on Communications*, *IEEE Transactions on Information Theory*, and *IEEE Transactions on Information Forensics and Security*.
- Co-chair, International Workshop on mmWave Communications: from Circuits to Networks, September 2010, Chicago, IL.
- Technical Program Co-Chair, 10th International Workshop on Information Hiding, May 2008, Santa Barbara, CA.
- Served on Technical Program Committees for WiOpt 2009, Information Theory Workshop on Networking and Information Theory (Volos, Greece, 2009), VTC 2007, Globecom 2004, ISITA 2000, SPAWC 1997
- Served on IEEE Information Theory Society paper award committee, and on committee for joint Information Theory and Communications Society paper award (2003 and 2009)
- Served on numerous NSF panels
- Organized and chaired invited sessions on Wireless Communications, 1995-1999, for the Allerton Conference on Communication, Control and Computing hosted by the University of Illinois.

## RESEARCH SUPERVISION

- Current graduate students (UCSB): Anant Gupta, Faruk Gencel, Soorya Gopalakrishnan, Andrew Irish, Babak Mamandipoor, Zhinus Marzi
- Ph. D. completed (UCSB): Gwen Barriac (2004 Ph. D., now with Qualcomm), Noah Jacobsen (2005 Ph. D., now with Alcatel-Lucent), Kaushal Solanki (2005 Ph. D., now CEO at Eyenuk, Inc.), Ken Sullivan (2005 Ph. D., now with Mayachitra, Inc.), Kris Bruvold (2005 Ph. D., now with Jet Propulsion Laboratories), Bharath Ananthasubramaniam (2007 Ph. D., now at Institute for Theoretical Biology, Humboldt University, Berlin ); Munkyo Seo (2008 Ph. D., now at Teledyne); Raghu Mudumbai (2007 Ph. D., now a faculty at the University of Iowa), Jaspreet Singh (2010 Ph. D., now at Samsung R&D), Sumit Singh (2010 Ph. D., now at Moseley Associates), Eric Torkildson (2011 Ph. D., now a research scientist at Arizona State University); Sandeep Ponnuru (2011 Ph. D., now at Qualcomm R&D); Sriram Venkateswaran (2011 Ph. D., now at Broadcom R&D); Hong Zhang (2012 Ph. D., now a consultant); Dinesh Ramasamy (2014 Ph. D., now at Amazon); Aseem Wadhwa (2014 Ph. D., now a postdoc at UCSB)
- M.S. completed (UCSB): Chi-Hsien Lin (2004 M. S., now with Marvell)
- Ph. D. completed (Illinois): Liping Julia Zhu (1999 Ph. D., currently CEO at DigitNexus), Hemant Chaskar (1999 Ph. D., now with AirTight Networks), Dilip Warriar (2000 Ph. D., now with Bose), Eugene Visotsky (2000 Ph. D., now with Nokia Siemens Networks), Julian Waldby (2001 Ph. D., independent consultant), Rong-Rong Chen (2003 Ph. D., now a faculty at University of Utah)
- M.S. completed (Illinois): Marcel Brouillet, Brian Johnson, Hedi Krichene, Eugene Visotsky, Julian Waldby

- Past postdoctoral researchers: Onkar Dabeer (now at Qualcomm R&D), Luis Galup (now with GE Research Labs), Raghu Madyastha (was with Aware, Inc.), Francois Quitin (now at NTU, Singapore)

**FUNDING** (obtained as sole PI, unless noted otherwise)

- National Science Foundation, 2015-2020, *GigaNets: A Path to Experimental Research in Millimeter Wave Networking*, \$2.4M (UCSB share: \$1.6M). PI, with 5 co-PIs from UCSB, Stanford and Wisconsin.
- Google Faculty Research Award, 2014: *Scalable mm-wave arrays for outdoor “wireless fiber,”* \$28.3K (UCSB share of gift awarded for collaboration with Prof. Amin Arbabian at Stanford).
- Facebook, Inc., 2014: *Millimeter wave communication link design*, \$25K (gift).
- Systems On Nanoscale Information fabriCs (SONIC) Center, a DARPA/SRC STARNET center, 2013-2017, \$1M (UCSB subcontract from U. of Illinois).
- National Science Foundation, 2013-2016, *Distributed coherence: fundamental building blocks, system concepts, and experimental demonstration*, \$1.2M (in collaboration with U. Iowa and WPI, with UCSB share \$350K).
- National Science Foundation, 2013-2016, *Mobile mm Waves: Addressing the Cellular Capacity Crisis with 60 GHz Picocells*, \$500K (PI, with one other co-PI).
- Army Institute for Collaborative Biotechnologies, 2013-2015, *Neuro-inspired Architectures for Inference and Control in Massively Scalable Multi-Agent Systems*, \$ 225K (co-PI with Prof. Hespanha).
- Samsung Research America, 2013-2015: *Signal processing and MIMO models for multiGigabit mm wave communications*, \$117K.
- DARPA GRAPHS program, 2012-2016: *Social Network Analysis: Geometry, Dynamics and Inference for Very Large Data Sets*, \$2.84M (co-PI in a four-PI team).
- Army Institute for Collaborative Biotechnologies, 2011-2014, *BioNav: Biomimetic UAV-based System for Soldier Navigation and Situation Awareness*, \$2.29M with UCSB share \$787.5K (co-PI with Prof. Hespanha).
- Army Institute for Collaborative Biotechnologies, 2008-2013, *Bio-inspired multi-agent networks in uncertain and adversarial environments*, \$1.17M (co-PI with Prof. Hespanha).
- National Science Foundation, 2008-2012, *MultiGigabit millimeter wave mesh networks: cross-layer design and experimental validation*, \$500K (PI, with two other co-PIs).
- National Science Foundation, 2007-2010, *Towards a theory of communication with sloppy analog-to-digital conversion: a framework for low-cost Gigabit wireless*, \$300K.
- Army Institute for Collaborative Biotechnologies, 2007-2009, *Bio-inspired communication and control for large-scale networks of autonomous agents*, \$480K (co-PI).
- Army Institute for Collaborative Biotechnologies, 2006-2007, *Computation and control in large-scale stochastic networks*, \$180K (co-PI).
- Network science project funded by Institute for Collaborative Biotechnologies (approximately \$60K/year per investigator), 2005-2007 (co-PI)
- National Science Foundation, 2006-2009, *Millimeter wave MIMO: a new architecture for 10-40 Gigabit wireless/optical hybrid networks*, \$450K (PI, with two other co-PIs).
- Office of Naval Research, 2005-2008: *Battlefield Sensor Networks: from Architectures to Applications*, \$300K.
- National Science Foundation, 2005-2009, *Imaging Sensor Nets: from Concept to Prototypes*, \$0.9M (PI, with two other co-PIs).
- National Science Foundation, 2004-2007, *Distributed Space-Time Communication for Wireless Sensor Networks*, \$240K.
- Motorola University Partnerships in Research (UPR) and University of California Communications Research (CoRe), 2001-2005: *Iterative Space-Time Codes for Mobile Radio*, approximately \$68K per year

- Office of Naval Research, 2002-2005, *Network-Centric Quality of Service in Heterogeneous Networks*, \$276K.
- National Science Foundation Information Technology Research (ITR) award, 2002-2006: *Cross-layer Optimization for 4G Wireless Networks: Heavy-tailed Traffic, Multiuser Channels, and Pseudocells*, approximately \$450K.
- Office of Naval Research, 2002-2004: *Data Hiding in Images and Video*, \$485K (co-PI).
- NSF research infrastructure award, 2000-2005: “Digital Campus: Scalable Information Services on a Campus-wide Wireless Network,” approximately \$1M (co-PI), based on collaborative proposal between CS and ECE departments at UCSB.
- NSF, 1999-2001: *An Integrated Exploration of Wireless Network Communication*, \$700K (co-PI).
- Army Research Office, 1998-2002: *Communications in the Digital Battlefield: Fundamental Problems in the Design of Heterogeneous Networks*, \$220K.
- NSF CAREER award, 1996-2001: *Key Problems in Wireless Communication*, \$210K.
- NASA, 1999-2000: *Wideband CDMA for a Satcom based Avionics Network* (PI: Madhow, co-PI: K. Ramchandran), \$110K.
- Motorola University Partnership in Research (UPR), 1996-2000: *Interference Suppression for CDMA Systems*, \$34K/year.
- Office of Naval Research, 1995-1997: *Adaptive Interference Suppression for the Demodulation of Direct-Sequence CDMA signals*, \$166K.
- Joint Services Electronics Program (JSEP), 1995-1998: *Acquisition and Demodulation for Wireless Communications* (joint with D. V. Sarwate and D. Jones.) \$266K.
- Army Research Office–DoD Focused Research Initiative, 1995-1998: *Wireless Distributed Multimedia Networks*, approximately \$1M/year (co-PI, joint grant awarded to Illinois, Purdue and Michigan, with industry partner Hughes).
- Participated in successful NSF equipment proposals for academic and research infrastructure at Illinois, thereby obtaining funding for wireless testbeds for both physical layer (interference suppression) and transport layer (TCP, voice, and video over wireless) experimentation. Total of about \$150K in equipment.

## PATENTS

(14 US patents awarded)

1. Co-inventor on US patent 5481533 (awarded August 30, 1994): Interference suppression in CDMA systems (filed by Bellcore, now Telcordia).
2. Co-inventor on US patent 5343496 (awarded January 2, 1996): Hybrid intra-cell TDMA/inter-cell CDMA for wireless networks (filed by Bellcore, now Telcordia).
3. Co-inventor on US patent 6078564 (awarded June 20, 2000): System for improving data throughput of a TCP/IP network connection with slow return channel (filed by Lucent for invention under consulting contract).
4. Co-inventor on US patent 6175587 (awarded January 16, 2001): Communication device and method for interference suppression in a DS-SS system (filed by Motorola for invention under consulting contract).
5. Co-inventor on US patent 6175588 (awarded January 16, 2001): Communication device and method for interference suppression using adaptive equalization in a spread spectrum communication system (filed by Motorola for invention under consulting contract).
6. Co-inventor on US patent 6426973 (awarded July 30, 2002): Differential minimum mean squared error communication signal compensation method (filed by the University of Illinois).
7. Co-inventor on US patent 7099273 (awarded August 29, 2006): Data transport acceleration and management within a network communication system (filed by Bytemobile for invention under consulting contract).

8. Co-inventor on US patent 7136353 (awarded November 14, 2006): Quality of service management for multiple connections within a network communication system (filed by Bytemobile for invention under consulting contract).
9. Inventor on US patent 7453855 (awarded November 18, 2008): Multiuser detection and interference suppression techniques for direct sequence spread spectrum systems in which all users employ same spreading code (filed by Meru Networks for invention under consulting contract).
10. Co-inventor on US patent 7652577 (awarded January 26, 2010): Systems and methods of beamforming in radio frequency identification applications (filed by Wirama, now part of Checkpoint Systems, for invention under consulting contract).
11. Inventor on US patent 8144668 (awarded March 27, 2012): Multiuser detection and interference suppression techniques for direct sequence spread spectrum systems in which all users employ same spreading code (filed by Meru Networks for invention under consulting contract, follow-up to patent 7453855).
12. Co-inventor on US patent 8217760 (awarded July 10, 2012): Applique nodes for performance and functionality enhancement in radio frequency identification systems (filed by Wirama, now part of Checkpoint Systems, for invention under consulting contract).
13. Co-inventor on US patent 8446,253 (awarded May 21, 2013): Localization using virtual antenna arrays in modulated backscatter RFID systems (filed by Wirama, now part of Checkpoint Systems, for invention under consulting contract).
14. Co-inventor on US patent 8988197 (awarded March 24, 2015): RFID repeater for range extension in modulated backscatter systems (filed by Wirama, now part of Checkpoint Systems, for invention under consulting contract).

## PUBLICATIONS

### Books

- Upamanyu Madhow, *Fundamentals of Digital Communication*, Cambridge University Press, 2008.
- Upamanyu Madhow, *Introduction to Communication Systems*, Cambridge University Press, 2014.

### Book Chapters

- G. Barriac, N. Jacobsen, U. Madhow, “The role of feedback, CSI and coherence in MIMO systems,” in *Space-Time Wireless Systems: from Array Processing to MIMO Communications*, edited by H. Bolcskei, D. Gesbert, C. Papadias, A. J. van der Veen, Cambridge University Press, 2006.

### Journal Articles Published (reverse chronological)

1. A. Kumar, R. Mudumbai, S. Dasgupta, M. M. Rahman, D. R. Brown, U. Madhow, P. Bidigare, “A scalable feedback mechanism for distributed nullforming with phase-only adaptation,” *IEEE Transactions on Signal and Information Processing over Networks*, to appear.
2. D. R. Brown, U. Madhow, M. Ni, M. Rebholz, P. Bidigare, “Distributed reception with hard decision exchanges,” *IEEE Transactions on Wireless Communications*, vol. 13, no. 6, pp. 3406-3418, June 2014.
3. D. Ramasamy, S. Venkateswaran, U. Madhow, “Compressive parameter estimation in AWGN,” *IEEE Transactions on Signal Processing*, vol. 62, no. 8, pp. 2012-2027, April 2014.
4. J. Choi, Z. Chance, D. J. Love, U. Madhow, “Noncoherent trellis coded quantization: a practical limited feedback technique for massive MIMO systems,” *IEEE Transactions on Communications*, vol. 61, no. 12, pp. 5016-5029, December 2013.
5. J. Singh, U. Madhow, “Phase-quantized block noncoherent communication,” *IEEE Transactions on Communications*, vol. 61, no. 7, pp. 2828-2839, July 2013.
6. F. Quitin, M. M. U. Rahman, R. Mudumbai, U. Madhow, “A Scalable Architecture for Distributed Transmit Beamforming with Commodity Radios: Design and Proof of Concept,” *IEEE Transactions on Wireless Communications*, vol. 12, no. 3, pp. 1418-1428, March 2013.



7. S. Venkateswaran, U. Madhow, "Localizing Multiple Events Using Times of Arrival: a Parallelized, Hierarchical Approach to the Association Problem," *IEEE Trans. Signal Processing*, vol. 60, no. 10, pp. 5464-5477, October 2012.
8. S. Singh, U. Madhow, E. M. Belding, "Shaping Throughput Profiles in Multihop Wireless Networks: A Resource-Biasing Approach," *IEEE Transactions on Mobile Computing*, vol. 11, no. 3, pp. 367-376, March 2012.
9. E. Torkildson, U. Madhow, M. Rodwell, "Indoor Millimeter Wave MIMO: Feasibility and Performance," *IEEE Transactions on Wireless Communications*, vol. 10, no. 12, pp. 4150-4160, December 2011. **2012 IEEE Marconi prize paper award in wireless communications.**
10. S. Singh, U. Madhow, R. Mudumbai, "Interference analysis for highly directional 60-GHz mesh networks: the case for rethinking medium access control," *IEEE/ACM Trans. Networking*, vol. 19, no. 5, pp. 1513-1527, October 2011.
11. J. Singh, R. Kumar, U. Madhow, S. Suri, R. Cagley, "Multiple target tracking with binary proximity sensors," *ACM Trans. Sensor Networks*, vol. 8, no.1, August 2011.
12. S. Ponnuru, M. Seo, U. Madhow, M. Rodwell, "Joint mismatch and channel compensation for high-speed OFDM receivers with time-interleaved ADCs," *IEEE Transactions on Communications*, vol. 58, no. 8, pp. 2391 - 2401, August 2010.
13. A. Sarkar, U. Madhow, B. S. Manjunath, "Matrix embedding with pseudorandom coefficient selection and error correction for robust and secure steganography," *IEEE Transactions on Information Forensics and Security*, vol. 5, no. 2, pp. 225-239, June 2010.
14. R. Mudumbai, J. Hespanha, U. Madhow, G. Barriac, "Distributed transmit beamforming using feedback control," *IEEE Transactions on Information Theory*, vol. 56, no. 1, pp. 411 - 426, January 2010.
15. J. Singh, O. Dabeer, U. Madhow, "On the limits of communication with low-precision analog-to-digital conversion at the receiver," *IEEE Transactions on Communications*, vol. 57, no. 12, pp. 3629-3639, December 2009.
16. N. Srivastava, R. Mudumbai, U. Madhow, S. Suri, "Target tracking with binary proximity sensors," *ACM Transactions on Sensor Networks*, vol. 5, no. 4, Article 30, November 2009.
17. S. Singh, F. Zilliotto, U. Madhow, E. M. Belding, M. Rodwell, "Blockage and directivity in 60 GHz wireless personal area networks: from cross-layer model to multihop MAC design," *IEEE Journal on Selected Areas in Communications*, special issue on Realizing Gbps Wireless Personal Area Networks, vol. 27, no. 8, pp. 1400-1413, October 2009.
18. R. Mudumbai, D. R. Brown, U. Madhow, H. V. Poor, "Distributed transmit beamforming: challenges and recent progress," *IEEE Communications Magazine*, special issue on Advances in Cooperative and Relay Communications (*one of 6 articles selected for publication out of 50 submitted*), pp. 102-110, February 2009.
19. N. Jacobsen, U. Madhow, "Coded noncoherent communication with amplitude/phase modulation: from Shannon theory to practical architectures," *IEEE Transactions on Communications*, vol. 56, no. 12, pp. 2040-2049, December 2008.
20. N. Jacobsen, G. Barriac, U. Madhow, "Noncoherent eigenbeamforming and interference suppression for outdoor OFDM systems," *IEEE Transactions on Communications*, vol. 56, no. 6. pp. 915-924, June 2008.
21. S. Singh, P. A. K. Acharya, U. Madhow and E. M. Belding-Royer, "Sticky CSMA/CA: implicit synchronization and real-time QoS in mesh networks," *Ad Hoc Networks*, 2007.
22. B. Ananthasubramaniam, U. Madhow, "On localization performance in imaging sensor nets," *IEEE Transactions on Signal Processing*, vol. 55, no. 10, pp. 5044-5057, October 2007.
23. R. Mudumbai, G. Barriac, U. Madhow, "On the feasibility of distributed beamforming in wireless networks," *IEEE Transactions on Wireless Communication*, vol. 6, no. 5, pp. 1754-1763, May 2007.
24. K. Solanki, U. Madhow, B. S. Manjunath, S. Chandrasekaran and I. El-Khalil, "'Print and Scan' Resilient Data Hiding in Images," *IEEE Transactions on Information Forensics and Security*, vol. 1, no. 4, pp. 464-478, December 2006.

25. K. Sullivan, U. Madhow, S. Chandrasekaran and B.S. Manjunath, "Steganalysis for Markov cover data with applications to images," *IEEE Transactions on Information Forensics and Security*, vol. 1, no. 2, pp. 275-287, June 2006.
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#### Conference Papers (reverse chronological)

1. D. Ramasamy, U. Madhow, “Compressive spectral embedding: sidestepping the SVD,” to appear, *Proc. NIPS (Neural Information Processing Systems) 2015*, Montreal, Canada, December 2015. (**22% acceptance rate**)
2. B. Mamandipoor, D. Ramasamy, U. Madhow, “Frequency estimation for a mixture of sinusoids: a near-optimal sequential approach,” to appear, *Proc. IEEE GlobalSIP 2015*, Orlando, FL, December 2015.

3. Z. Marzi, U. Madhow, H. Zheng, "Interference analysis for mm-wave picocells," to appear, *Proc. IEEE Globecom 2015*, San Diego, CA, December 2015.
4. H. Roufarshbaf, U. Madhow, M. Rodwell, S. Rajagopal, "Efficient analog multiband channelization for bandwidth scaling in mm-wave systems," *Proc. 2015 IEEE International Conference on Communications (ICC 2015)*, London, UK, June 2015.
5. M. F. Gencel, M. E. Rasekh, U. Madhow, "Scaling wideband distributed transmit beamforming via aggregate feedback," *Proc. 2015 IEEE International Conference on Communications (ICC 2015)*, London, UK, June 2015.
6. M. F. Gencel, M. E. Rasekh, U. Madhow, "Distributed transmit beamforming with one bit feedback revisited: how noise limits scaling," *Proc. 2015 IEEE International Symposium on Information Theory (ISIT 2015)*, Hong Kong, June 2015.
7. M. E. Rasekh, U. Madhow, R. Mudumbai, "Frequency tracking with intermittent wrapped phase measurement using the Rao-Blackwellized particle filter," *Proc. 2014 Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 2014.
8. B. Mamandipoor, G. Malysa, A. Arbabian, U. Madhow, K. Noujeim, "60 GHz synthetic aperture radar for short-range imaging: theory and experiments," *Proc. 2014 Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 2014.
9. E. Akbas, A. Wadhwa, M. Eckstein, U. Madhow, "A framework for machine vision based on neuro-mimetic front end processing and clustering," *Proc. 52nd Allerton Conference on Communication, Control and Computing (Allerton 2014)*, Monticello, IL, October 2014.
10. H. Roufarshbaf, U. Madhow, S. Rajagopal, "OFDM-based analog multiband: a scalable design for indoor mm-wave wireless communication," *Proc. 2014 IEEE Global Communications Conference (Globecom 2014)*, Austin, TX, December 2014.
11. Y. Zhu, Z. Zhang, Z. Marzi, C. Nelson, U. Madhow, B. Zhao, H. Zheng, "Demystifying 60GHz outdoor picocells," *Proc. 20th Annual International Conference on Mobile Computing and Networking (MobiCom 2014)*, Maui, Hawaii, September 2014 (**acceptance rate 16.4%**).
12. A. Irish, J. Isaacs, D. Iland, J. Hespanha, E. Belding, U. Madhow, "Demo: ShadowMaps, the Urban Phone Tracking System," *Proc. 20th Annual International Conference on Mobile Computing and Networking (MobiCom 2014)*, Maui, Hawaii, September 2014. **Runner-up Best Demo Award.**
13. A. T. Irish, D. Iland, J. T. Isaacs, J. P. Hespanha, E. M. Belding, U. Madhow, "Using crowdsourced satellite SNR Measurements for 3D mapping and real-time GNSS positioning Improvement," *Proc. 2014 ACM Wireless of the Students, by the Students, for the Students Workshop (S3)*, Maui, Hawaii, September 2014. **Best Paper Award.**
14. J. T. Isaacs, X. Magee, A. Subbaraman, F. Quitin, K. Fregene, A. R. Teel, U. Madhow, J. P. Hespanha, "GPS-optimal micro air vehicle navigation in degraded environments," *Proc. 2014 American Control Conference (ACC 2014)*, Portland, OR, June 2014.
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21. A. T. Irish, F. Quitin, U. Madhow, M. Rodwell, "Achieving multiple degrees of freedom in long-range mm-wave MIMO channels using randomly distributed relays," *Proc. 2013 Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 2013.
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23. S. Venkateswaran, *et al.*, "RF Source-Seeking by a Micro Aerial Vehicle Using Rotation-Based Angle of Arrival Estimates," *Proc. 2013 American Control Conference (ACC 2013)*, Washington DC, June 2013.
24. D. Ramasamy, R. Ganti, U. Madhow, "On the capacity of picocellular networks," *Proc. 2013 IEEE International Symposium on Information Theory (ISIT 2013)*, Istanbul, Turkey, July 2013.
25. D. R. Brown, U. Madhow, P. Bidigare, "Distributed Reception with Coarsely-Quantized Observation Exchanges," *Proc. 2013 47th Annual Conference on Information Sciences and Systems (CISS 2013)*, Baltimore, MD, March 2013.
26. J. Choi, D. Love, U. Madhow, "Limited Feedback in Massive MIMO Systems: Exploiting Channel Correlations via Noncoherent Trellis-Coded Quantization," *Proc. 2013 47th Annual Conference on Information Sciences and Systems (CISS 2013)*, Baltimore, MD, March 2013.
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35. D. R. Brown, P. Bidigare, S. Dasgupta, U. Madhow, "Receiver-coordinated zero-forcing distributed transmit nullforming," **invited paper**, *Proc. 2012 IEEE Statistical Signal Processing Workshop (SSP 2012)*, pp. 269 -272, Ann Arbor, MI, August 2012.
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