

Balasubramaniam (Bala) Natarajan

CURRICULUM VITAE

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PART I – Academics

◆ Academic Record

Ph.D. Colorado State University, Fort Collins, CO 09/97 - 04/02
Electrical Engineering

Dissertation Title: *Carrier Interferometry for next generation CDMA and TDMA wireless systems: A multi-carrier framework*
GPA – 4.00

B.E (Hons.) Birla Institute of Technology and Science, Pilani , India 09/93 - 05/97
Electrical Engineering

GPA – 3.7 (Degree of “Distinction” awarded by Birla Institute of Technology and Science, Pilani, India in 1997)

◆ Research

Research Interests

Wireless Systems and Spread Spectrum, Cognitive Radio networks, Multi-Carrier Modulation and Diversity combining (OFDM and MC-CDMA), Multi-user detection, Channel modeling, Statistical Communications. Applications of Evolutionary Algorithms (or more generally, stochastic optimization algorithms) to Wireless Communications, Distributed Detection and Estimation in Sensor networks, Sensor Signal Processing and Localization.

Current and Past Research Projects/Thrusts

1. *Ultrawideband and Cognitive Radios*

- dynamic spectrum management
- spectrum usage modeling and availability prediction
- designing adaptive spreading sequences for CDMA based cognitive radios
- Designing precoders for MB-OFDM based UWB system
- UWB and GPS coexistence issues
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2. *Wireless and Wired Sensor Networks*

- Distributed detection and classification
- Effect of feedback on system performance
- Heterogenous sensor fusion
- Collaborative target tracking
- Resource allocation in cooperative sensor networks
- Sensor localization and optimal placement
- Biomedical and veterinary telemedicine applications

3. *Crack detection via Imaging sensors*

- Process images of concrete pavements and classify various types of cracks.

4. *GPS Receiver Design*

- Co-existence issues between GPS and UWB systems
- Designing programmable tracking loops for high dynamic environments

5. *Carrier Interferometry and Multi-carrier Modulation*

- Exploit the classic principles of interferometry in supporting multiple access.
- Demonstrate the ability of carrier interferometry (CI) technology to support future generation wireless (4G, WLANs, PANs).

6. *Multi-carrier implementation of Single-carrier systems (Software Radio Applications)*

- Develop a multi-carrier implementation of any pulse shape and implement an OFDM like transceiver scheme in single-carrier systems.
- Provide a common hardware platform for software radio applications
- Emulate these systems to demonstrate performance and throughput benefits.

7. *Multi-user Detection in MC-CDMA*

- Develop advanced optimal and blind multiuser detectors (MUD) specifically for MC-CDMA systems.
- Develop different variants of non-linear MUDs (multi-stage parallel and serial interference cancellers) for MC-CDMA.

8. *Optimal Spreading Sequence Design for DS-CDMA and MC-CDMA*

- Employ evolutionary algorithms (e.g., genetic algorithms) to generate theoretically optimum complex spreading sequences.
- Design of a modified viterbi algorithm for code design

9. *Spread-OFDM performance in the presence of Jamming and Impulse Noise*

- Evaluate the performance of Spread-OFDM (S-OFDM) in the presence of narrowband and wideband jamming and develop anti-jamming signal processing techniques for military applications.
- Investigate the effects of impulse noise on the performance of S-OFDM and MC-CDMA.

10. *Other Applications of Evolutionary Algorithms in Wireless Communications*

- Design optimal multiuser detectors for synchronous and asynchronous DS-CDMA using particle swarm intelligence.
- Design ultrawideband waveforms with desired spectral characteristics using genetic algorithms.
- Designing a genetic algorithm based detector for MIMO systems.

11. Application of LDPC Codes in Spread OFDM

- Design and analysis of regular and irregular low density parity check codes specifically for S-OFDM systems.
- Optimal design of parity check matrices for S-OFDM systems in multipath channels.

Research Awards

- “Exemplary Project” award in the state of Colorado, for the year 2000. Awarded by the governing body of the Colorado Advanced Software Institute (CASI), a division of Colorado Commission on Higher Education.
- K-state President’s “Faculty Development Award” for travel to Calgary, Canada in Summer 2003 to present at the Wireless 2003 conference. Amount - \$800.00
- K-state President’s “Faculty Development Award” for travel to Korea for IEEE International conference in Communications conference, 2005. Amount - \$1400.00
- K-state President’s “Faculty Development Award” May 2006, \$500 for travel to IEEE VTC in Melbourne, Australia, PI – B. Natarajan.

Research Grants

- Kansas Department of Transportation, KTRAN KSU-09-1: Analysis of Road Condition Data Employing Sensor Fusion and Data Visualization Techniques, 06/01/08-05/31/09, \$ 50,000 , PI- B. Natarajan, Co-PI – D. Day
- eG Innovations, Enhancing IT Infrastructure Monitoring via advanced Baselineing, Event Detection and Prediction Techniques, August 2008- July 2010, \$161,497, PI – B.Natarajan, Co-PI – D. Gruenbacher
- Sandia National Labs, Model based Design and Simulation of GPS receiver track loops for High Dynamic Applications, October 2007-2009, \$152,000, PI – B.Natarajan and C.Lewis
- U.S Marine Corps - Urban Operations Environmental Laboratory, Automated Surveillance and Control Using Smart Robots, October 2007-2009, \$ 121,000, PI- B. Natarajan
- Kansas Department of Transportation, KTRAN KSU-08-1: Analysis of Road Condition Data Employing Sensor Fusion and Data Visualization Techniques, 06/01/07-05/31/08, \$ 45,000 , PI- D. Day, Co-PI - B. Natarajan
- Garmin Inc., UWB technology for GPS products, 01/01/07-12/31/07, \$ 35,575, PI-B. Natarajan, Co-PI -W. Kuhn
- NSF, An Experimentation Platform for Developing Customized Large-Scale Sensor Systems; 04/01/06 - 03/31/08; \$ 200,000; PI - G. Singh, Co-PI - B. Natarajan, S. Warren, D. Anderson, S. Deloach.

- KSU Targeted Excellence Program, Center for Sensors and Sensor Systems, 07/01/06 - 06/30/09, \$ 1,500,000, PI - G. Singh, Senior Personnel - B. Natarajan.
- NSF, Shared Laboratory Experience: A Comprehensive Resource for Teaching Engineering Concepts (NSF-DUE (CCLI)); 10/01/05 - 09/31/08; \$ 160,000; PI - B. Natarajan; Co-PIs - D. Gruenbacher and W. Kuhn.
- Tri-Square Communications, Analysis of Frequency hopping sequence design strategies, January 2005 – April 2005, \$8,210, PI - B. Natarajan.
- NSF EPSCoR, IGERT Program in Sensor networks and their real-world applications - A cross-disciplinary approach, Planning grant, July 2005 - Dec 2005, \$ 10,000 PI - E. Sawan (WSU); Co-PI: B. Natarajan (KSU) along with 3 other WSU faculty members.
- NSF EPSCoR, S. K. Jayaweera (WSU), K. Namuduri (WSU), R. Pendse (WSU), J. Steck (WSU), B. Natarajan (KSU), Gateway to New Research Opportunities: A Low-Energy Wireless Ad-Hoc Sensor Networks Test-bed, 07/15/04 - 03/31/05, \$ 130,000.
- KSU Mentoring Fellowship: Adaptive Complex Spreading Code Design for Next Generation Wireless Systems; 2 months support for 2 graduate students during summer 2004; \$5,920; PI - B. Natarajan.
- KSU Mentoring Fellowship: Designing Optimal Complex Spreading Codes via Evolutionary Algorithms; 2 months support for 2 graduate students during summer 2003; \$5,620; PI - B. Natarajan; Mentor - W. Kuhn

PART II – Publications

◆ Books

C.R.Nassar, **B.Natarajan**, Z.Wu, D.Weigandt, S.Zekavat, *Multi-Carrier Technologies for Wireless Communications*, Kluwer Academic Publishers:Fall 2001.

◆ Book Contributions

L.Akter, **B.Natarajan** and C.Scoglio, “Spectrum Usage modeling and forecasting in cognitive radio networks,” *Cognitive Radio Networks*, Auerbach Publications, 1st edition, December 24, 2008.

B.Natarajan, *MATLAB Tutorials for Telecommunications Demystified: A Streamlined Course in Digital Communications (and some Analog) for EE students and Practicing Engineers*, Butterworth-Heinmann Publishing: January 2001.

B.Natarajan and Zhiqiang Wu, *Solutions Manual for Telecommunications Demystified*, Butterworth-Heinmann Publishing: January 2001.

◆ Journal Publications

A.Serener, **B. Natarajan** and D. Gruenbacher, “Lowering the Error Floor of Optimized Short Block Length LDPC Coded OFDM via Spreading,” *IEEE Transactions on Vehicular Technology*, vol. 57, no. 3, May 2008, pp. 1646-1656.

J. Dyer and **B. Natarajan**, "A Fast Elementwise Update Algorithm for Mean-Square Aperiodic Correlation Metrics," *IEEE Communications Letters*, vol. 11, no. 10, Oct 2007, pp. 772-774.

S.Das, **B.Natarajan**, D.Stevens and P.Koduru, "Multiobjective and constrained optimization for DS-CDMA code design based on the clonal selection principle," *Elsevier Applied Soft Computing Journal*, Dec 2007, doi:10.1016/j.asoc.2007.05.012, pp. 365 1-10.

J. Dyer and **B. Natarajan**, "Designing DS-CDMA spreading sequences via a low-complexity deterministic approach," *IEEE Transactions on Wireless Communications*, vol. 6, no. 1, pp. 302-313, January 2007.

N. Gnanapandithan and **B. Natarajan**, "Decentralized sensor network performance with correlated observations," *International Journal of Sensor Networks*, vol. 2 , no. 3/4 , pp. 179-187, March 2007.

N.Gnanapandithan and **B.Natarajan**, "Joint optimization of local and fusion rules in a decentralized sensor network," *Journal of Communications*, Vol. 1, No. 6, September 2006, pp.9-17.

B.Natarajan , S.Das, D.Stevens, "An evolutionary approach to designing complex spreading codes for DS-CDMA," *IEEE Transactions on Wireless Communications*, vol. 4, no. 5, pp. 2051-2056, September 2005.

S. Hijazi, **B.Natarajan** , "Novel low-complexity ant-colony based multiuser detector for direct sequence code division multiple access," *International Journal of Computational Intelligence and Applications*, vol. 5, no. 2, pp. 1-14, September 2005.

B.Natarajan and C.R.Nassar, "Crest factor reduction in MC-CDMA employing Carrier Interferometry codes," *EURASIP Journal on Wireless Communications and Networks*, vol. 2, pp. 374-379, November, 2004.

B.Natarajan, Z.Wu, C.R.Nassar and S.Shattil, "Large set of CI spreading codes for high performance MC-CDMA," *IEEE Transactions on Communications*, vol. 52, no. 11, November 2004.

S.Hijazi, M.Michelini, **B.Natarajan**, C.R.Nassar and Z.Wu, "Enabling the FCC's proposed spectral policy at the physical layer," *IEEE Wireless Communications Magazine* (Special Issue on 4G Mobile Communications – Towards Open Wireless Architecture), 2004.

B.Natarajan, C.R.Nassar and S.Shattil, "CI/FSK: Bandwidth efficient multi-carrier FSK for high-performance, high-throughput and enhanced applicability," *IEEE Transactions on Communications*, vol. 52, no.3, pp. 362-367, March 2004.

B.Natarajan, C.R. Nassar and S.Shattil, "High-Throughput High-Performance TDMA through Pseudo-orthogonal Carrier Interferometry Pulse Shaping," *IEEE Transactions on Wireless Communications*, vol. 3, no. 3, pp. 689-695, May 2004.

Carl R. Nassar, **B. Natarajan**, and Z. Wu, "Multi-carrier platform for wireless communications. Part 1: High-performance, high-throughput TDMA and DS-CDMA via multi-carrier implementations," *Wireless Communications and Mobile Computing*, Vol. 2, No. 4, June 2002, pp. 357-380.

Carl R. Nassar, **B. Natarajan**, and Z. Wu, "Multi-carrier platform for wireless communications. Part 2: OFDM and MC-CDMA systems with high-performance, high throughput via innovations in spreading," *Wireless Communications and Mobile Computing*, Vol. 2, No. 4, June 2002, pp. 381-403.

B.Natarajan, C.R.Nassar, S.Shattil, Z.Wu, M.Michelini "High-Performance MC-CDMA via Carrier Interferometry Codes," *IEEE Transactions on Vehicular Technology*, vol. 50, no.6, pp. 1344-1353, November 2001.

B.Natarajan, C.R.Nassar, S.Shattil, "Innovative Pulse Shaping for High-Performance Wireless TDMA," *IEEE Communication Letters*, vol. 5, no. 9, pp. 372-374, September 2001.

B.Natarajan, C.R. Nassar and V.Chandrasekhar “Generation of Correlated Rayleigh fading envelopes for spread spectrum applications,” *IEEE Communications Letters*, vol.4, no. 1, pp. 9-11, January 2000.

◆ **Journal Publications [under review/preparation]**

A.Ababnah and **B.Natarajan**, “ Optimal Control based strategy for Sensor Deployment,” *IEEE Transactions on Systems, Man and Cybernetics*, August 2008. (under review)

K.Rajan, D.Day and **B.Natarajan**, “Detection and Classification of Pavement distress via Principal component analysis and sensor fusion techniques,” *Elsevier Image Processing Journal*, May 2008 (under review)

D.Zhu and **B.Natarajan** , “Residue number system arithmetic assisted coded frequency-hopped OFDMA,” *EURASIP Journal on Wireless Communications Networks*, August 2008. (under review)

D.Zhu and **B.Natarajan**, “PAPR reduction in precoded MIMO-OFDM through trellis based precoding,” (under preparation)

D.Zhu and **B.Natarajan**, “Redundant residue number system arithmetic assisted space-time code design,” (under preparation)

N.Krishnan and **B.Natarajan**, “Energy Efficiency of Cooperative SIMO schemes – Amplify forward and Decode forward,” (under preparation)

◆ **Refereed Conference Publications**

R.Krishnan and **B.Natarajan**, “Joint Power and Quantization Optimization for Target Tracking in Wireless Sensor Networks,” accepted for publication in *Proceedings of IEEE Global Communications Conference, IEEE GLOBECOM 2008*, New Orleans, Nov. 2008. (Acceptance Rate – 36.8%)

R.Krishnan, **B.Natarajan** and S.Warren, “[Motion Artifact Reduction in Photoplethysmography Using Magnitude-Based Frequency Domain Independent Component Analysis](#),” *Proceedings of the 17th IEEE International Conference on Computer Communications (ICCCN)*, St. Thomas, Virgin Islands, August 2008. (Acceptance Rate – 26%)

L.Akter and **B.Natarajan**, “[Modeling and Forecasting Secondary User Activity in Cognitive Radio Networks](#),” *Proceedings of the 17th IEEE International Conference on Computer Communications (ICCCN)*, St. Thomas, Virgin Islands, August 2008. (Acceptance Rate – 26%)

K.Rajan, D.Day and **B.Natarajan**, “Analysis of Pavement condition employing principal component analysis and sensor fusion techniques,” *Proceedings of 2008 International Conference on Image Processing, Computer Vision and Pattern Recognition, IPCV 08*, Las Vegas, vol. 2, pp. 422-427, June 2008. (Acceptance Rate – 29%)

K.Rajan and **B.Natarajan**, “[A Distance based Comparison of Optimal Power Allocation to Distributed Sensors in a Wireless Sensor Network](#),” *Proceedings of IEEE International Conference on Communications, ICC 2008*, Beijing, China, May 2008. (Acceptance Rate – 36%)

H.Zamat and **B.Natarajan**, “[Use of Dedicated Broadband Sensing Receiver in Cognitive Radio](#),” *Proceedings of IEEE Cognitive Networks Workshop (CogNets)*, part of *IEEE International Conference in Communications, ICC 2008*, Beijing, China, May 2008 (Acceptance Rate – 29.7%)

S.Hijazi and **B.Natarajan**, “[An Improved Decorrelator MUD for Asynchronous MC-CDMA with Extended Observation Window](#),” *Proceedings of IEEE International Conference on Communications, ICC 2008*, Beijing, China, May 2008. (Acceptance Rate – 36%)

N.Anand, C.Scoglio and **B.Natarajan**, "GARCH-Non-linear time series model for traffic modeling and prediction," Proceedings of IEEE/IFIP Network Operations and Management Symposium NOMS 2008, pp. 694-697.

R.Krishnan, **B.Natarajan** and S. Warren, "Analysis and Detection of Motion Artifact in Photoplethysmographic data using higher order statistics, Proceedings of IEEE International Conference on Acoustics, Speech and Signal Processing, Las Vegas, April 2008, ICASSP 2008 (Acceptance Rate – 49.5%)

T.Van Slyke W.Kuhn and **B.Natarajan**, "Measuring Interference from a UWB Transmitter in the GPS L-1 band," Proceedings of Radio and Wireless Conference 2008, Orlando, Jan 2008. (Acceptance Rate – 54%)

A. Serener, **B. Natarajan** and D. Gruenbacher, "Optimized LDPC Codes for OFDM and Spread OFDM in Correlated Channels," Proceedings of *IEEE Vehicular Technology Conference*, Spring 2007, Dublin, Ireland (Acceptance rate - 44.9%)

Z. Wu, **B. Natarajan** and C.R. Nassar, "Interference Tolerance Agile Cognitive Radio: Maximize Channel Capacity of Cognitive Radio," Proceedings of *IEEE Consumer Communications and Networking Conference (CCNC 2007)*, Las Vegas, Jan 2007. (Acceptance rate for regular papers - 40%)

N. Gnanapandithan and **B. Natarajan**, "Analysis of the Performance of Decentralized Sensor Network with Correlated Observations," Proceedings of *IEEE International Symposium on Wireless Pervasive computing*, Feb 5-7, Puerto Rico, 2007 (Acceptance rate for regular papers - 37.5%).

S. Kopparthi and **B. Natarajan**, "Performance of parallel decentralized detection system with decision feedback," Proceedings of *IEEE International Symposium on Wireless Pervasive computing*, Feb 5-7, Puerto Rico, 2007. (Acceptance rate for regular paper - 37.5%).

H. Raza, J. Dyer and **B. Natarajan**, "Generating Spreading Codes for MC-CDMA with Desirable Crest Factor and Error Weight Distribution," Proceedings of *IEEE International Symposium on Wireless Pervasive computing*, Feb 5-7, Puerto Rico, 2007. (Acceptance rate for regular paper - 37.5%).

N. Panday and **B. Natarajan**, "Impact of Error weight distribution in MB-OFDM based UWB system with spreading," Proceedings of *IEEE International Symposium on Wireless Pervasive computing*, Feb 5-7, Puerto Rico, 2007. (Acceptance rate for regular paper - 37.5%).

S. Hijazi and **B. Natarajan**, "Near-Optimal Multiuser Detection in Asynchronous MC-CDMA via the Ant Colony Approach," Proceedings of *IEEE International Symposium on Wireless Pervasive computing*, Feb 5-7, Puerto Rico, 2007. (Acceptance rate for regular paper - 37.5%).

H.Zamat and **B.Natarajan**, "Enabling a Practical Cognitive Radio," Proceedings of *second International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM 07)*, Orlando, FL, August 2007. (Acceptance rate – 60%)

D. Gruenbacher, **B. Natarajan**, A. Pahwa, C. Scoglio, C. Lewis, and M. Muguira, "Increasing Women Graduate Students in STEM Fields through a Focused Recruitment Workshop," *Proceedings of 27th ASEE/IEEE Frontiers in Education Conference*, Milwaukee, Oct. 2007.

J. Dyer, **B. Natarajan** and S. Jayaweera, "Bayesian data fusion for asynchronous DS-CDMA sensor networks in Rayleigh fading," Proceedings of *IEEE Global Communications Conference (Globecom 2006)*, San Francisco, Nov. 2006. (Acceptance Rate – 40%)

D. Gruenbacher, **B. Natarajan**, and W.B. Kuhn, "An Integrated Laboratory Experience - A New Environment for Teaching Communications," Proceedings of *36th ASEE/IEEE Frontiers in Education Conference*, San Diego, California, Oct 28-31, 2006, pp. 7-8.

W.B. Kuhn, **B. Natarajan**, and D.Gruenbacher, "A Comprehensive Design Experience based on Product Development across Multiple Courses," Proceedings of 36th ASEE/IEEE Frontiers in Education Conference, San Diego, California, Oct 28-31, 2006, pp. 21-22.

N. Gnanapandithan and **B. Natarajan**, "Impact of Local decision rules in distributed sensor networks," Proceedings of *IEEE Vehicular Technology Conference*, VTC 2006, Melbourne, Australia, May 2006. (Acceptance Rate for Oral Presentations – 35.2%)

N. Gnanapandithan and **B. Natarajan**, "Genetic Algorithm assisted optimal fusion rule in sensor networks," Proceedings of *IEEE Consumer Communications and Networking conference*, CCNC 2006, vol. 2, Las Vegas, Jan 7-10, 2006, pp. 763-767. (Acceptance Rate – 42%)

Z.Wu, C.R.Nassar, **B.Natarajan** , D.Weigandt, "The road to 4G: two paradigm shifts, one enabling technology," *Proceedings of First IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks*, 2005. DySPAN 2005, pp. 688-694, Nov. 2005 (Acceptance Rate – 25%).

J. Dyer and **B. Natarajan**, "A novel low-complexity deterministic algorithm for DS-CDMA signature sequence generation," in *Proceedings of IEEE 62nd Vehicular Technology Conference*, Dallas, Texas, vol.3, pp. 2086-2090, Sep 2005 (Acceptance rate – 45%).

S. L. Hijazi, Andrew J. Best, **B.Natarajan**, and Sanjoy Das, "Ant-Colony based optimal MC-CDMA Multi-user detector," *IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob2005)* , Montreal, Canada, vol.1, pp. 128-132, Aug 2005 (Acceptance Rate – 40%)

A.J.Best and **B.Natarajan**, "The Effect of Jamming on the Performance of Carrier Interferometry/OFDM," *IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob2005)* , Montreal, Canada, vol.1, pp. 66-70, Aug 2005 (Acceptance Rate – 40%)

J. Dyer and **B. Natarajan**, "A new deterministic algorithm for DS-CDMA signature sequence generation," in *Proceedings IEEE 40th International Conference on Communications (ICC 2005)*, Seoul, Korea, vol. 4, pp. 2348-2351, May 2005 (Acceptance Rate – 35%).

J.Kipp and **B.Natarajan**, "Peak-to-average power ratio analysis of multi-carrier pulse shape synthesis," *Proceedings of IEEE Wireless Technologies Symposium, Pomona, CA*, pp. 136-142, April 2005 (Acceptance Rate – 39%).

V.Thippavajjula and **B.Natarajan**, " Performance analysis of asynchronous carrier interferometry/MC-CDMA uplink with interference cancellation techniques," *Proceedings of IEEE Wireless Technologies Symposium, Pomona, CA*, pp. 131-135, April 2005 (Acceptance Rate – 39%).

S. L. Hijazi, A. Best, **B. Natarajan**, S. Das, "Novel Low Complexity MC-CDMA Multiuser Detection Based on Ant Colony Optimization", *Proceedings of the Genetic and Evolutionary Computing Conference*, Washington, D. C., pp. 2121-2126, 2005. (Acceptance Rate – 46%)

D. Stevens, **B. Natarajan**, S. Das, "A multi-objective algorithm for DS-CDMA code design based on the clonal selection principle," *Proceedings of the 2005 conference on Genetic and evolutionary computation (GECCO'05)*, Vol. 2, pp. 2015-2020, Washington D.C, 2005. (Acceptance Rate – 46%)

B.Natarajan , S.Das and D.Stevens, "Design of optimal complex spreading codes for DS-CDMA using an evolutionary approach," Proceedings of *IEEE Global Telecommunications Conference, GLOBECOM 2004*, Dallas, Nov. 2004.

S.Hijazi and **B.Natarajan**, "Novel low-complexity DS-CDMA multiuser detector based on ant colony optimization," Proceedings of *IEEE Vehicular Technology Conference, Fall 2004*, Los Angeles, September 2004.

V.Thippavajjula and **B.Natarajan**, "Parallel interference cancellation techniques for synchronous Carrier Interferometry/MC-CDMA uplink," Proceedings of *IEEE Vehicular Technology Conference, Fall 2004*, Los Angeles, September 2004.

D. Stevens, **B. Natarajan**, S. Das, "Multi-objective Immune Systems Based Complex Spreading Code Sets for DS-CDMA", *Proceedings of IASTED Conference on Communication Systems and Applications*, Banff, Alberta, Canada, July 2004.

V.Thippavajjula and **B.Natarajan**, "Performance of serial interference cancellation receivers in synchronous carrier interferometry/MC-CDMA uplink," Proceedings of the *International Conference on Wireless Networks, ICWN 04*, vol. 1, pp. 347-352, Las Vegas, Nevada, June 2004.

A.J.Best and **B.Natarajan**, "Carrier Interferometry/OFDM performance in the presence of multipath and impulse noise," Proceedings of the *International Conference on Wireless Networks, ICWN 04*, vol. 2, pp. 527-532, Las Vegas, Nevada, June 2004.

S.Hijazi, M.Michelini, **B.Natarajan**, C.R.Nassar and Z.Wu, "Enabling the FCC's proposed spectral policy via carrier interferometry," accepted for publication in the Proceedings of *IEEE Wireless Communications and Networking Conference, WCNC 2004*, Atlanta, GA, March 2004.

B.Natarajan and C.R.Nassar, "Multi-carrier pulse shape synthesis and decomposition for high performance wireless systems," *Proceedings of IASTED International Conference on Communications, Internet and Information Technology (CIIT)*, Scottsdale, AZ, Nov. 2003.

S.Hijazi, C.R.Nassar, Z.Wu and **B.Natarajan**, "Spectral sharing in DS-CDMA: A multi-carrier approach," accepted for publication in the *Proceedings of IASTED International Conference on Communications, Internet and Information Technology (CIIT)*, Scottsdale, AZ, Nov. 2003.

A.Serener, **B.Natarajan** and D.Gruenbacher, "LDPC coded spread OFDM in indoor environments," *Proceedings of the 3rd IEEE International Symposium on Turbo Codes & Related Topics*, France, pp. 549-552, September 2003.

A.Serener, **B.Natarajan** and D.Gruenbacher, "Performance of spread OFDM with LDPC coding in outdoor environments," *Proceedings of IEEE 58th Semiannual Vehicular Technology Conference*, Orlando, Florida, October 2003.

E. Buehler, **B. Natarajan**, S. Das, "Multiobjective Genetic Algorithm Based Complex Spreading Code Sets with a Wide Range of Correlation Properties", *Proceedings, IEEE 15th International Conference on Wireless Communications*, Vol. 2, pp. 548-552, Calgary, Alberta, Canada, 2003.

E. Buehler, S. Das, **B. Natarajan**, "A Multi-objective Genetic Algorithm for Designing Complex Spreading Codes for DS-CDMA", *Proceedings, Joint Conference on Information Sciences*, Vol.1, pp. 1665-1668, Cary, North Carolina, 2003.

B.Natarajan, C.R.Nassar and S.Shattil, "High Data Rate FSK via Multi-Carrier Implementations for Wireless Personal Area Networks," *Proceedings of SPIE's IT-COM 2002: Enabling Technologies for 3G and Beyond*, Boston, MA, July 29-Aug. 2, 2002.

B.Natarajan, C.R.Nassar and S.Shattil, "Novel Multi-Carrier Implementation of FSK for Bandwidth Efficient, High Performance Wireless Systems," *Proceedings of IEEE International Conference on Communications, ICC 2002*, New York City, vol. 2, pp. 872-876, May 2002.

Z.Wu, **B.Natarajan**, C.R.Nassar and S.Shattil, "High Performance, High Capacity MC-CDMA via Carrier Interferometry Codes" Proceedings of *IEEE Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2001*, September 30-October 3, San Diego, 2001.

B.Natarajan, C.R.Nassar and S.Shattil, "Enhanced Bluetooth and IEEE 802.11 (FH) via Multi-Carrier Implementation of the Physical Layer," Proceedings of *IEEE Emerging Technologies Symposium on Broadband Communications*, pp. 129-133, Richardson, TX, September 10-11, 2001.

B.Natarajan and C.R.Nassar, "Crest Factor Considerations in MC-CDMA with Carrier Interferometry Codes," Proceedings of *IEEE Pacific-Rim Conference on Communications, Computers and Signal Processing, PACRIM 2001*, vol. 2, pp. 445-448, August 26-28, Victoria, Canada, 2001.

Z.Wu, C.R.Nassar and **B.Natarajan** "FD-MC-CDMA: A frequency based multiple access architecture for high performance wireless communication," Proceedings of *IEEE Radio and Wireless Conference, RAWCON 2001*, pp. 169-172, Waltham, Massachusetts, USA, August 19-22.

B.Natarajan, C.R. Nassar and S.Shattil "Throughput Enhancement in TDMA through Carrier Interference Pulse Shaping," *IEEE Vehicular technology Conference Proceedings*, vol.4, pp.1799-1803, Fall 2000, Boston.

B.Natarajan and C.R.Nassar "Introducing Novel FDD and FDM in MC-CDMA to Enhance Performance," Proceedings of *IEEE Radio and Wireless Conference 2000 (RAWCON 2000)*, pp.29-32, Denver, September 10-13, 2000.

B.Natarajan, C.R.Nassar and S.Shattil "Exploiting Frequency Diversity in TDMA through carrier interferometry," Proceedings of *Wireless 2000, 12th International Conference on Wireless Communications*, vol.2, pp. 469-476, July 10-12, 2000, Calgary, Canada.

B. Natarajan, C.R. Nassar and V.Chandrasekhar "Correlated Rayleigh Fading Envelopes with spread spectrum applications," Proceedings of *IEEE Radio and Wireless Conference (RAWCON 1999)*, Denver, August 1-4, 1999, pp. 45-48.

C.R.Nassar, **B. Natarajan** and S. Shattil "Introduction of Carrier Interference to spread spectrum multiple access," Proceedings of the *IEEE Emerging Technologies Symposium on Wireless Communications and Systems*, Dallas, April 12-13, 1999.

◆ Patents

- *A Novel Low-Complexity Deterministic Algorithm for CDMA Signature Sequence Generation*, US Patent filed in May 2005. Inventors – J.Dyer and B.Natarajan
- *Pre-coding for Multiple-Input-Multiple-Output Communications*, US Patent filed in May 2006. Inventors – J.Dyer and B.Natarajan

◆ Invited Talks

- Plenary Speaker at US Army Information and Cyberspace Symposium, US Army Combined Arms Center, Ft. Leavenworth, September 2008
- SPRINT Corporation, "Orthogonal Frequency Division Multiplexing" Talk broadcast around the country to all SPRINT R&D locations, January 2006
- "How to succeed in Graduate School", part of the "Finding the right Graduate School" workshop for undergraduate women students at KSU
- Dept. of Electrical Engineering, Villanova University, "Promise of Multi-carrier modulation," Nov 2005
- Philips Research Center, "Enabling SDR via a multi-carrier framework", Briarcliff Manor, July 2005
- Rockwell Collins Research Division, "Communications Research at K-State", Cedar Rapids, IA, April 2005

- **Graduate Teaching Assistant** Colorado State University Fall 1997- Spring-1999

In-charge of junior level Analog Electronics Laboratory, from designing experiments to evaluation of performance. Was also involved in the development of a graduate-level wireless communications course with my advisor.

- **System Engineer** Daimler Benz Research Center, Bangalore, India Spring 1997

Assistant Investigator in a project involving the design of a Direct Broadcasting Satellite receiver system with specific application in Road Condition Detection. Under supervision, performed the necessary simulations and studies.

PART IV – Students

- **Doctoral Students**

Samer L. Hijazi (Graduated in 2006)
Ali Serener (Graduated in 2006 – co-advised with Dr. Don Gruenbacher)
Lutfu Akter (current)
Hassan Zamat (current)
Dalin Zhu (current)
Rajet Krishnan (current)
Ahmad Ababnah (current)

- **Masters Students**

Andrew Best (Graduated in 2004)
Vijaya Thipavajjula (Graduated in 2004)
Jason Kipp (Graduated in 2005)
Nidhi Panday (Graduated in 2006)
Hassan Raza (Graduated in 2006)
Justin S. Dyer (Graduated in 2006)
Yingsong Yang (Graduated in 2006)
Krithika Rajan (Graduated in 2008)
Tyler Van Slyke (Graduated in 2008).
Mark Schrempp (current)
Narayanan Krishnan (current)
Anirudh Radhakrishnan (current)
Sohini Roy Chaudhury (current)

PART V – Service Activities

◆ Institutional Activities

Department of Electrical and Computer Engineering

1. Graduate Committee (2004-current).
2. IEEE Student Branch Adviser (Aug 2008 – May 2009)

3. Publicity and Website Committee (2007)
4. Organizing Committee, NSF ADVANCE workshop for women undergraduate students interested in graduate studies (Fall 2006).
5. Department Head Search Committee, (2003-04).
6. Equipment Committee (2002-03).
7. Faculty Advisor, Engineering Open House, Spring 2003 and 2004.

College of Engineering/University

1. Frankenhoff Research Award Committee (2007).
2. Faculty Advisor, Indian Student Association (2007-08).
3. Initiated the academic collaboration between KSU and BITS-Pilani Dubai Campus resulting in a Memorandum of Understanding (MoU signed in 2006) and opening up other potential collaborations. Performed all necessary course equivalency reports along with exploratory reports on collaborative activities.
4. Conference organizer and primary K-State representative for NSF-EPSCoR sponsored IGERT mini conference on Biosensors and Biosensor Networks held at Wichita State University, Fall 2005 and Summer 2006.
5. Faculty Advisor, SABHA (Society for Appreciation of Bharathiya Heritage and Arts) (2004).

◆ Professional Society Activities

Member

1. IEEE (1998-current).
2. IEEE Communication Society (1998-current).
3. IEEE Technical Committee on Cognitive Networks (TCCN) (2006-current).
4. ASEE (2002-current).
5. IEEE Vehicular Technology Society (2002-03, 2006-current).
6. IEEE Education Society (2002-03).
7. IEEE Standards Association (2002-03).

Journal Reviewer

1. IEEE Communications Letters.
2. IEEE Transactions on Communications.
3. IEEE Transactions on Wireless Communications.
4. IEEE Transactions on Vehicular Technology.
5. IEEE Journal on Selected Areas in Communication (J-SAC).
6. IEEE Transactions on Systems, Man and Cybernetics.

Chair/Program Committee Member

1. Track Chair (Wireless Communications and Signal Processing)– 2008 and 2009, 17th and 18th International Conference on Computer Communications and Networks (ICCCN)
1. IEEE Global Telecommunications Conference (GLOBECOM), 2005 - 2008. Served as session chair in all years.
2. IEEE International Conference in Communications (ICC), 2005-2009. Served as session chair every year since 2006.
3. IEEE Wireless communications and Networking conference, WCNC 2009.
3. IEEE Vehicular Technology Conference (VTC), 2003-2007 (Fall and Spring conferences) Served as session chair in Fall 2005 and 2006 conferences.
4. IEEE Computer Communications and Networking, CCNC 2006 and 2007. Session organizer and chair in 2006.
5. IEEE Cognitive Networks 2007 (CogNets 07).

6. CrownCom 2007
7. IEEE Wireless Communications and Networking Conference 2006.
8. 2004 IEEE International Workshop on Ultrawideband Systems, IWUWBS, Kyoto, Japan, May 2004.
9. IEEE International conference on Ultrawideband systems and technologies (UWBST), 2003, Virginia Tech, VA.
10. International Conference on Communications and Wireless Networks (ICWN) 2003, Las Vegas, NV.
11. IASTED Conference Committee on Telecommunications and Information Systems - 2003-2006.

Public

1. Book Reviewer in the communications and wireless area for Wiley Publications.
2. NSF Panel Reviewer for Theoretical Foundations, CCF program, CISE Directorate 2006, 2008.
3. NSF Reviewer for DUE Directorate, CCLI Program, July 2005.
4. NSF Reviewer for Theoretical Foundations, CCF program, CISE Directorate, May 2005.
5. NSF Panel Reviewer (SBIR - Wireless Transceivers) 2003.
6. NSF Panel Reviewer (SBIR - Signal Processing) 2003.
7. Served on the Patent Advisory Committee for White Pine Consulting, Minneapolis, MN (2003).
8. Manhattan Habitat for Humanity.

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