Sharan Naribole

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Research Areas Wireless networking, IEEE 802.11 WLANs, cross-layer MAC-PHY protocol design.

Education

Rice University, Houston, Texas, USA (**2012-2018**)

Ph.D., Electrical and Computer Engineering, March 2018.
GPA: 3.72 / 4.0

- Area of study: 60 GHz communication, Visible light communication, Light-Radio WLANs
- Dissertation Topic: "Enhanced WLAN Performance with New Spectrum at 60 GHz and Visible Light"
- Committee: Edward W. Knightly (*Chair*), Behnaam Aazhang, Lin Zhong, T.S. Eugene Ng

M.S., Electrical and Computer Engineering, May 2014.
GPA: 3.75 / 4.0

- Area of study: Heterogeneous cellular networks, Service quality management
- Thesis: "Small Cells and Mobile Clients: a Measurement Study of an Operational Network"
- Committee: Edward W. Knightly (*Chair*), Behnaam Aazhang, Lin Zhong

Indian Institute of Technology Kharagpur, Kharagpur, India (**2008-2012**)

B.Tech. (Honors), Electronics and Electrical Communication Engineering, May 2012.
GPA: 8.73 / 10.0

GRE: Quantitative - 800/800 (*94 percentile*), Verbal - 690/800 (*97 percentile*), Writing - 4.0/6.0

IIT JEE: All India rank of 312 (*99.9 percentile*) in IIT Joint Entrance Examination 2008.

Scholarships

Texas Instruments Fellowship, 2012 - 2017

National Science Foundation Travel Grant for IEEE SECON 2016 and IEEE SECON 2017

DAAD (German Academic Exchange Service) WISE scholarship 2011

Work Experience

Apple Inc., California, USA **March 2021 - present**
Wireless System Engineer, Platform Architecture

Samsung Semiconductor Inc., San Jose, California, USA **March 2018 - March 2021**
Senior Software Engineer, US Connectivity & Wi-Fi Systems Group

- **Protocol design.** Designing algorithms and protocols at MAC layer and joint MAC-PHY cross-layer for wireless communication in the unlicensed spectrum.
- **Network Simulations.** Implement latest 802.11 standards (802.11ac, 802.11ax, 802.11be etc.) features in custom ns-3 network simulator and perform comprehensive evaluation for various WLAN scenarios.
- **IEEE 802.11 Standards activities.** Active participation and contributions to 802.11ax and next-generation 802.11be task groups.

Rice University, Houston, Texas, USA **August 2012 - December 2017**
Research Assistant, Rice Networks Group

- **Light-Radio WLAN.** Designed, implemented and experimentally evaluated a WLAN that fuses simplex Visible Light downlink and bi-directional Wi-Fi on a frame-by-frame basis at the

MAC layer. In order for Visible Light clients to transmit ACKs via Wi-Fi without excessive contention-based delays, designed a scalable Visible Light feedback channel over RF. Designed protocol to utilize Visible Light as a uni-directional control channel for contention-free access on the radio band.

- **Multicast in 60 GHz WLANs.** Designed, implemented and experimentally evaluated scalable techniques for (a) training the access point with per-beam per-client RSSI measurements via partially traversing a codebook tree. The training balances the objectives of limiting overhead with collecting sufficient data to form efficient beam groups. (b) beam grouping that approximates the minimum multicast group data transmission time.
- **Small Cells.** Performed the first large-scale measurement study of voice and data service performance of operational small cell cellular network. Analyzed nation-wide fine-grained service measurements to gain insight into the nature and implications of handovers on service performance.
- **Wireless Health Monitoring.** Deployed Blue Scale, a CVD measuring device for wireless health monitoring, at homes in an under-served community of Houston. Designed anomaly detection algorithms and framework for early cardiac event detection.

NEC Labs America, Princeton, New Jersey, USA **June 2015 - August 2015**
Summer Research Assistant, Mobile Communications and Networking

- **60 GHz Signature Extraction.** Developed wireless testbed for fine-grained signature extraction using commercial off the shelf 60 GHz technology and analyzed techniques for phase extraction from raw signal traces.

AT&T Labs Research, Florham Park, New Jersey, USA **June 2013 - August 2013**
Technical Intern, Service Quality Management Group

- **Statistical Correlation.** Designed and implemented a novel framework for automated learning of statistical dependencies between network events and service events across multiple base stations and multiple cellular technologies. Demonstrated the effectiveness of framework using real traces collected from UMTS, LTE and Small Cell cellular networks.

Universität Paderborn, Nordrhein-Westfalen, Germany **May 2011 - July 2011**
Summer Intern, Theory of Distributed Systems Group

- **Jamming-resistant MAC.** Developed and simulated adversarial jammer-resistant wireless medium access control protocol using the signal-to- noise-interference ratio model. The protocol was thoroughly investigated against different types of jammers and different distributions of nodes.

Publications

S. Naribole, S. Kandala and A. Ranganath, "Multi-Channel Mobile Access Point in Next Generation IEEE 802.11be WLANs," accepted to *IEEE ICC*, Montreal, Canada, June 2021.

S. Naribole, S. Kandala, W. Lee and A. Ranganath, "Simultaneous Multi-Channel Downlink Operation in Next Generation WLANs," in *Proceedings of IEEE GLOBECOM*, Taipei, Taiwan, December 2020.

S. Naribole and E. Knightly, "LiSCAN: Visible Light Uni-Directional Control Channel for Uplink Radio Access," in *Proceedings of IEEE WCNC*, Seoul, South Korea, April 2020.

S. Naribole, W. Lee, S. Kandala and A. Ranganath, "Simultaneous Transmit-Receive Multi-Channel Operation in Next Generation WLANs," in *Proceedings of IEEE WCNC*, Seoul, South Korea, April 2020.

S. Naribole, W. Lee, and A. Ranganath, "Impact of MU EDCA channel access on IEEE 802.11ax WLANs," in *Proceedings of IEEE VTC Fall*, Honolulu, USA, September 2019.

S. Naribole, "Enhanced WLAN Performance with New Spectrum at 60 GHz and Visible Light," Ph.D. Thesis, May 2018.

S. Naribole and E. Knightly, "Scalable Multicast in Highly-Directional 60 GHz WLANs," in *IEEE/ACM Transactions on Networking*, 25 (5): 2844-2857, October 2017.

S. Naribole, S. Chen, E. Heng, S. Zheng and E. Knightly, "LiRa: a WLAN architecture for Visible Light Communication with a Wi-Fi uplink," in *Proceedings of IEEE SECON*, San Diego, USA, June 2017.

S. Naribole and E. Knightly, "Scalable Multicast in Highly-Directional 60 GHz WLANs," in *Proceedings of IEEE SECON*, London, UK, June 2016.

S. Naribole, "Small Cells and Mobile Clients: a Measurement Study of an Operational Network," Masters Thesis, December 2014.

J. Chen, S. Quadri, L. Pollonini, S. Naribole, J. Ding, Z. Zheng, E. Knightly and C. Dacso, "Blue Scale: Early Detection of Impending Congestive Heart Failure Events via Wireless Daily Self-Monitoring," in *Proceedings of IEEE EMBS HIC-POCT*, Seattle, October 2014.

Patent Applications

S. Naribole, S. Kandala, W. Lee and A. Ranganath, "Method and system for multi-link aggregation in wireless local area network," US20210076419A1, March 2021.

S. Naribole, S. Kandala, W. Lee and A. Ranganath, "Systems, methods, and devices for association and authentication for multi-access point coordination," US20210084493A1, March 2021.

S. Naribole, S. Kandala and W. Lee, "Multi link operation channel access," US20210076412A1, March 2021.

S. Naribole, S. Kandala, W. Lee and A. Ranganath, "Multi link txop aggregation," US20210076398A1, March 2021.

S. Naribole, S. Kandala, W. Lee and A. Ranganath, "Method and system for simultaneous multi-channel downlink operation in wireless local area network," US20210076340A1, March 2021.

R. Gidvani, S. Naribole and A. Ranganath, "System and method for providing wi-fi media access control (mac) layer for uplink multi-user operating mode transitions by non-access point station," US20210045120A1, February 2021.

R. Gidvani, A. Ranganath, W. Lee, S. Naribole and Shailender Karmuchi, "System and method for providing a synchronized mode for wlan operation in a wlan band," US20200077350A1, March 2020.

IEEE 802.11 Standards Contributions

TGbe 11-20/1263, "Non-STR Blindness Rules Discussion," November 2020.

TGbe 11-20/977, "MLD Spatial Multiplexing Considerations," August 2020.

TGbe 11-20/370, "Multi-link Power Save Discussion," May 2020.

TGbe 11-20/277, "Shared TXOP Operation," April 2020.

TGbe 11-20/226, "MLO Constraint Indication and Operating Mode," March 2020.

TGbe 11-19/1836, "Multi-link Channel Access Discussion Follow-up," January 2020.

TGbe 11-19/1505,"Multi-link Aggregation Considerations," September 2019.

TGbe 11-19/1451, "Virtual BSS for Multi-AP Coordination Follow up," September 2019.

TGbe 11-19/1405, "Multi-link Channel Access Discussion," September 2019.

TGbe 11-19/824, "Multi-band Operation Performance," July 2019.

EHT TIG/SG 11-19/360, "MAC Architectures for EHT Multi-band Operation," March 2019.

TGax 11-18/1827, "6 GHz operation for 11ax follow up", Jan 2019.

PRESENTATIONS

"Simultaneous Multi-Channel Downlink Operation in Next Generation WLANs," IEEE GLOBECOM, Taipei, Taiwan, December 2020.

"Non-STR Blindness Rules Discussion," IEEE 802.11 TGbe, November 2020.

"MLD Spatial Multiplexing Considerations," IEEE 802.11 TGbe, August 2020.

"IEEE 802.11be Multi-link Operation in ns-3," Workshop on ns-3, June 2020.

"Multi-link Power Save Discussion," IEEE 802.11 TGbe, May 2020.

"Simultaneous Transmit-Receive Multi-Channel Operation in Next Generation WLANs," IEEE WCNC, Seoul, South Korea, April 2020.

"Shared TXOP Operation," IEEE 802.11 TGbe, April 2020.

"MLO Constraint Indication and Operating Mode," IEEE 802.11 TGbe, March 2020.

"Multi-link Channel Access Discussion Follow-up," IEEE 802.11 TGbe, January 2020.

"Impact of MU EDCA channel access on IEEE 802.11ax WLANs," IEEE VTC Fall, Honolulu, USA, September 2019.

"Virtual BSS for Multi-AP Coordination Follow up," IEEE 802.11 TGbe, September 2019.

"Multi-link Aggregation Considerations," IEEE 802.11 TGbe, September 2019.

"Multi-link Channel Access Discussion," IEEE 802.11 TGbe, September 2019.

"Multi-band Operation Performance," IEEE 802.11 TGbe, July 2019.

"MAC Architectures for EHT Multi-band Operation," IEEE 802.11 EHT TIG/SG, March 2019.

"Enhanced WLAN Performance with New Spectrum at 60 GHz and Visible Light," Ph.D. Thesis Defense, December 2017.

"LiRa: a WLAN architecture for Visible Light Communication with a Wi-Fi uplink," IEEE SECON, San Diego, USA, June 2017.

"Li-Fi meets Wi-Fi," Rice 90-second Thesis Competition, November 2016.

"Scalable Multicast in Highly-Directional 60 GHz WLANs," IEEE SECON, London, UK, June 2016.

"Multicasting over mm-Wave," Rice 90-second Thesis Competition, November 2014.

"Small Cells and Mobile Clients: a Measurement Study of an Operational Network," Masters Thesis Defense, May 2014.

Wireless Testbed Experience

Wireless Open-Access Research Platform (WARP) **2015 - 2018**

- **60 GHz Wardriving.** Implemented the key components of 60 GHz IEEE 802.11ad beam training in MATLAB and used a mechanically steerable 60 GHz RF-frontend combined with WARP v1 boards for transmissions. Validated the significance of imperfect codebook traversal in realistic indoor environments using over-the-air measurements.
- **WiFi Centralized Scheduling.** Implemented a centralized uplink access protocol by extending the IEEE 802.11 MAC reference design in WARP v3 platform. Implemented a timer to trigger the Access Point for aggressive channel access over WiFi. Performed comprehensive evaluation for different combinations of trigger timer, client size and traffic characteristics.

Universal Software Radio Peripheral (USRP) **May 2015 - Aug 2015**

- **60 GHz Feature Extraction.** Generated multi-tone baseband signals using C++ framework for USRP N200 boards. Performed over-the-air highly-directional 60 GHz transmissions to various objects using motion controller. Performed FFT analysis of the reflected baseband signal for object classification and feature extraction.

NS-3 discrete-event network simulator **2014 - Present**

- **Poisson-Pareto Burst Process.** Extended the application-layer traffic generation model for newer versions of ns-3.
- **Dual-Band Contention-Free Access.** Implemented custom MAC protocols and wireless node architectures on top of WiFi PHY layer implementation in ns-3. Performed extensive evaluation for different combinations of client size, interference levels and traffic characteristics.
- **IEEE 802.11ax OFDMA.** Implemented key components of 802.11ax downlink and uplink OFDMA-based access including trigger-based access sequence, buffer status reporting, multi-user transmission protection mechanisms, custom scheduling strategies, TXOP optimization and OFDMA link adaptation.
- **IEEE 802.11be Multi-link Operation.** Extended ns-3 Wi-Fi architecture to support multi-channel-multi-band operation. Implemented key multi-link channel access mechanisms being considered in the 802.11be task group including asynchronous operation with simultaneous transmit-receive constraints and multi-link aggregation alternatives.

Related Coursework

- Random Processes & Applications
- Mobile and Wireless Networking
- Algorithm Design & Analysis
- Statistical Learning & Mining
- Professional Communications
- Data Analysis with Python
- Communication Networks
- Adv. Topics in Wireless Networking
- Computer Architecture
- IEEE 5G mmWave Course
- Data Analysis with R
- Machine Learning with Python

Professional Activities

Affiliations

IEEE Student Member	2013 - 2017
IEEE Member	2019 - *present*
IEEE Standards Association Member	2019 - *present*
IEEE Communications Society Member	2013 - *present*

Session Chair

IEEE VTC Fall Conference - State-of-the-Art Wi-Fi Technologies Sept 2019

Reviewer

IEEE/IFIP Annual Conference on Wireless On-demand Network Systems and Services (WONS)
ACM Workshop on Visible Light Communication Systems (VLCS)
IEEE Workshop on Millimeter-wave Networking Workshop (mmNet)
IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN)

Leadership

Professional Development Director, Rice ECE Graduate Student Association May 2016 - May 2017
SCREECH Committee Member, Rice Center for Engineering Leadership Sept 2016 - Nov 2016
Secretary, Indian Students at Rice (ISAR) May 2013 - May 2015
Graduate Mentor, ECE Department, Rice University 2013 - 2016
Pet Adoption Counselor, Harris County Public Animal Shelter 2016

Computer Skills

MATLAB, C++, Python (numpy, scipy, pandas, scikit-learn, Scrapy, seaborn, Flask), R (dplyr, ggplot, Shiny), SQL, git, GitHub, MS Office, perl, LaTeX.

Personal

Indian citizen with proficiency in Telugu and Hindi

Last updated: April 27, 2021