

**BHUVANA KRISHNASWAMY**  
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## RESEARCH INTERESTS

Molecular Communication, Wireless Networks, Sensor Networks

## RESEARCH SUMMARY

My research goal is to build an autonomous and efficient bionetwork that interconnects a system of bio-sensors and other biological computing devices in environments that are unreachable using existing communication technologies. In my PhD thesis, I worked towards this goal and developed communication algorithms to establish a one-to-one link between bacterial transceivers in a microfluidic chip. I also studied a single-hop network with a star topology and developed novel addressing and medium access control algorithms that are practical and efficient in a bioNetwork. I collaborated with biologists and mechanical engineers to design proof-of-concept experiments to verify the feasibility of a bionetwork and understand the challenges and opportunities specific to a bionetwork.

## EDUCATION

### **Ph.D in Electrical and Computer Engineering**

Advisor: Dr. Raghupathy Sivakumar

Spring 2013-Summer 2018

Georgia Institute of Technology, Atlanta

### **Masters in Electrical and Computer Engineering**

Advisor: Dr. Raghupathy Sivakumar

Fall 2011-Fall 2013

Georgia Institute of Technology, Atlanta

### **Bachelors of Electronics and Communication Engineering**

College of Engineering, Guindy, Chennai, India

Fall 2007-Spring 2011

## AWARDS AND ACHIEVEMENTS

- *Most Promising Future Technology* award at Marconi Young Scholar Symposium, 2015
- Ranked 5<sup>th</sup> (out of 160) in the graduating batch of College of Engg., Guindy, 2011
- Ranked 2<sup>nd</sup> (out of over 400,000) in Tamilnadu State Higher Secondary Examination in 2007
- Travel Grants for ICC 2013, MobiCom 2014, MobiSys 2017

## PUBLICATIONS

### **Journal**

1. **Krishnaswamy, B.**, Austin, C.M., Jian, Y., Perdomo, J.E., Patel, S.C., Hammer, B.K., Forest, C.R. and Sivakumar, R., 2018. ADMA: Amplitude-Division Multiple Access for Bacterial Communication Networks, *IEEE Transactions on Molecular, Biological and Multi-Scale Communications* 3(3), pp.134-149
2. **Krishnaswamy, B.**, Austin, C.M., Bardill, J.P., Russakow, D., Holst, G.L., Hammer, B.K., Forest,

C.R. and Sivakumar, R., 2013. Time-elapse communication: Bacterial communication on a microfluidic chip. *IEEE Transactions on Communications*, 61(12), pp.5139-5151.

3. Jian, Y., **Krishnaswamy, B.**, Austin, C.M., Bicen, A.O., Einolghozati, A., Perdomo, J.E., Patel, S.C., Fekri, E., Akyildiz, I.F., Forest, C.R. and Sivakumar, R., 2017. nanoNS3: A network simulator for bacterial nanonetworks based on molecular communication. *Nano Communication Networks*, 12, pp.1-11.
4. Shih, C.F., **Krishnaswamy, B.**, Jian, Y. and Sivakumar, R., 2016. Scheduled WiFi using distributed contention in WLANs: algorithms, experiments, and case-studies. *Wireless Networks*, pp.1-24.

## Conference

1. **Krishnaswamy, B.** and Sivakumar, R., 2018 Amplitude-Width Encoding for Error Correction in Bacterial Communication Networks to be published *In ACM International Conference on Nanoscale Computing and Communication (ACM NanoCom)*, 2018
2. **Krishnaswamy, B.** and Sivakumar, R., 2016, September. Advanced Receiver Designs for Bacterial Communication with Amplitude Source Addressing. *In Proceedings of the 3rd ACM International Conference on Nanoscale Computing and Communication* (p. 35)
3. **Krishnaswamy, B.** and Sivakumar, R., 2015, September. Source addressing and medium access control in bacterial communication networks. *In Proceedings of the Second Annual International Conference on Nanoscale Computing and Communication* (p. 1)
4. **Krishnaswamy, B.**, Henegar, C.M., Bardill, J.P., Russakow, D., Holst, G.L., Hammer, B.K., Forest, C.R. and Sivakumar, R., 2013, June. When bacteria talk: Time elapse communication for super-slow networks. *In Communications (ICC), 2013 IEEE International Conference on* (pp. 6348-6353).
5. Jian, Y., **Krishnaswamy, B.**, Austin, C.M., Bicen, A.O., Perdomo, J.E., Patel, S.C., Akyildiz, I.F., Forest, C.R. and Sivakumar, R., 2016, September. nanoNS3: Simulating bacterial molecular communication based nanonetworks in Network Simulator 3. *In Proceedings of the 3rd ACM International Conference on Nanoscale Computing and Communication* (p. 17).
6. Shih, C.F., **Krishnaswamy, B.** and Sivakumar, R., 2015, December. Rhythm: Achieving scheduled WiFi using purely distributed contention in WLANs. *In Global Communications Conference (GLOBECOM), 2015 IEEE* (pp. 1-7).
7. Jian, Y., Shih, C.F., **Krishnaswamy, B.** and Sivakumar, R., 2015, June. Coexistence of Wi-Fi and LAA-LTE: Experimental evaluation, analysis and insights. *In Communication Workshop (ICCW), 2015 IEEE International Conference on* (pp. 2325-2331).

## TALKS

- *Algorithms and protocols for Molecular Communication*, invited talk at Indian Institute of Technology, Madras, India, April 2017
- *Algorithms and protocols for Molecular Communication*, invited talk at CableLabs, CO, March 2017
- *QnA: Towards a new Communication Paradigm for Unmatched Asymmetric Network Environments*, poster presentation at MobiSys Women's Workshop, Niagra Falls, NY, June 2017

## RESEARCH EXPERIENCE

### Embedded Error Correction (EEC)

Spring 2016-Present

*To be Published in NanoCom '18*

- Designed EEC, a simple and efficient Forward Error Correction mechanism that can be implemented using bio-circuits reliably in real-time. FEC techniques allows the receiver to detect and correct for errors by introducing redundancy in the message transmitted. EEC introduces redundancy by varying the on-period of the signal transmitted across senders. By increasing the distance within and between on-periods assigned, the error resilience of EEC is increased. Bit error rate of the order of  $10^{-2}$  is achieved using EEC.

### Source Addressing and Medium Access Control

Spring 2014-2016

*NanoCom '15, NanoCom '16*

- This work focuses on source addressing in a star topology bacterial communication network. Using address fields and dedicated medium access control (MAC) algorithms are not feasible to implement. We propose Amplitude-Division Multiple Access (ADMA), a novel local addressing method that assigns the amplitude of the transmitted signal as the address of the source. We demonstrate using genetically engineered Escherichia coli (E. Coli) bacteria in a microfluidic device that using ADMA is feasible. We also demonstrate that ADMA implicitly solves the problem of MAC.

### Time Elapse Communication (TEC)

Spring 2012-2014

*ICC '13, IEEE ToC*

- In networks with extremely high processing delays and latency, existing energy based modulation techniques are inefficient and expensive in terms of delay. We proposed a unique time based communication technique, TEC, that encodes information in the time between transmitted signals. Number of clock cycles elapsed between two signals conveys the information, thus limiting the number of signals to two per message/frame. We showed using experiments with E.Coli bacteria and simulations that TEC shows 10x improvement in datarate compared to On-Off-Keying and minimizes channel traffic.

### Rhythm

Spring 2013

*GLOBECOMM '15*

*In collaboration with Chao-Fang Shih*

- Proposed and implemented algorithms to identify packets and their source in a new MAC protocol, "Rhythm". Rhythm is a new MAC protocol for WiFi network to make nodes follow a "schedule". Implemented algorithms to identify MAC address of a sender in a low SNR scenario using correlation methods in USRPs using GNU Radio.

## TEACHING EXPERIENCE

### Teaching Assistant

ECE 6610 : Wireless Networks, Georgia Tech, Atlanta

Spring 2013, Fall 2013, Fall 2015

Responsibilities include the design and grading of programming assignments in NS2. Designed assignments to understand networks using simulations and practical use of networking tools including iperf, Wireshark, tcptrace.

### Guest Lecture on Molecular Communication

- ECE 6610 : Wireless Networks, Georgia Tech, Atlanta

October 2013, November 2015

## WORK EXPERIENCE

### Research Intern, Cisco

Summer 2016

- *Manager : John Chapman, Cisco*
- Developed APIs to integrate Video Quality Analytics with WiFi Radio Resource Management to enhance end-user video experience over WiFi
- Analysed impact of TCP flavors for different applications over wired and wireless environment

### Research Intern, CableLabs, Boulder

Summer 2015

- *Manager : Dr. Alberto Campos, CableLabs*
- Analyzed impact of WiFi systems on cable network
- Proposed and implemented *Wireless Drop*, a new architecture for broadband systems to achieve low cost high throughput broadband connection

### Research Intern, Nokia Research Center, Berkeley

Summer 2014

- *Manager : Dr. Sayantan Choudury, Nokia Labs*
- Proposed algorithms for Radio Resource Management in an uncoordinated dense WiFi network
- Evaluated the performance of proposed algorithm in a custom built network simulator
- Studied the practical limits of OFDMA on downlink and uplink 802.11 WiFi traffic

### Research Intern, Indian Institute of Technology-Madras, India

Summer 2010

- *Advisor : Dr. Manivasakan.R*
- Developed an algorithm to achieve Time Division Multiplexed behavior of Resilient Packet Ring (RPR) frames
- Achieved a jitter free transmission before converting RPR frames to Ethernet frames
- Implemented the algorithm in VHDL and ported into Xilinx ML506 board for real-time evaluation

### Research Intern, Indian Institute of Technology-Madras, India

Spring 2008

- *Advisor : Dr. Shankar Balachandran*
- Noise pollution during heavy traffic muffles useful sounds and necessary cues for motorists.
- Designed a noise filter to attenuate unwanted frequency in heavy traffic and render the motorist with only the useful sounds in the optimal range.

## SERVICE

**Peer Review:** Served as reviewer in different peer-reviewed journals including IEEE Transactions on Mobile Computing, Transactions on Communications, Computer Communications, Wireless Networks.

**Mentoring:** i) Mentored two undergraduate teams towards a course project for *Wireless Networks* in Spring 2013 (ii) Mentored high school student on a project focusing on bacterial sensors, 2017 (iii) Mentor new PhD students as part of ECE PhD mentoring program at Georgia Tech to help new students with school and research.