Innovative Wireless Technologies for Emerging IoT Domains

October 15, 2020 11:00 am - 12:10 pm

11:00am

Extreme IoT: Wireless and Batteryless Sensors for Oceans, Health, and Supply Chain
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Fadel Adib is an Associate Professor with tenure at MIT and Founder-CEO of Cartesian Systems. At MIT, he holds joint appointments in the MIT Media Lab and the Department of Electrical Engineering and Computer Science. He is also the founding director of the Signal Kinetics group which invents wireless and sensor technologies for networking, health monitoring, robotics, and ocean IoT.

Prof. Adib's research has led to multiple startups. His most recent startup, *Cartesian Systems*, aims to map the physical world at unprecedented scale and precision. Prior to that, his PhD research on wireless sensing led to *Emerald Innovations*, whose devices are used for remote health monitoring of thousands of patients.

Prof. Adib is widely recognized for his research, technological, and commercial impact. He was named by *Technology Review* as one of the world's top 35 innovators under 35 and by *Forbes* as 30 under 30. His research on wireless sensing *(X-Ray Vision*) was recognized as one of the 50 ways MIT has transformed Computer Science, and his work on robotic perception *(Finder of Lost Things)* was named as one of the *103 Ways MIT is Making a Better World*. Prof. Adib's commercialized technologies have been used to monitor thousands of patients with Alzheimer's, Parkinson's, and COVID-19, and he has had the honor to demo his work to President Obama at the White House. His research has also been broadly featured in the public media, including *CNN*, *BBC*, *The Wall Street Journal, The Washington Post*, *The Guardian*, and *Der Spiegel*.

Prof. Adib's research has received various academic honors. He was awarded the *CAREER Award* (2019) from the US National Science Foundation, the *Young Investigator Award* (2019) and the *ONR Early Career Grant* (2020) from the Office of Naval Research, the *Google Faculty Research Award* (2017), the *Sloan Research Fellowship* (2021), and the *ACM SIGMOBILE Rockstar Award* (2022). His publications have also received awards for best papers, demos, and highlights at premier academic venues including *SIGCOMM*, *MobiCom*, *CHI,* and *Nature Electronics*.

Adib received his Bachelor's from the American University of Beirut (2011), which named him *Distinguished Young Alumnus* in 2017. He completed his graduate degrees at MIT, where he received awards for Best Master's and Best PhD theses in Computer Science in 2013 and 2016. His PhD thesis was also recognized internationally with the *ACM SIGMOBILE Doctoral Dissertation Award*.

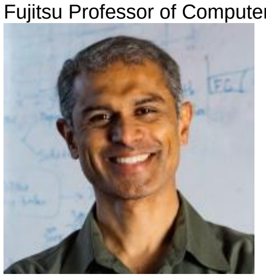
[View full bio]
The evolution of communication technologies over the past 140 years has enabled ubiquitous connectivity with billions of sensors globally. However, today's technologies still face fundamental obstacles, which prevent them from seamlessly extending to complex domains like the ocean, the human body, or supply chain environments.

In this talk, I will describe new technologies developed by my group that allow us to bring Internet-of-Things (IoT) to extreme environments. First, I will describe a *new generation of underwater sensors* that can sense, compute, and communicate without requiring any batteries; these devices enable real-time and ultra-long-term monitoring of ocean vitals (temperature, pressure, coral reefs) with important applications to scientific exploration, underwater climate monitoring, and defense. Next, I will talk about new wireless technologies for sensing the human body, both from inside the body as well as from a distance *(contactless)*; these technologies have already been used to monitor disease progression (including in COVID19 patients), and pave way for novel diagnostic and treatment methods. Finally, I will describe new RFID-based *micro-logistics* solutions that can bring extreme visibility to supply chain processes, with applications to retail, warehousing, and manufacturing; these technologies also allow us to extend robotic perception beyond line-of-sight, enabling robotics to perform complex manipulation tasks that were not possible before.

The talk will cover how we have designed, built, and tested these technologies in the real-world, and highlight their applications to various industries. The talk will also outline the ongoing and potential impact of this line of work in addressing global challenges in climate, health, and automation.

11:40am

RFocus: Large-Scale Beamforming with Smart Surfaces
Hari Balakrishnan
Fujitsu Professor of Computer Science



Hari Balakrishnan
Fujitsu Professor of Computer Science

Hari Balakrishnan is the Fujitsu Professor of Computer Science at MIT and a Director of MIT's Center for Wireless Networks and Mobile Computing. His research is in networked computer systems, with current interests in networking, sensing, and perception for sensor-equipped mobile devices connected to cloud or edge services running in datacenters. He has made many highly-cited contributions to mobile and sensor computing, Internet transport and routing, overlay networks and P2P systems, and data management.

In 2010, based on the CarTel project, Balakrishnan co-founded Cambridge Mobile Telematics, a company that uses mobile sensing, statistical methods, AI, and behavioral science to make roads safer by making drivers better. Over the past few years, CMT has become the world's largest telematics service provider, serving millions of users in 25 countries via partnerships with insurers, cellular carriers, rideshare companies, and automobile makers. He was an advisor to Meraki from its inception in 2006 to its acquisition by Cisco in 2012. In 2003, Balakrishnan co-founded StreamBase Systems (acquired by TIBCO), the first high-performance commercial stream processing (aka complex event processing) engine.

Balakrishnan received his PhD in 1998 from UC Berkeley and a BTech in 1993 from IIT Madras, which named him a distinguished alumnus in 2013. He was elected to the National Academy of Engineering in 2015 and to the American Academy of Arts and Sciences in 2017. His honors include the IEEE Kobayashi Computers and Commnications Award (2021), Fellow of the ACM (2008), Fellow of the IEEE (2020), Sloan Fellow (2002), and the ACM dissertation award (1998). He has received several best-paper awards including the IEEE Bennett paper prize (2004), and six "test of time" awards for papers with long-term impact from ACM SIGCOMM (2011), SIGOPS (2015), SIGMOD (2016), and SIGMOBILE (2017, 2018), and SenSys (2019). He has also been honored for excellence in research and teaching at MIT: the Harold E. Edgerton faculty achievement award (2003), the HKN best instructor award (2018), the Jamieson award (2012), the Junior Bose teaching award (2002), and the Spira teaching award (2001).

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(Hari Balakrishnan video time stamp starts at: 38.28)

When radios communicate with each other, the transmitter spreads its signal in all directions. Hence only a small fraction of what is transmitted hits the receiver. Radios with multiple antennas can *beamform*, i.e., direct their signal so more of it reaches the receiver. How precisely a radio can beamform depends fundamentally on its size; a larger radio with more antennas can direct its signal better than smaller radios. Unfortunately, practical constraints on mobile and IoT devices prevent us from making radios large.

To address this challenge, we introduce **RFocus**. RFocus adds many thousands of antennas to the environment arranged as a 2D surface, where each antenna is a simple and inexpensive backscatter reflector similar to a passive RFID tag. They do not emit any signal of their own; instead they either reflect an incident signal or just pass it through. Each of these elements can be “on” or “off”, and the question is how to find the optimal state of each element so that the signal at any given receiver is maximized? This is a combinatorially explosive problem, but we have developed an elegant and practical approximation algorithm that works well. We have built a prototype of RFocus with 3200 elements, which may well be the largest number of antennas ever used for a single communication link! We show through real-world experiments that RFocus can improve received signal strength by a median of 10x in an office environment, and as high as 20x in challenging locations on an office floor. We will discuss applications to IoT, Wi-Fi, and 5G networks.

This is joint work with PhD student Venkat Arun.

12:15pm	Discussion with Q&A
	Q&A Discussion video time stamp starts at: 118.30