Development of a Millimeter Wave Software Defined Radio Platform

Russell Ford, Aditya Dhananjay, Sundeep Rangan
New York University
russell.ford@nyu.edu, aditya@cs.nyu.edu, srangan@nyu.edu

Millimeter wave (mmWave) frequencies – roughly between 30 and 300 GHz – are a new and promising frontier for cellular wireless communication. With the rapidly growing demand for cellular data traffic, conventional cellular bands below 3 GHz are now highly congested. In contrast, the mmWave bands offer vast, largely untapped spectrum – up to 200 times all cellular allocations by some estimates. MmWave cellular networks comprising of small, densely-deployed base stations with highly-directional beams, are thus commonly cited as a potential technology for 5G cellular networks that can deliver orders of magnitudes increases in capacity.

However, mmWave cellular wireless communications is still very much in its infancy and there is an urgent need for software defined radio (SDR) platforms to enable the research and development to bring these systems to reality. Developing such mmWave SDR platforms presents several challenging requirements:

- *Phased array front-end:* Most significantly, mmWave communication depends on highly directional transmissions to overcome the high isotropic path loss of transmissions in these frequencies. Mobile applications will require that the directional beams be steered electrically to track mobile users. While a few companies have developed mmWave phased arrays for internal research, there are currently no publicly available solutions that offer access to the phase controls needed to explore new beamforming and searching algorithms.
- *High performance baseband processing:* One of the main motivations for mmWave systems is the ability to achieve very high data rates and low latency. Capacity studies have predicted multi-Gbps cell throughputs for realistic systems in the mmWave bands. However, platforms that can actually these data rates will require platforms with orders of magnitude more computational power than current systems available in academic labs. In addition, it is widely expected that mmWave systems will be capable of reducing round-trip data plane latency to 1 to 2 ms– an order of magnitude faster than currently supported in 3GPP LTE. Achieving these low latencies for cellular systems will require new SDR platforms with very highly optimized data flows due to the large number of MAC-PHY interactions for scheduling, packet assembly and ACK processing.
- *Configurability:* MmWave systems are still very early in the design phase. For example, standards bodies such as 3GPP are only beginning to consider channel modeling and other aspects. As a result, flexibility and configurability are essential for research and design groups to experiment with different design options.

The broad goal of this project is to develop a powerful, flexible, and programmable platform suitable for the design and validation of next-generation mmWave systems. This platform will integrate two main components: a) a high-bandwidth baseband processor with high computational power and optimized data flows using a widely-used National Instruments platform; and b) an electrically steerable phased array antenna system designed by SiBeam. This platform would enable design exploration and rapid prototyping of mmWave systems, including: a) dynamic and rapid channel sounding; b) designing and testing MAC protocols and c) adaptive beamforming.

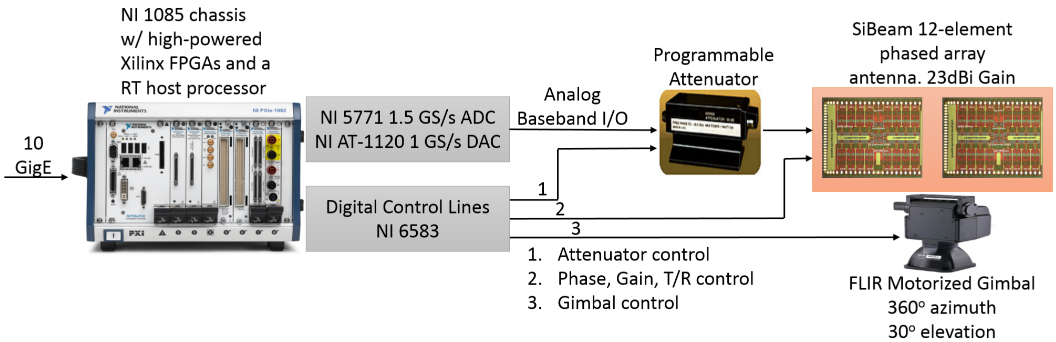

Figure 1: Proposed mmWave SDR architecture consisting of two main parts: a) a SiBeam 12-element phased array antenna mounted on a motorized gimbal; and b) a high-bandwidth programmable baseband processor on NI's PXI platform

About the Presenter

Russell Ford is a Ph.D. candidate and researcher with the NYU WIRELESS center in Brooklyn, New York. His background and research interests include 5G cellular MAC-layer design and network architecture, Software-Defined Radio prototyping and wireless network simulation. He has been a main contributor to the development of a millimeter wave module for ns-3, which extends the popular LTE LENA module with support for simulating mmWave cellular access networks. Russell has previously interned for National Instruments and NI Dresden (Signalion), where he helped develop a testbed for experimentation with LTE small-cells as well as advanced 5G cellular demo systems using the NI SDR platform. Russell is advised by Prof. Sundeep Rangan.

About NYU WIRELESS

NYU WIRELESS is a multi-disciplinary academic research center located at New York University's Brooklyn campus. The center combines NYU's Tandon School of Engineering program with NYU's School of Medicine and the Courant Institute of Mathematical Sciences, and offers a depth of expertise with unparalleled capabilities for the creation of new wireless networks. NYU WIRELESS is made up of over 25 full-time faculty and post-docs along with over 30 Ph.D. and master's students from across the NYU community. The center is sponsored by and collaborates with 17 industry affiliates, all of which are leaders in the wireless space.

NYU WIRELESS Affiliates National Instruments (NI) and SiBeam are two of the key NYU WIRELESS affiliates supporting this project.

NI is the industry leader in automated test equipment and virtual instrumentation. They also are the developers of the powerful LabVIEW platform. Their system has been featured in several high-profile demonstrations of mmWave communications links, including a 10Gb/s link at 73 GHz, which was developed jointly with Nokia. NYU WIRELESS is a lead user for NI products and has extensive experience with their platform for the development of transceivers and channel sounders.

Additionally, SiBeam is a leading company in millimeter wave RF products and is playing an important role providing "Gigabit Wireless Everywhere." They have fabricated phased arrays on standard silicon chips and supply them to a number of wireless vendors.