A Platform for At-Scale Wideband UHF MU-MIMO Systems

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Abstract

We present a Multi-User MIMO (MU-MIMO) array utilizing the Wideband Ultra-high frequency Radio daughter-Card (WURC), a new open platform for at-scale MU-MIMO transmissions in the UHF band. Using this platform, we demonstrate an application that measures and displays wideband MU-MIMO channel estimates and capacity for both UHF and 2.4 GHz WiFi channels, then performs single-carrier beam-formed transmissions in real-time. An array of WURC analog front-ends coupled with WARP Software-Defined Radios (SDRs) is, to the best of our knowledge, the first open UHF MU-MIMO research platform that allows for high-power transmissions and at-scale topologies and experiments.

1 Wideband UHF Radio

The WURC is a new SDR analog front-end with a high-power, configurable radio transceiver for compatible digital baseband systems [3]. It is designed to operate in the Ultra-High Frequency (UHF) band from 470-700 MHz with a maximum output power of 30 dBm, and within the 2.4-2.5 GHz ISM band with a maximum output power of 26 dBm. The linear ultra-wideband power transfer network for the UHF front end was accomplished using real-frequency matching techniques [4].

The WURC implements the LMS6002DFN wideband transceiver IC from Lime Microsystems, which includes programmable analog low-pass channel and anti-aliasing filters within its direct-conversion RF chain, and adaptable channel bandwidth of 1.5-28 MHz [2]. An on-board micro-controller provides a library of control and calibration algorithms for the transceiver, and presents a simple API to host systems allowing in-field adjustment of RF parameters by software. Contrasting with many existing SDR front-ends, the WURC provides Tx/Rx switching capabilities to enable half-duplex protocol implementation using a single antenna, while also providing independent transmit and receive chains and frequency synthesizers to enable frequency-division duplex (FDD) applications with two antennas.

2 Wideband UHF MU-MIMO Array

By combining four WARP boards, each with their own WURC, existing frameworks for rapid physical-layer prototyping (WARPLab) and real-time protocol implementation (802.11 Reference Design) have been adapted to operate in the UHF band [1]. Our testbed provides 4x 2.4 GHz antennas and 4x UHF antennas separated by their respective 1/2 wavelength distance (Fig 1). This provides a way to directly estimate and compare actual MU-MIMO channels to clients at 2.4 GHz and UHF, both indoors and outdoors.

Channel estimation is accomplished by transmitting back-to-back 802.11g OFDM preamble sequences from each of the four base-station antennas. The preamble allows the single-radio receivers to perform automatic-gain control, recover symbol timing and carrier-frequency offset, and finally estimate the wireless channel. For each subcarrier, a complex magnitude and phase is estimated then used to calculate MU-MIMO channel capacity.

Wideband channel estimation is performed with the 802.11 framework, while single-carrier MU-MIMO transmissions are accomplished with WARPLab.

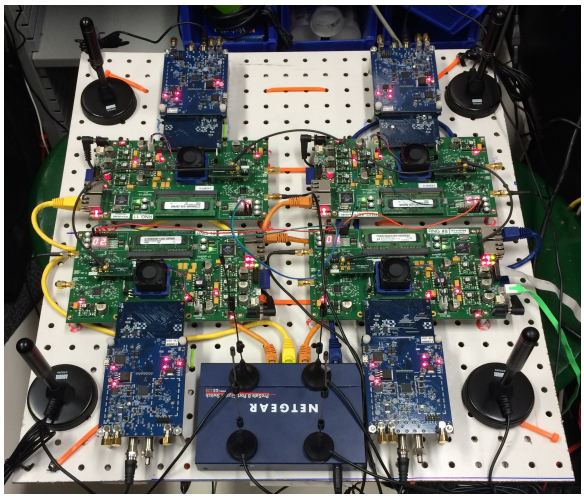

Figure 1: UHF MU-MIMO platform with 4x UHF WURC and 4x 2.4 GHz radios

References

[1] Rice University WARP project. Available at: http://warp.rice.edu.

[2] LMS6002DFN Documentation, Feb 2014. Available at: http://www.limemicro.com/products/LMS6002D.php.

[3] WURC documentation, Feb 2014. Available at: http://www.volowireless.com/products/WURC.

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