UT and Drexel Use NI PXI and LabVIEW for Wireless Research

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Industry:
Telecommunications

Product:
LabVIEW, PXI/CompactPCI, RF

The Challenge:
Designing a next-generation multiple input, multiple output (MIMO) network prototype.

The Solution:
Using National Instruments PXI RF modules, RF software, and LabVIEW to provide an effective prototyping platform for a wireless system design, implementation, and prototyping.

The Project


MIMO Ad-Hoc Mode

The emphasis of our National Science Foundation-funded research is on MIMO wireless systems, which use antenna arrays at both the transmitter and the receiver. Through MIMO communication, cluttered urban areas (where signal quality fluctuates widely due to diffraction) multiple reflections, and scattering, can experience high-quality and high-capacity communication. The technology is being considered in next-generation wireless local area networks, broadband fixed-wireless access, and fourth-generation cellular systems.

It is essential to prototype MIMO wireless communication systems to close the design loop and provide practical verification of our theoretical research. Traditionally, this would require expensive dedicated hardware, which is time-consuming to program and difficult to maintain in an academic environment. However, with National Instruments integrated software and modular hardware, we now can build such wireless communication links with all wireless system elements, including modulation, synchronization, and equalization. Moreover, the hardware is fully programmable, making it easy to develop and test new ideas.

Our project, implemented jointly by the University of Texas at Austin and Drexel University, consists of two phases - prototyping a MIMO communication point-to-point link and implementing a MIMO ad-hoc network. Ad-hoc networks are wireless networks without a centralized controller. They provide rapid deployment and flexibility, and are of substantial interest in military and consumer electronics applications.

The following is a list of recommended National Instruments products for such prototyping:

Hardware	Software

PXI–5670 RF Vector Signal Generator: 250 kHz to 2.7 GHz 16-bit resolution, 100 MS/s arbitrary waveform generator (AWG) (400 MS/s interpolated) 22 MHz real-time bandwidth 8, 32, 256, or 512 MB memory High-stability OCXO timebase -145 to +11 dBm output power	LabVIEW 7.1 Modulation Toolkit: It includes measurements such as bit error rate, phase error, burst timing, and frequency deviation Handles standard and custom modulation formats including AM, FM, PM, ASK, FSK, MSK, GMSK, PSK, QPSK, PAM, and QAM Contains powerful 3 D eye diagrams Provides quality measurements including EVM and modulation error ratio
PXI–5660 RF Vector Signal Analyzer: 9 kHz to 2.7 GHz frequency range 20 MHz real-time bandwidth 80 dB spurious-free dynamic range 14-bit resolution, 64 MS/s digitizer 32 or 64 MB onboard memory High-stability OCXO timebase	

Prototyping a MIMO Wireless Communication Link

Our first project milestone was developing a MIMO wireless communication system simulation using the NI LabVIEW Modulation Toolkit. With this simulation, we can control the system parameters, including data transfer rate and error correction code type, and offer options for the fading and multipath interference that occurs in wireless channels.

During the project hardware implementation, the system converted the software simulation into an actual MIMO wireless link. The transmitter contained a LabVIEW program to create and modulate the message to be transmitted; an NI PXI AWG to create the analog waveform; an NI PXI-5610 RF up converter to further modulate the carrier to 2.4 GHz; and a transmitting antenna. The receiver was a separate PXI system consisting of a receiving antenna; an NI PXI-5600 RF down converter to bring the signal back to the IF band; an NI PXI-5620 high-speed digitizer; and the student-written LabVIEW demodulation and analysis program.

Implementing a MIMO Ad-Hoc Network

Currently, Drexel and UT have duplicate experimental facilities to study two different aspects of MIMO ad-hoc networks:

- At Drexel, researchers use a cluster of nodes to study antenna array design, channel characterization, and interference management algorithms from an electromagnetic point of view.
- At UT, researchers use a cluster of nodes to study receiver algorithms, relaying, multiuser synchronization, and MAC design.

For maximum flexibility, each university ultimately will be equipped with a five-node, ad-hoc network. Each node will be configured with four transmit and four receive antennas. With this equipment, researchers can test a number of different connectivity scenarios. The RF transceivers operate with a maximum bandwidth of 20 MHz and frequency-agile operation in the ISM/UNII bands. We implemented physical-layer software with LabVIEW on the NI PXI-1045 chassis. We interfaced the NI chassis using an NI PXI-8231 Gigabit Ethernet card to a separate Linux machine, which implemented the medium-access control and higher-layer protocols with the click modular router.

Through this project, our graduate students trained in the areas of cross-layer network design, MIMO communication, multiple access, MAC design, LabVIEW, and prototyping. As a result, they are prime candidates for becoming next-generation leaders in wireless communications.

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