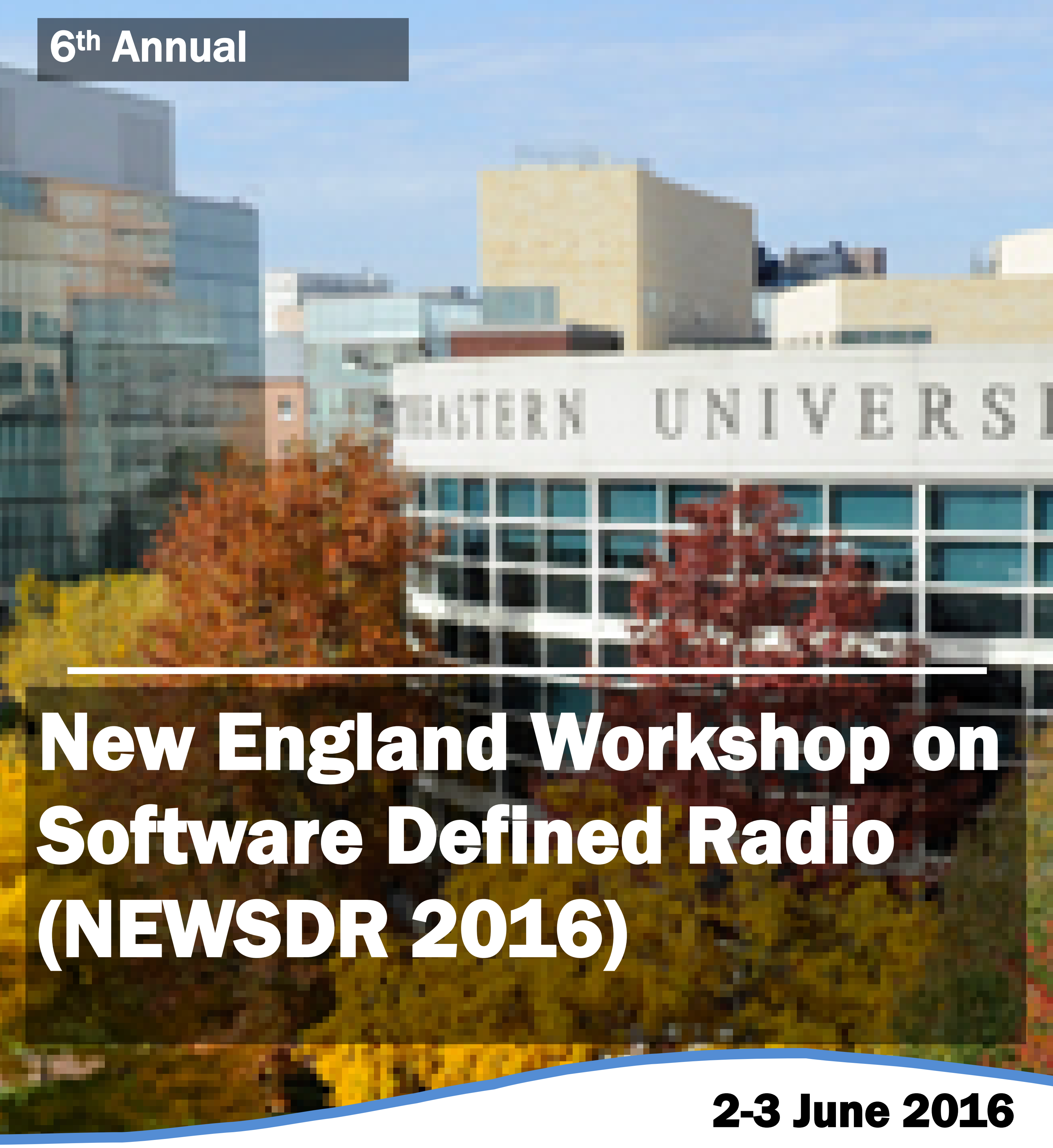
6th Annual



New England Workshop on Software Defined Radio (NEWSDR 2016)

2-3 June 2016

Northeastern University | Boston, Mass

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Welcome

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The 2016 New England Workshop on Software Defined Radio (NEWSDR) is the sixth installment of an annual series of workshops organized by the Boston SDR User Group (SDR-Boston). This year, we are very excited about having Northeastern University generously serve as the host institution for NEWSDR 2016; the Raytheon Amphitheater is a fantastic venue for this event!

The goal of this series of workshops is to provide a forum through which individuals working on SDR-related projects in the New England area can get together in order to collaborate and introduce SDR concepts to those interested in furthering their knowledge of SDR capabilities and available resources.

Following on the success of these workshops, this year's NEWSDR event offers a chance for presenting the latest developments in SDR and Cognitive Radio research by individuals from academia, industry, and government in the New England area, as well as from across the Nation. In addition to providing an opportunity for researchers in this area to network and interact on issues relating to SDR and Cognitive Radios, NEWSDR 2016 will include:

- Keynote Presentations on the latest in SDR
- Poster Presentations with Short "Elevator-Pitch" Oral Presentations
- Technology demonstrations
- Hands-On Tutorials
- Breakfast / coffee / lunch included with advanced registration

During this event, we would like to encourage all of you to engage in conversation with your fellow attendees, exchange ideas, and talk about your latest findings with respect to SDR. We hope that you will find NEWSDR 2016 a productive event to expand your knowledge and horizons regarding SDR technology, and we would like to wish you a very positive and rewarding workshop!

Agenda – 3 June 2016

8:30AM-8:40AM	**Welcome and Introduction**
8:40AM-10:00AM	**Sponsor Flash Talks (20 minutes each)**
10:00AM-10:30AM	**“Elevator Pitch” Oral Presentations of Poster Presenters (2 minutes each)**
10:30AM-11:00AM	**Coffee, Networking Break, Poster Presentations, Sponsor Exhibits and Demos**
11:00AM-12:00PM	**Invited Presentation: “NASA’S Future Communication Architecture and Approach for Cognitive Communications”** *Mr. Richard Reinhart, NASA Glenn Research Center*
12:00PM-1:00PM	**Lunch and Networking**
1:00PM-2:00PM	**Invited Presentation: “Wireless Beyond RF: From Underwater to Intra-body Ultrasonic Software Defined Radios”** *Professor Tommaso Melodia, Northeastern University*
2:00PM-3:00PM	**Coffee, Networking Break, Poster Presentations, Sponsor Exhibits and Demos**
3:00PM-4:00PM	**Short Course: Moving from Prototyping to Production** *Robin Getz, Analog Devices & Noam Levine, MathWorks*
4:00PM-4:10PM	**Closing Remarks and Adjournment**

Invited Speakers

Richard Reinhart is a senior communications engineer with NASA's Glenn Research Center, located in Cleveland, Ohio. He is the Principal Investigator for NASA's software defined radio (SDR) flight experiment aboard International Space Station, called the Space Communications and Navigation Testbed and is leading studies and assessing technologies to define NASA's future communications' architecture. He has worked with space communications technology development for over 25 years on various satellite, radio and array antenna technologies. He received his Bachelors and Masters Degrees in Electrical Engineering from The University of Toledo and Cleveland State University, respectively. Mr. Reinhart has published a number of technical papers and conference presentations associated with the SCAN Testbed, SDR technology, and the Ka-band Advanced Communications Technology Satellite (ACTS), one of the first Ka-band satellites. He is a principal author of the SDR Space Telecommunications Radio Standard (STRS) architecture, now a NASA-wide standard. He founded and chaired the Wireless Innovation (SDR) Forum's Space Applications Study Group and is the Technical Chair for the 2016 AIAA International Communications Satellite Systems Conference (ICSSC-2016).

Tommaso Melodia is an Associate Professor with the Department of Electrical and Computer Engineering at Northeastern University in Boston. He received his Ph.D. in Electrical and Computer Engineering from the Georgia Institute of Technology in 2007. He is a recipient of the National Science Foundation CAREER award, and coauthored a paper that was recognized as the ISI Fast Breaking Paper in the field of Computer Science for February 2009 and of ACM WUWNet 2013 and 2015 Best Paper Awards. He serves in the Editorial Boards of IEEE Transactions on Mobile Computing, IEEE Transactions on Wireless Communications, IEEE Transactions on Multimedia, and Computer Networks (Elsevier). His current research interests are in modeling, optimization, and experimental evaluation of networked communication systems, with applications to ultrasonic intra-body networks, cognitive and cooperative networks, multimedia sensor networks, and underwater networks.

Hands-On SDR Experimentation & Short Courses

Hands-On SDR Experimentation: SDR Challenge – Identifying Mystery Waveform Using Simulink and RTL-SDR

Mike McLernon (MathWorks), Ethem Sozer (MathWorks)

During this evening event, the audience will be tasked with identifying a "mystery waveform" that is being generated in their vicinity. Using MATLAB/Simulink and the RTL-SDR platform, both of which will be provided during this event, each team will be given several partially completed models and some details of the mystery waveform. The objective of this challenge is to add the remaining functionality to the models provided and leverage the RTL-SDR in order to classify the received signal and potentially even decode the signal.

The learning outcomes of this event include:

- Obtaining an understanding of the MATLAB/Simulink software environment and its capabilities.
- Gaining knowledge on how MATLAB/Simulink interfaces with the RTL-SDR device.
- Experience hands-on real-time wireless experimentation using MATLAB/Simulink and the RTL-SDR in a controlled wireless scenario.

Given the limited number of computer workstations and RTL-SDR platforms available, this event has a registration limit of 30 individuals (teams of 3 individuals will be formed at this event).

Hands-On SDR Experimentation: Hands-On Tutorial on FPGA Computing for SDR with RFNoC

Jonathon Pendlum (Ettus/NI), Wan Liu (NI), Neel Pandeya (Ettus/NI)

Ettus Research has introduced a platform called RF Network-on-Chip (RFNoC) which makes FPGA computing for SDR more accessible and flexible. RFNoC is a new architecture for USRP devices that use Xilinx 7-series FPGAs (E310, X300, and X310). RFNoC is built around a packetized network infrastructure in the FPGA that handles the transport of control and sample data between the host CPU and the radio. Users target their custom algorithms to the FPGA in the form of Computation Engines (CE), which are processing blocks that attach to this network. CEs act as independent nodes on the network that can receive and transmit data to any other node (e.g., another CE, the radio block, or the host CPU). This architecture permits scalable designs that can distribute processing across many nodes. Users can create modular, FPGA-accelerated SDR applications by chaining CEs into a flow graph. RFNoC is supported in UHD and GNU Radio. In this workshop, we will present an interactive tutorial on RFNoC, including a discussion on its design and capabilities, demonstrations of several existing examples, and a walk-through on implementing a user-defined CE and integrating the CE into GNU Radio.

Prerequisites:

- Attendees must create Xilinx user accounts at least three days before the workshop, in order to obtain Xilinx licenses for the free WebPack Edition of Vivado version 2015.4.
- Attendees are expected to bring their own laptops to the workshop. The laptop should have at least 2 GB memory, have at least one Ethernet port and one USB 3.0 port, and be able to boot into a Linux environment from a USB 3.0 flash drive.

USB flash drives and USRP hardware will be provided in the workshop.

Enrollment is limited to 20 people.

Short Course: Moving from Prototyping to Production

Robin Getz (Analog Devices), Noam Levine (MathWorks)

There is a significant gap between the concept of a wireless system and the realization of that working design. Bridging this gap typically involves teams of engineers with a variety of different skill sets (such as RF, SW, DSP, HDL, and embedded Linux®), and in many cases projects get derailed early in the development stage because of the difficulty in coordinating the efforts of these varied design entities. Over the next hour, we will examine the advances in platforms and tools that allow developers to quickly simulate and prototype wireless systems while establishing and maintaining a deployable path to production. As a real-world example of the process, we will prototype a wireless SDR platform that receives and decodes QPSK signals. The resources required in this case are MATLAB® and Simulink and the skills to integrate and embed hardware/software. The hardware platform will be the Analog Devices/Xilinx/Avnet PicoZed SDR system, which uses the ADI RadioVerse AD9361, and the Xilinx Zynq 7035 All Programmable SoC. A demo of MATLAB and Simulink® performing the following tasks will be performed:

- Design of signal processing algorithms used to decode QPSK messages
- Simulation of the RF transceiver receiving QPSKsignals
- Generation of C and HDL code
- Verification of the HDL code with recorded and live data on the target transceiver and FPGA, tethered and untethered from a PC.

Poster Presentations

Bumblebee-Inspired Vehicular Communications

Bengi Aygun (WPI), Rob Gegear (WPI), Liz Ryder (WPI), Alex Wyglinski (WPI)

We present dynamic spectrum access mechanism for vehicle-to-vehicle communications inspired by the optimal flower selection process employed by foraging bumblebees. The proposed interdisciplinary solution of translating bumblebee learning, memory, and decision-making processes into a highly time varying connected vehicle framework. Different memory lengths and scheme are implemented to IEEE 802.11p standard. The proposed approach will be implemented on USRP N210 radios. This work is sponsored by the US National Science Foundation. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

MATLAB Multicore DataFlow

Travis Collins (WPI), Alex Wyglinski (WPI)

In this poster we present a DataFlow architecture for MATLAB. Providing thread level pipelining of MATLAB functions as well as general concurrency. Resulting in significant speedup of current MATLAB based SDR implementations on multicore systems. Demonstrated by a 20x speed increase for a 802.11a receiver, running in real-time. This work is sponsored by the Mathworks. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

Real-time DOA and Localization Testbed

Travis Collins (WPI), Srikanth Pagadarai (WPI), Aki Hakkarainen (Tampere University of Technology), Mike Koivisto (Tampere University of Technology), Mikko Valkama (Tampere University of Technology), Alex Wyglinski (WPI)

In this poster we presented a real-time implementation for direction of arrival (DoA) estimation. We utilize 5 USRP's in a linear phased array, capable of automatic synchronization. GNURadio provides all back-end signal processing, include DoA measurements through the MuSIC algorithm with antenna compensation. This is the foundational work for a larger localization project, scaling to multiple arrays. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

What ships are in Boston Harbor?

Mike Donovan (Microsoft Research)

This question can be answered if you have an SDR and MATLAB. This poster describes a demo that uses the RTL-SDR to decode Automatic Identification System (AIS) messages, which ships use to report their ID, position, course and other information to other ships and harbor stations. This information is used to make waterways safer and prevent accidents in harbors and at sea.

AIS uses GMSK modulation to transmit data at a rate of 9600 bps over 12.5 or 25 kHz channels. Even though the standard is fairly simple, several challenges need to be addressed to successfully decode the messages, including:

- Setting up an SDR and capturing AIS transmissions
- Compensation for frequency errors
- Timing synchronization using a message preamble
- Making bit decisions and calculating a figure of merit
- Calculation of the message checksum

An over-the-air demo of AIS using a USRP transmitter and an RTL-SDR receiver will be presented. In addition, the MATLAB source code and an easy to use MATLAB app will be available for anyone interested in testing this program with live AIS data.

Profiling 802.11a standard on the Xilinx Zynq system-on-chip

Benjamin Drozdenko (Northeastern), Matthew Zimmermann (MITRE), Tuan Dao (Northeastern), Kaushik Chowdhury (Northeastern), Miriam Leeser (Northeastern)

The recent increase in the number of wireless devices has been accompanied by an explosion in the number of protocols for wireless communications, each focusing on different purposes such as execution time reduction, energy reduction, handling higher congestion levels, or operation at different bandwidths. Software-defined radios have introduced new platforms for dynamically modifying wireless system designs, and heterogeneous computing has opened up implementation of such designs on different computing elements. Up to now, researchers have focused on designing complete protocol-specific processing chains. In contrast, our goal is to develop a modeling environment that captures reusability of various processing blocks at the physical layer for several modern protocols, and makes decisions regarding whether processing blocks should be part of reconfigurable hardware or embedded processor software. In this poster, we introduce an integrated profiling approach to implement the 802.11a standard on the Xilinx Zynq system-on-chip. Our approach creates several different MathWorks Simulink model variants for both the transmitter and the receiver, each with a different boundary between hardware and software components. We use these models to generate a bitstream for the FPGA and executable code for the ARM processor. Using this modeling environment, we investigate the HW/SW divide point and identify specific processing blocks to focus on improving. Our results collect such metrics as CPU execution time, data path delay, resource utilization, and power usage to demonstrate how exploring variants to processing blocks can further enhance the design. We show how modifications to the preamble detection and Viterbi decoder blocks can reduce the total resource utilization and make use of underutilized resources such as BRAM. We assert that this 802.11a PHY layer implementation can be used as a basis for future work in MIMO, higher OSI layers, and LTE Wi-Fi coexistence. As a first step, we identify which 802.11a processing blocks can be reused for these alternate protocols, and measure the effects on resource utilization for larger IFFT sizes in OFDM modulation.

Cognitive Radio-Based Satellite Communications

Paulo Victor Ferreira (WPI), Randy Paffenroth (WPI), Alex Wyglinski (WPI)

Previous research on cognitive radios proposed the usage of several machine learning and optimization algorithms, which mainly focused on spectrum sensing for terrestrial wireless communications systems. Based on the adoption of adaptive payloads in satellite systems, cognitive radio approaches are beginning to become feasible. In this poster, we explore the use of temporal multi-objective optimization techniques using software-defined radio adaptive parameter configurations for satellite communications. This work is sponsored by the CAPES program of the Brazilian Government. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

Network Simulations for Vehicular Networking

Renato Iida (WPI), Le Wang (WPI), Alex Wyglinski (WPI)

The current WAVE implementation inside the NS-3 creates and send the BSM messages. However, the message is a blank frame with predefined size. In this poster, we present our initiat findings to extend this model to handle the real information defined in SAE J2735 to evaluate the performance of the scenarios addressed uniquely by vehicle-to-vehicle communications defined in DOT HS 812 014. This work is sponsored by the Mathworks and the CAPES program of the Brazilian Government. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

Indoor Positioning using SDR-Based Visible Light Communications

Jean-Michel Jamesy (Boston University), Consuelo Morleo (Boston University), Emily Lam (Boston University), Michael Rahaim (Boston University), Thomas D.C. Little (Boston University)

For this project, we explore the use of visible light radiated from light emitting diodes (LEDs) and received by a photodiode for indoor positioning. We implemented this indoor positioning system on a Software Defined Radio (SDR) platform, where the signal processing operations are performed on a general purpose processor (GPP) and the signal acquisition and digital to analog and analog to digital conversions are performed on programmable hardware. The SDR platform provides the system with high flexibility and modularity regarding a pure hardware-based implementation. This allows the system to evolve and improve with future enhancements without requiring a long development time. Our system is divided in two subsystems: 1. A hardware subsystem consisting of an Avalanche Photodiode (APD), four driver circuits, and two Universal Software Defined Radio (USRPs); 2. A software subsystem consisting of two personal computers using GnuRadio for signal processing. The presented system incorporates a positioning algorithm that uses Received Signal Strength (RSS) to perform triangulation, which finds the receiver's position by taking the least square fit. RSS is low cost, requires minimal hardware, and maintains good positioning accuracy. Simulation results show that this visible light positioning (VLP) system has positioning errors of around 0 centimeters within the entire test desk surface, when a photodiode with a Field of View (FOV) of 90° is applied. On the other hand, practical results show position errors less than 20 cm when a photodiode with a FOV of 65° is used.

Neural Networks-Based Modulation Classification

Jessica Marshall (Cooper Union), Sam Keene (Cooper Union)

We study the application of convolutional neural networks to the problem of modulation classification. We compare the efficacy of radio modulation classification using simulated data as well as real data generated with software-defined radios. Using a MATLAB model, we generated OFDM with BPSK, QPSK, 16QAM, and 64QAM modulated subcarriers at SNRs ranging from 0 - 20 dB. This data was used to train a deep neural network in tensorflow. Subsequent testing resulted in a test error of .0026 for the simulated dataset at 0 SNR. Similar OFDM data was transmitted and received via USRP N200's. The received data was used to train and test the same network, resulting in a test error of .3442.

Fast RLS Algorithm for Digital Pre-Distortion of OFDM Transmissions

Srikanth Pagadarai (WPI), Rohan Grover (ORB Analytics), Samuel J. MacMullan (ORB Analytics), Alex Wyglinski (WPI)

Due to the high peak-to-average-power ratio (PAPR) of orthogonal frequency division multiplexing (OFDM)-based IEEE 802.22 signals, the power amplifier (PA) in the transmitter RF chain is operated in its saturation region, causing signal clipping and hence, spectral leakage in the adjacent channels. To combat this issue, we demonstrate a GNU-Radio based implementation of a novel, computationally fast RLS algorithm for digital predistortion (DPD) of the PA such that the RF mask is complied with. This work is sponsored by the US National Science Foundation. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

Optimizing Detection of UAS Signals

Jonathan Peck (Gryphon Sensors, LLC), Eric Lentz (Gryphon Sensors, LLC)

Unmanned Aircraft Systems (UAS), commonly known as drones, are increasing commonly found in the air around us. Locating UAS within the airspace is critical for safe integration of UAS into the airspace and security. Many sensors that are capable of locating UAS have difficulty differentiating between drones and other small objects in the air such as birds. Spectrum sensing can be used as a solution to this problem. UAS and related equipment emit signals for command and control, video, and telemetry data. This poster presents a series of detection methods for UAS signals. Each detection method is appropriate to the level of a prior knowledge of the waveforms transmitted.

Energy detection, a method commonly used by cognitive radios, is most appropriate if there is little or no knowledge of the signal transmitted by the UAS. A matched filter (correlator) is the optimal detection method if the spectrum sensor has complete knowledge of signal transmitted by the UAS. These are the extremes of detection methods. Through proper analysis and characterization, the amount of knowledge of transmitted waveforms is somewhere in between these two extremes. As the knowledge of the signal increases, different detection methods are available.

Furthermore, for any particular UAS signal, the knowledge of frequency domain signal characteristics may be greater than time domain characteristics, or vice versa. Detection methods can either be implemented in the time domain or frequency domain, and should be implement in whichever domain there exists a greater understanding of the signal. For example, if the spectral shape of the signal is well known, but it is unknown if there is any periodic time domain data, such as training data, then a correlation detector (matched filter) implemented in the frequency domain is the optimal detector. On the other hand, if the spectral characteristics are more random, but signal contains periodic data, such as training data or cyclic prefix, then time domain detection methods are better.

This poster explores the relationship between knowledge of UAS signals and optimizing detection performance by employing different detection methods, implemented in either the time or frequency domain, to capitalize on the knowledge of the signals.

Prototype Bidirectional Transceiver SDR Implementation of IEEE 802.11b Standard

Ramanathan Subramanian (Northeastern), Benjamin Drozdenko (Northeastern), Eric Doyle (Northeastern), Rameez Ahmed (Northeastern), Miriam Leeser (Northeastern), Kaushik Chowdhury (Northeastern)

Software defined radio (SDR) allows unprecedented levels of flexibility by transitioning the radio communication system from a rigid hardware platform to a more user-controlled software paradigm. However, it can still be time consuming to design and implement such SDRs as they typically require thorough knowledge of the operating environment and a careful tuning of the program. In this work, we describe a systems contribution concerning the design of a bidirectional transceiver that runs on the commonly used USRP® platform and implemented in MATLAB® using standard tools like MATLAB CoderTM and MEX to speed up the processing steps. We outline strategies on how to create a state-action based design, wherein the same node switches between transmitter and receiver functions. Our design allows optimal selection of the parameters towards meeting the timing requirements set forth by various processing blocks associated with a DBPSK physical layer and CSMA/CA/ACK MAC layer so that all operations remain functionally compliant with the IEEE 802.11b standard for the 1 Mbps specification. The code base of the system is enabled through the Communications System Toolbox TM and incorporates channel sensing and exponential random back-off for contention resolution. The current work provides a testbed to experiment with and enables creation of new MAC protocols starting from the fundamental IEEE 802.11b compliant standard. Our system design approach guarantees the consistent performance of the bi-directional link and the three node experimental results demonstrate the robustness of the system in mitigating packet collisions and enforcing fairness among nodes, making it a feasible framework in higher layer protocol design.

RASDR: Radio Astronomy Software Defined Receiver

Bogdan Vacaliuc (Society of Amateur Radio Astronomers), Paul Oxley (Society of Amateur Radio Astronomers), David Fields (Society of Amateur Radio Astronomers), Stan Kurtz (Society of Amateur Radio Astronomers), Tom Crowley (Society of Amateur Radio Astronomers), Wayne McCain (Society of Amateur Radio Astronomers)

The Radio Astronomy Software Defined Receiver (RASDR) is an Open Hardware project undertaken by members of the Society of Amateur Radio Astronomers (SARA) to develop a low cost, high performance software defined receiver for use by SARA members. The receiver tunes between 400MHz and 3.8GHz with an adjustable bandwidth from 1.5MHz to 28MHz and up to 61dB of system gain. RF is downconverted on chip, amplified, filtered and sampled in quadrature at 12-bit using a clock derived from a 30.72MHz TCXO that can be phase locked to an external reference. Connection to the computer is via USB3 at up to 160MB/sec.

RASDR is the *only* software defined radio that supports add-in expansion cards. The design follows the Raspberry PI HAT specification that allows any HAT module to be used with the RASDR base platform. Initial modules supported by the firmware include a GPS module, analog output module with two channel output at 192KHz sampling rate, an RF upconverter module to support 50MHz to 400MHz input and a GPIO connector module.

All of the software, firmware codes, hardware design files and manufacturing information are open source licensed and available on the project's github.com repository. The development team has formed a not-for-profit company to manufacture the receiver at the cost to produce so that educational institutions and amateur radio astronomers may obtain a well-designed and carefully tuned instrument for making astronomical measurements.

Our poster submission can be viewed from this link:
https://drive.google.com/file/d/0B7-l3qmo0KcBNGFGaUhFZkRkVE0/view?usp=sharing

None of the authors will be able to attend the conference, but I can mail a printed poster and handout materials for display at the conference, if appropriate.

MATLAB implementation of MAC for WAVE/802.11p

Le Wang (WPI), Renato Iida (WPI), Alex Wyglinski (WPI)

In this poster, we present an investigation of the protocol stack used in DSRC frequency band is WAVE/802.11p. This standard demands more features in the MAC layer like QoS, HCF and multichannel, thus providing more opportunities for optimization on MAC layer using those features. In this work, we will utilize MATLAB as verification tool with respect to the optmization of those platforms using this standard, including SDR-based systems. This work is sponsored by the Mathworks and the CAPES program of the Brazilian Government. For more information about this and other research activities conducted at WPI's Wireless Innovation Laboratory, please visit http://www.Wireless.WPI.edu.

SDR-Based RADAR Solution

Jingzhi Yu (Northeastern)

Existing architecture and hardware designs of software defined radio (SDR) platforms on market result in high cost and big size with large power consuming. The considerable monetary investment does not guarantee the real-time performance for demonstrating the idea of cognitive radio networks working from hundreds of MHz to even several GHz using by academy and military due to their processing delays. They also cannot support high sampling rate with high resolutions. Most importantly, they do not support very high carrier frequencies and therefore their applications are limited to be used in extensive detection and imaging areas. Their limited frequency band not only blocks various advantage of wave propagation properties of high frequencies, such as directional and reflectivity, but also isolates itself from an important inexpensive option of waves. Recently issued IEEE 802.11ad and IEEE802.15.3c standards admit high frequency wave of 60GHz to be the solution of reducing network link cost. This authentically approves promising prospect of applying SDR into traditionally expensive areas of detection and imaging. However, higher frequency demands higher sampling frequency analog-to-digital converter (ADC). Currently, ADC chip costs from $30 to $1000 as frequency increases to gega level. It means hardware investment will increase significantly with ADC cost. It leads to unfortunate consequence that using 60GHz does not benefit the public but only reduces link cost at the expense of further investment on hardware by end users. To solve this issue and allow more people to access, this paper proposes an inexpensive and real-time very high frequency self-defied radio solution for expensive radar system and enables its capacity on traditional expensive detection and imaging application areas.

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Since 1976, National Instruments has equipped engineers and scientists with tools that accelerate productivity, innovation, and discovery. NI's graphical system design approach provides an integrated software and hardware platform that simplifies development of any system that needs measurement and control. Engineers and scientists use this platform from design to production in multiple industries, advanced research, and academia. The company's long-term vision and focus on improving society through its technology has led to strong, consistent company growth and success of its customers, employees, suppliers, and shareholders.

Ettus Research™, a National Instruments (NI) company since 2010, is the world's leading supplier of software defined radio platforms, including the Universal Software Radio Peripheral (USRP™) family of products. With a low overall system price, expansive capabilities, and software availability, USRP products are used by thousands of engineers worldwide and remain the top choice in software defined radio hardware for algorithm development, exploration, and prototyping.

MediaTek is a pioneering fabless semiconductor company, and a market leader in cutting-edge systems on a chip for wireless communications, HDTV, DVD and Blu-ray. MediaTek created the world's first octa-core smartphone platform with LTE and our CorePilot technology released the full power of multi-core mobile processors. MediaTek [TSE:2454] is headquartered in Taiwan and has offices worldwide.

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SDR-Boston

Boston SDR User Group

A community within the New England area that possesses members from academia, industry, and government who are involved in the design and implementation of software-defined radio (SDR) technology in order to advance the current state-of-the-art in wireless communication systems and networks.