10th Annual

New England Workshop on Software Defined Radio (NEWSDR 2020)

12 August 2020

Virtual Event

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#NEWSDR

Greetings!

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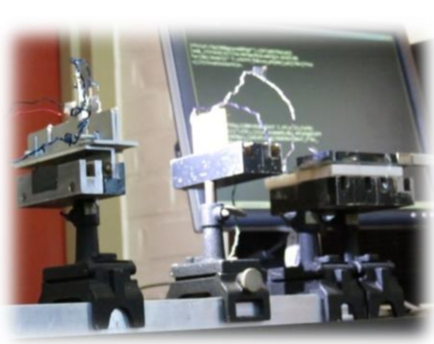

We are very excited to welcome all of you to the 10th New England Workshop on Software Defined Radio (NEWSDR 2020), an annual event organized by the Boston SDR User Group (SDR-Boston). Due to the global health crisis of the COVID-19 pandemic, this year's NEWSDR event is being conducted entirely online to ensure everyone's safety while the community comes together to share the latest developments in SDR and Cognitive Radio research conducted by individuals from academia, industry, and government in the New England area, as well as from across the Nation.

To support this online collaborative environment, NEWSDR 2020 will include the following online sessions:

- Short technical presentations by our NEWSDR 2020 sponsors
- Keynote presentation by Dr. Tom Rondeau (DARPA)
- Virtual booths for each of our NEWSDR 2020 sponsors
- Community spotlight talks and virtual posters
- Three fireside chats one the topics of spectrum coexistence, Internet-of-Things, and open source software
- Evening tutorial sessions with several of our NEWSDR 2020 sponsors

We would like to sincerely thank the generous support of the NEWSDR 2020 sponsors: MathWorks, NI/Ettus Research, Analog Devices, MediaTek, Lynk, and Verizon.

Throughout 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 2020 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 – Wednesday 12 August 2020

9:00 AM – 9:15 AM	Welcome Address
9:15 AM – 10:15 AM	Sponsor Session 1: Analog Devices (#adi) MathWorks (#mathworks) National Instruments/Ettus Research (#ni) MediaTek (#mediatek)
10:15 AM – 10:30 AM	Q&A
10:30 AM – 11:15 AM	Keynote Talk: Dr. Tom Rondeau (#trondeau)
11:15 AM – 11:45 AM	Sponsor Session 2: Lynk (#lynk) Verizon (#verizon)
11:45 AM – 12:00 PM	Q&A
12:00 PM – 1:00 PM	Lunch & Sponsor Virtual Tables
1:00 PM – 2:00 PM	Community Spotlight Talks
2:00 PM – 2:30 PM	Community Spotlight Virtual Poster Session
2:30 PM – 3:00 PM	Fireside Chat 1: “Spectral Coexistence: What is its future in the US?” (#fsc1)
3:00 PM – 3:30 PM	Fireside Chat 2: “A Software-Defined Wireless Communications Network Research Infrastructure for the Internet of Things (IoT)” (#fsc2)
3:30 PM – 4:00 PM	Fireside Chat 3: “Open-Source Software in Software-Defined Radio” (#fsc3)
4:00 PM – 4:15 PM	Closing Comments, Adjournment
5:00 PM – 7:00 PM	Sponsor Tutorial Sessions (Reserved)

Keynote Presentation: Dr. Tom Rondeau

Tom Rondeau is a DARPA program manager with a focus on adaptive and reconfigurable radios, improving the development cycle for new signal-processing techniques, and exploring new approaches and applications with the electromagnetic spectrum. Prior to joining DARPA, Tom was the maintainer and lead developer of the GNU Radio project, a visiting researcher with the University of Pennsylvania, and an Adjunct with the IDA Center for Communications Research in Princeton, NJ.

Fireside Chats

Chat 1: "Spectral Coexistence: What is its future in the US?"

Philip Erickson (MIT Haystack Observatory)
Tim Fisher-Jeffes (Mediatek)
Dola Saha (University of Albany)
Moderator: Alex Wyglinski (Worcester Polytechnic Institute)

The 6 GHz band recently made unlicensed by US regulatory agencies in April 2020 has resulted in several challenges across different spectrum stakeholders, potentially increasing the level of tension among these different communities. For this fireside chat, we have brought together several of these stake holders to discuss this and other changes to the regulation of the electromagnetic spectrum.

Chat 2: "A Software-Defined Wireless Communications Network Research Infrastructure for the Internet of Things (IoT)"

Song Han (University of Connecticut)
Brian Kelley (University of Texas at San Antonio)
Matthew Knight (Agitator)
Moderator: Yousof Naderi (Northeastern University)

Industry 4.0 is entirely dependent on reliable connectivity within the manufacturing ecosystem, including technologies such as Internet-of-Things and 5G. This fireside chat will bring together the latest perspectives and discuss advances in this emerging area, and show how software-defined radio prototyping and design can help push the current state-of-the-art to explore new ways of performing complex tasks in this new industrial revolution.

Chat 3: "Open-Source Software in Software-Defined Radio"

Pau Closas (Northeastern University)
Fraida Fund (NYU Tandon School of Engineering)
Juha Vierinen (University of Tromso)
Moderator: John Swoboda (MIT Haystack Observatory)

The software-defined radio community has embraced many of the tenets of the open-source software movement. This has helped create many of the standard tools in the community and also has helped lower the barrier to entry. The speakers in this session have all contributed to this community through their open-source projects. They can offer their insight and perspectives on the future of open-source software in the SDR community.

Evening Tutorials

Deploying 5G NR Wireless Communications on SDR: A Complete MATLAB and Simulink Workflow

Jing Ma (MathWorks)

Algorithmic innovation drives progress in wireless communications, enabling advances in personal connectivity, space and satellite communications, high-reliability automated driving systems, and the Internet of Things (IoT). Designing, implementing, and testing these systems requires close collaboration across multiple disciplines. Deploying algorithmic models to FPGA hardware makes it possible to do over-the-air testing and verification. Automatically generating HDL code directly from the system-level algorithms and models eliminates the need for engineers to rely on specification documents or manually architect and write code. This presentation demonstrates the process of converting MATLAB® algorithms and Simulink® models directly into HDL for FPGAs: Topics include:

(a) 5G New Radio (NR) standard-compliant algorithmic modeling with MATLAB and 5G Toolbox™,
(b) Transitioning from a frame-based MATLAB algorithm to a streaming Simulink implementation,
(c) Fixed-point implementation using Fixed-Point Designer™ and target hardware knowledge,
(d) Speeding design by using proven intellectual property (IP) blocks,
(e) Generating HDL and deploying on SDR platform, in this case a Xilinx® Zynq® device with Analog Devices AD9361/AD9364 radio.

A 5G NR cell search design is used to illustrate the process. MathWorks originally created this design to meet critical customer requirements. The design has evolved into a reference application that is available with Wireless HDL Toolbox™. This workflow also uses 5G Toolbox and HDL Coder™.

FPGA Programming on the USRP using the RFNoC Framework

Jonathon Pendlum (NI/Ettus Research), Neel Pandeya (NI/Ettus Research)

Ettus Research's RFNoC (RF Network-on-Chip) software framework is designed to decrease the development time for experienced FPGA engineers seeking to integrate IP into the USRP FPGA signal processing chain. RFNoC is the framework for USRP devices that use Xilinx 7-series and Zynq FPGAs (E310, E312, E320, X300, X310, N300, N310, N320, N321). 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 user-defined RFNoc blocks, which are processing blocks that attach to this network. RFNoC blocks act as independent nodes on the network that can receive and transmit data to any other node (e.g., another RFNoC block, the radio block, or the host CPU). Users can create modular, FPGA-accelerated SDR applications by chaining RFNoC blocks into a flow graph. RFNoC is supported in UHD and GNU Radio. In this workshop, we will present an interactive hands-on 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 RFNoC block and integrating the block into GNU Radio.

Prerequisites:

Attendees should have some previous experience with Linux and using the Linux command line, and basic familiarity with a programming language such as C, C++, or Python, and have basic understanding of fundamental concepts in DSP and RF. Attendees should also have some basic familiarity with Verilog. Extensive or deep experience with these topics is not necessary.

Poster Presentations

P01: Evolving LTE Security Via Software-Defined Radio Test-Bed

YaYa Brown, Julien Ataya, Matthew Farah, Cynthia Teng, Kuldeep S. Gill, Alexander M. Wyglinski (Worcester Polytechnic Institute)

We present an LTE testbed using software-defined radios that can be used to test potential vulnerabilities to cellular technologies. The dependency and prevalence of mobile technology has started to raise questions regarding security concerns. At the physical layer, malicious users could cause Denial of Service (DoS) using jamming attacks which could significantly affect the network by disrupting connectivity to many of its users. In order to gain a better understanding of how these types of attacks affected mobile usage in cellular networks, an LTE test-bed is implemented using software-defined radio (SDR) technology and the open source software environment OpenAirInterface (OAI) to study under real world conditions how jamming and cellular networks interact with each other and their effects on mobile communications. The implementation of the proposed test-bed as well as a sample use-case in which an LTE signal was jammed is the focal point of the project.

P02: Multi-Object Localization of Signals of Opportunity Under Ambiguity Using Unsupervised Learning

Kyle McClintick, Jeffrey Tolbert, Faith Kurtz, Alexander Wyglinski (Worcester Polytechnic Institute)

Comprehensive Situational Awareness (SA) in mixed traffic environments (i.e., both autonomous and human-operated platforms) is a critical requirement in addressing some of the challenges that hinder the deployment of autonomous vehicle (AV) systems onto roadways.

In this paper, a novel framework that leverages unsupervised learning techniques for utilizing Signals of Opportunity (SoO) for robust localization of all vehicles operating along a stretch of roadway is presented. By making use of ubiquitous wireless emissions from vehicles, the presented approach performs vehicle localization without any active participation/assistance from vehicles thus making it a suitable candidate for SA in mixed traffic environments. The method is demonstrated in a 2D RSSI multilateration experiment making use of Tire Pressure Monitoring System (TPMS) as an SoO.

P03: Testing and Fingerprinting the Physical Layer of Wireless Devices with Software-defined Radios

David Starobinski, Johannes K. Becker, Stefan Gvozdenovic, Liangxiao Xin (Boston University)

Performance characteristics of wireless devices are fundamentally influenced by their vendor-specific physical layer implementation. In this research, we propose a new testbed architecture for benchmarking and fingerprinting the physical layer of wireless devices. The testbed allows tight control of timing events, at a microsecond time granularity, and is capable of accessing and measuring physical layer protocol features of real wireless devices, which allows to fingerprint the device type with high accuracy. The key novelty of this architecture resides in emulating parts of the channel environment (including interference from other users) within a software-defined radio (SDR) toolchain. The testbed reduces the complexity and expense required to conduct high-precision physical layer performance benchmarking, while leveraging the precise time synchronization and parameter control within the SDR to enable consistent and reproducible testing results.

We demonstrate the testbed capabilities by comparing the behavior and performance of Wi-Fi and Zigbee cards from different manufacturers under precisely controlled physical layer testing conditions. First, we show that the cards exhibit noticeable differences in their receiver sensitivity (i.e., the lowest power level at which they can detect and demodulate RF signals). Next, we show how device types can be fingerprinted based on chipset-specific implementations. In particular, our results indicate distinct device responses to precisely crafted packet collision scenarios as well as so-called "truncated packets" that the testbed allows us to craft. Finally, based on a similar approach of packet truncation, we demonstrate that many IoT devices are vulnerable to stealthy, physical layer-based starvation attacks.

P04: Hardware Architecture of MIMO Matrix Processor for SDR

Jieming Xu, Miriam Leeser (Northeastern University)

Massive Multiple In and Multiple Out (MIMO) is being used in the fifth generation of wireless communication systems. As the number of antennas increases, the computational complexity grows dramatically, and this involves matrix calculations with complex numbers. The traditional software based matrix processing cannot meet the requirement of real-time wireless communication. In order to accelerate the matrix processing, we designed and implemented a general matrix arithmetic processor in hardware. The matrix arithmetic processor includes matrix multiplication, Singular Value Decomposition (SVD), and QR decomposition. The design can be implemented in fixed-point or single-precision floating-point depending on the requirements of the application. The system behavior can be controlled by instructions such as elementary multiplication, rotation and vector projection, which allows the system to work as a coprocessor in a baseband System on a Chip (SoC). The whole system is developed using MathWorks Simulink which simplifies the design for wireless communication researchers. The design is implemented and verified on the Xilinx RFSoC development board using fixed point and single precision floating point numbers. Acceleration of the SVD algorithm is up to two orders of magnitude. The design can be used in the SDR community to speed up the processing time and development period. We plan to open source the Simulink design on Mathworks central.

P05: Weather Sensor Monitoring & Dashboard

Andrew Rivett (QRUQSP.org)

Building an open source platform for capturing 433mhz weather sensors via RTL-SDR and custom monitoring dashboard.

P06: Software Defined Global Navigation Satellite Systems and Resilient Navigation for Embedded Automation

Jeffrey Wallace (Rocket Technology Systems, LLC), Douglas Kirkpatrick (Eridan Communications, Inc.), Dubravko Babic (Eridan Communications d.o.o), Srdjan Kovacevic (Orqa d.o.o)

The current generation of navigation devices used on everything from robotic systems, various crewed vehicles – aircraft, watercraft, and spacecraft – integrate global navigation satellite systems (GNSS) with inertial navigation systems (INS) or measurement units (IMUs). The ubiquitous and continuous need of advanced automation and robotics for accurate and precise positioning, navigation, and timing (PNT) data require a resiliency beyond what this capability can deliver, considering the ease with which GNSS signals can be jammed and spoofed without advanced technology measures that also consume size, weight, power and cooling/cost (SWaP-C) resources. Advances in hardware such as software defined radios (SDRs) and single board computers (SBCs) enable virtualization of both GNSS and navigation systems that address the shortcomings of today's technology, allowing the emergence of resilient software defined GNSS and navigation systems for embedded automation. Our approach enables multiple communication and navigation systems to share SDR resources, which can significantly improve the mission capabilities of a platform. The F-35 is used as an example whereby multiple radio and navigation systems can be consolidated, leading to critical SWaP-C improvements that solve long-standing operational challenges in the modern battlespace.

P07: A Software Defined Radio Based Real Time Baseband Processing Platform for Wireless Communication Research

Suranga Handagala, Miriam Leeser (Northeastern University)

Using software defined radios (SDR) for wireless communication studies is increasingly becoming popular. They provide the convenience and flexibility for researchers to prototype complex systems. SDR hardware and software tools are well established. However academic researchers do not usually fully make use of the power of such tools. In this work, we leverage modern SDRs to create a test platform to experiment with waveforms in the sub-6 GHz spectrum. The purpose of this platform is to bridge the gap between algorithms/simulations and actual physical hardware by providing hardware and software configurations that support deployment and validation of algorithms for real world applications. Our platform supports real time receiver side baseband processing of orthogonal frequency division multiplexing (OFDM) based over-the-air (OTA) signals using a field programmable gate array (FPGA), when natural impairments are present. We have used multiple Xilinx ZC706 and ADI FMComms3 evaluation platforms for transmitter, interferer and receiver functions. We setup OTA links between the transmitter and receiver to operate at 3.5 GHz carrier frequency. In the receiver baseband, we implemented an accurate channel estimation and equalization technique from which we were able to demodulate higher order modulated signals such as 256 and 1024 quadrature amplitude modulation (QAM) with error vector magnitude (EVM) values that are comparable to those in standards. We added extra functionality to this baseline platform to characterize effects of power amplifier (PA) nonlinearities by including NXP's BGA7210 PA in the transmitter chain and measured how receiver side EVM and the constellation shape is affected when PA gain is increased. In addition, we used spectral shaping methods at the receiver to suppress adjacent channel asynchronous interference, and we show that the effects of high power interference on the received signal constellation can be mitigated by using sharp roll-off filters even when the guard band size is only a few subcarriers.

P08: Advanced Receiver for IEEE 802.15.4 OQPSK Physical Layer

Evan Faulkner, Zelin Yun, Shengli Zhou, Zhijie Shi, Song Han, Georgios Giannakis (University of Connecticut)

We have developed and implemented in GNU Radio an advanced receiver for the IEEE 802.15.4 OQPSK physical layer which uses attains a 6dB power improvement over the existing GNU Radio implementation. Whereas the previous implementation utilizes a noncoherent decoding scheme which treats the waveform as MSK, our receiver is a coherent one which also includes decision directed equalization and alternative synchronization strategies to achieve greatly improved performance. Our GNU Radio implementation is being polished for release for use by the community.

P09: Team MarmotE: lessons learned from the DARPA SC2

Miklos Maroti, Peter Horvath, Sandor Szilvasi, Peter Volgyesi (University of Szeged, Hungary)

We discuss our experiences with machine learning based spectrum sharing during the 3-year DARPA Spectrum Collaboration Challenge. We will briefly discuss the competition framework, our system architecture and how we envision machine learning to be used in the future.

P10: Self-Optimized Irrigation Based on the Internet of Things in the Sahel Region

Fatoumata Thiam (University Gaston Berger & Worcester Polytechnic Institute), Alexander Wyglinski (Worcester Polytechnic Institute), Maissa Mbaye (University Gaston Berger)

We propose to build techniques that will facilitate water access and preserve that resource in our dry region threatened by the scarce rainfall, and unpredictable nature. We aim to figure out the irrigation paradigm in Niayes and propose a solution that seeks to optimize and automate the irrigation systems using the Internet of Things (IoT) and Artificial Intelligence (AI). Identify the relevant parameters for optimizing irrigation. Most importantly, we present a survival analysis of A-IoT networks. Reliability requirements are essential in a wireless sensor network (WSN). The framework, we presented considers two different network sizes. The goal of is to: (i) motivate and show the importance of reliability in A-IoT systems, particularly and (ii) propose a technique of reliability evaluation. We've proposed a novel operation-based reliability framework that depends on energy consumption which is a consequent cause of node failure.

P11: EEFFAH: Energy-Efficient, Fault-tolerant, Fault-avoidance, Adaptive and Heterogeneous Clustering-based Agric-IoT network

Emmanuel Effah (University Gaston Berger & Worcester Polytechnic Institute), Alexander Wyglinski (Worcester Polytechnic Institute), Ousmane Thiare (University Gaston Berger)

This research focuses on multi-objective optimization (MOO) of clustering-based routing protocols for Agricultural Internet of Things (A-IoT) networks from three main perspectives namely fault management (FM) (fault detection-FD, fault tolerance-FT, and fault avoidance-FA), power optimization, and network adaptability to varying topological dynamism, network size and node density. A-IoT is at the core of smart or precision farming for enabling resource optimization, farm monitoring and automation via a variety of wirelessly-connected electronic devices called sensor nodes (SNs), systems and platforms. Many of these devices (SNs) are frequently powered by batteries which constrains their data transmission rate, computational capabilities, and communication distance, and are densely deployed in hostile environments to operate autonomously without post-deployment maintenance services. Consequently, several key challenges of A-IoT networks include high vulnerability to faults and failures, high susceptibility to topological turbulence, and power optimization issues which greatly hinder the operational efficiencies of these networks. These issues are frequently addressed via the associated routing protocol which moderates the core tasks of the SNs (sensing, computation and communication). Specifically, this study proposes a novel, adaptive clustering-based event routing approach that is based on a proposed MOO-framework, energy-efficient multihop routing framework, and FM techniques to effectively address challenges related to network energy losses, fault management, network scalability/adaptability, and event monitoring accuracy/precision.

This study uniquely provides a holistic remedy to the principal hindrances to the efficient operation of A-IoT technology to advance the socio-economic impacts of the Agricultural sector. The sample simulation results which is yet to be verified in real-world experiments showed better performance relative to the state of the art in terms of network power optimization, network/coverage stability periods, network adaptability to scalable or topological dynamism and efficient fault management.

Our theoretical frameworks are also expected to leveraged the existing gap between the philosophy of clustering-based A-IoT (CA-IoT) networks and practice, which is imperative for the smart world agenda.

P12: Fully-Digital Beamforming Demonstration with Pi-Radio mmWave SDR Platform

Aditya Dhananjay, Marco Mezzavilla (NYU Tandon School of Engineering)

Pi-Radio's vision is to democratize wireless research by providing advanced mmWave Software Defined Radio (SDR) platforms to the community at plainly affordable price points. Pi-Radio's v1 SDR features a 4-channel fully-digital transceiver that operates in the 57-64 GHz band. Fully-digital (a.k.a. MIMO) transceiver architectures enable multiple simultaneous TX/RX beams, standing in stark contrast with phased arrays featuring analog beamformers that are capable of transmitting/receiving only one beam at a time. This opens up a whole set of research problems to work on, across virtually every layer of the protocol stack. In this demo, the team will: (1) prove the correct formation of different TX/RX beams by applying geometrically determined beamforming weights, and (2) prove the benefits of fully-digital beamforming by transmitting four independent streams of data with an OFDM-based physical layer.

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Verizon Communications Inc. (NYSE, Nasdaq: VZ) was formed on June 30, 2000 and is celebrating its 20th year as one of the world's leading providers of technology, communications, information and entertainment products and services. Headquartered in New York City and with a presence around the world, Verizon generated revenues of $131.9 billion in 2019. The company offers voice, data and video services and solutions on its award-winning networks and platforms, delivering on customers' demand for mobility, reliable network connectivity, security and control. Verizon was the first company in the world to launch a commercial 5G mobile network with a commercially-available 5G-enabled smartphone. The company's operating structure focuses on three customer-facing areas: Consumer, Business and Media.

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. Find out more about SDR-Boston at our website: **http://www.sdr-boston.org**