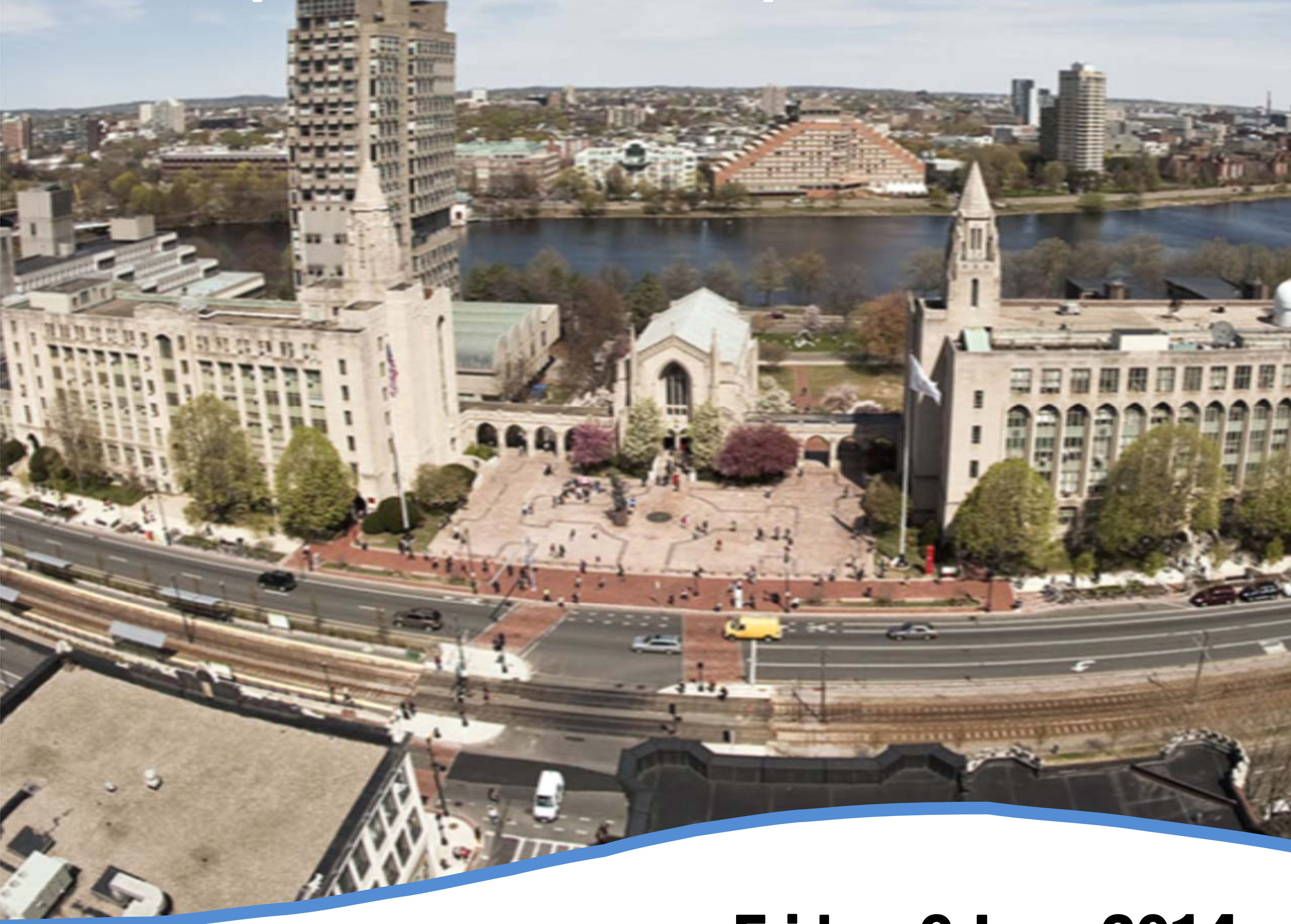
4th Annual

New England Workshop on Software Defined Radio (NEWSDR 2014)



Friday, 6 June 2014

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Welcome

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The 2014 New England Workshop on Software Defined Radio (NEWSDR) is the fourth installment of an annual series of workshops organized by the Boston SDR User Group (SDR-Boston).

The first NEWSDR event was held on Saturday 1 October 2011 at Boston University (BU), the second NEWSDR event was held at Northeastern University (NU) on Friday 11 May 2012, and the third NEWSDR event was held at Worcester Polytechnic Institute (WPI) on Friday 17 May 2013. This year, we are very excited about having Boston University generously serving as the host institution for NEWSDR 2014; the 9th floor of the Photonic Building 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 2014 will include:

- Keynote and invited talks on the latest in SDR
- Technical oral and poster presentations
- Technology demonstrations
- Industry panel session
- Free parking / 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 2014 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!

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Keynote Presentation

Challenges and Opportunities in SDR for Spectrum Sharing

Dr. Jeffrey H. Reed, Virginia Tech

Abstract – Spectrum sharing is the most significant paradigm change for managing spectrum in decades. In the US, the President's Council of Advisors in Science and Technology (PCAST) recently recommended that nearly 1GHz of federal spectrum be made available for spectrum sharing with commercial systems. The FCC has issued a Notice of Proposed Rule Making (NRPM) to begin executing this new approach to allocating spectrum in which commercial and military systems share spectrum. While making spectrum available through sharing could provide a significant boost to innovation and economic growth, its success is dependent on providing practical implementation through Software Defined Radio. This presentation provides a technical description of the spectrum management vision proposed by PCAST and the FCC and the challenges that SDR faces to enable this vision. These challenges are discussed along with a sampling of SDR research at Virginia Tech which address these challenges.

Biography – Dr. Jeffrey H. Reed currently serves as Director of Wireless @ Virginia Tech. He is the Founding Faculty member of the Ted and Karyn Hume Center for National Security and Technology and served as its interim Director when founded in 2010. His book, Software Radio: A Modern Approach to Radio Design was published by Prentice Hall. He is co-founder of Cognitive Radio Technologies (CRT), a company commercializing of the cognitive radio technologies; Allied Communications, a company developing technologies for 5G systems; and for Power Fingerprinting, a company specializing in security for embedded systems. In 2005, Dr. Reed became Fellow to the IEEE for contributions to software radio and communications signal processing and for leadership in engineering education. He is also a Distinguished Lecture for the IEEE Vehicular Technology Society. In 2013 he was awarded the International Achievement Award by the Wireless Innovations Forum. In 2012 he served on the President's Council of Advisors of Science and Technology Working Group that examine ways to transition federal spectrum to allow commercial use and improve economic activity. Dr. Reed is a member CSMAC a group that provides advice to the FCC on spectrum issues.

Invited Presentations

SDR Sentimental Journey – 20 Years and Still in the Making

Dr. Zoran Zvonar, MediaTek Wireless

Abstract – Looking back into 20 years of my career is looking back into two fascinating decades of SDR technology. The first one was dominated by rapid development of enabling technologies with the focus on performance. The following decade commercialized these SDR concepts for the most competitive wireless communication market. Through the talk, examples from cellular industry will be used to illustrate the progress. The last part of the presentation will address emerging trends and will outline challenges of SDR based solutions for the next decade.

Biography – Zoran Zvonar, FIEEE, is the Director of Engineering and MediaTek Fellow. He received the Dipl. Ing. and M.S. degree University of Belgrade, Serbia, and the Ph.D. degree Northeastern University, Boston. 1994-2008 he had pursued industrial career within Analog Devices (ADI). He was a member of the core development team for ADI's baseband platform and direct conversion transceiver wireless product families, and has been a recipient of the company's highest technical honor of ADI Fellow. Since January 2008, he is with MediaTek focusing on the design of algorithms and architectures for cellular standards, with applications to integrated chip-set solutions and real-time software.

The GNU Radio Ecosystem

Dr. Tom Rondeau, Rondeau Research LLC

Abstract – In this talk, the speaker will provide a history of the GNU Radio framework, discuss its current status and capabilities, and then present a roadmap of future development.

Biography – Tom Rondeau holds a Ph.D. in Electrical Engineering from Virginia Tech. While pursuing research in optimization theory for cognitive radio, it quickly became obvious that software radio, the key technology required to enable the kind of flexibility and adaptation we are striving for, didn't yet exist. Since then, Tom has been heavily involved in the GNU Radio project, an open source software radio platform, as a means of improving the flexibility and dynamics of available communications platforms. Through this project, he tries to explore new modes and methods for communicating as well as build a robust, efficient, and useful tool to enable new insights and ideas for developers and students alike.

Tom worked as a postdoctoral research engineer with CTVR, Trinity College Dublin from 2007 to 2008 looking into software and cognitive radio. He currently runs the GNU Radio project and is heavily involved in both the development of the project through his consulting firm Rondeau Research, LLC as well as using it to continue his research as a visiting scholar with the University of Pennsylvania.

Tom currently lives in Shelburne, VT where he works, reads, writes, and spends time with his many cats.

Industry Panel Presentations

Plumbing and Pipefitting for Software Defined Radio Applications

Mr. Robin Getz, Analog Devices, Inc.

Abstract – In order to make applications like cognitive radio function at all, there is a massive amount of base infrastructure required before anyone can attempt to develop the interesting/channeling aspects of these sorts of applications. While everyone likes to work on and talk about digital modulation, MAC layers , physical and logical addressing, or things like path determination, there are a lot of inter related pieces in a reconfigurable/software defined radio that must be complete before any of the fun work can start. In this discussion, we will look at the base "plumbing" design that goes into a system level prototyping solution that is necessary to get RF samples to a baseband processor or FPGA and in turn eventually up to MATLAB for algorithmic simulation. This includes a lot of grueling work from teams of developers with very inter disciplinary skills ranging from RF design to digital filter design, to HDL to software. We will peel back the covers, and examine some of this "sweat equity" that everyone uses, ever day, without really realizing it.

Biography – Robin Getz has spent 20 years in the semiconductor industry, and has held a variety of engineering development and support positions. He has worked on a variety of systems both in the power, analog, digital and software domains, with both large and small projects/customers. Robin currently holds the position of Engineering Director for ADI's Global Alliances organization, where he works creating HDL interfaces, and device drivers for ADI's mixed signal IC products. ADI's Global Alliances group was instrumental in releasing the AD9361, single chip transceiver, which is used in many SDR applications, where they worked with Xilinx, Mathworks, and Avnet to ensure a complete prototyping system was available. He holds four patents, and holds a BSc (EE) from the University of Saskatchewan.

Model Based Design for Wireless Prototyping

Dr. Don Orofino, MathWorks

Abstract – SDR continues to gain considerable attention from commercial, academic and maker communities, where the term generally describes characteristics of radio hardware that lend itself to programmability and adaptability. To accelerate the pace of wireless innovation, community focus should turn toward creating workflows that integrate all aspects of the design and verification of wireless systems — one embodiment being the integration of SDR into Model Based Design. That workflow is envisioned and described as Wireless Prototyping.

Biography – Don Orofino is director of engineering for signal processing at MathWorks, where he guides product development across MATLAB and Simulink in support of signal processing, communications, RF modeling, computer vision, robotics, embedded systems, FPGA prototyping and more. With nearly 20 years at MathWorks, he still remembers his previous employment at HP Imaging Systems, and obtaining a PhD in Electrical Engineering from WPI in 1992.

Platform Approach to Design of Next Generation Wireless Systems

Mr. Erik Luther, National Instruments

Abstract – The growing number of wireless devices and scarcity of available spectrum is spurring unprecedented levels of research to design the next generation of wireless systems. Use of software defined radios (SDR) is emerging as a viable way to rapidly prototype custom protocols, analyze performance in real-world environments, and iterate on designs because it closely mirrors the functionality found in real wireless devices with the added flexibility of broader frequency coverage and re-programmable baseband processing. In this talk we discuss the importance of a platform approach to design next generation wireless systems. This approach allows design teams more efficiently utilize new, more advanced hardware and software while shortening time to results with deployment through reuse along the product development, validation, verification and deployment cycle.

Biography – Erik Luther (KF5LTV), SDR Marketing Group Manager, leads the team responsible for marketing National Instruments and Ettus Research Software defined radio products. Since joining NI in 2002, Luther has held positions across applications engineering and product marketing focused on advancing NI design platforms, specifically making prototyping and experimentation more accessible for both research and education. Early in his career, Luther pioneered NI's efforts to support universities with curriculum and textbooks, launching NI's independent textbook publishing arm NTS Press. His accomplishments include the publication of more than 50 textbooks and lab related materials on topics that include RF/communications, DSP, circuit design, and real-time control which have been utilized by more than 100,000 engineering students around the world. Luther is currently Chair for the IEEE ComSoc Resources for Education and Trainers working group focused on establishing teaching best practices and hands-on education resources. Luther graduated from the University of Missouri, Columbia in 2003 with a bachelor's degree in Electrical Engineering.

The Softer Side of SDR

Dr. Yuan Lin, MediaTek Wireless, Inc.

Abstract – The increased SDR adoption in the wireless industry is linked to the new generation of innovative multi-core DSP processors. This generation of DSP processors can achieve impressive performance, but introduces the challenge to the programming model. This results in software solutions that either under-utilize the processors or take longer-than-expected development time. In this talk, I will discuss some of the key challenges in developing high-performance DSP software.

Biography – Yuan Lin is a staff wireless system engineer at MediaTek. He is currently the programming methodology technical lead for MediaTek's SDR-based wireless modem technology. Yuan received a BS in Electrical Engineering from Cornell University, and a PhD in computer engineering from University of Michigan at Ann Arbor. His work in SDR area, A Study in Designing Mobile Supercomputers, was supported by ARM and commercialized by Cognovo Ltd., and received the best paper award in computer architecture in 2008 published in IEEE Micro.

Oral Technical Presentations

CRASH: Cognitive Radio Accelerated with Software and Hardware

Jonathon Pendlum, Miriam Leeser, Frank Bruno, Northeastern University

Abstract – Two key algorithms in Cognitive Radio are spectrum sensing and the spectrum decision. Many spectrum sensing algorithms have inherent parallelism and map well to a Field Programmable Gate Array (FPGA). Conversely, spectrum decision algorithms tend to require more sequential processing and lean towards a software implementation. These processing requirements suggest implementation on a heterogeneous computing system that accelerates parallel algorithms by offloading them to the FPGA fabric while performing sequential processing on the CPU.

Recently, FPGA vendors have released System-on-Chip (SoC) devices that tightly couple programmable logic and a multicore ARM processor. Due to the low latency interconnect, these SoCs show promise as an effective heterogeneous computing system. We have developed CRASH (Cognitive Radio Accelerated with Software and Hardware), a new software and programmable logic framework for Xilinx's Zynq SoC, to explore their potential in accelerating Cognitive Radio. CRASH provides the framework and interfaces to facilitate splitting algorithms between the Zynq's ARM processor and FPGA fabric. We built CRASH on a Xilinx ZC706 Zynq development board and used an Ettus Research USRP N210 software defined radio as the RF hardware. CRASH uses CRUSH's (Cognitive Radio Universal Software Hardware) hardware to directly interface the ZC706 and the USRP. This provides a low latency transmit and receive sample data path that supports the USRP's full sampling rate of 100 Megasamples per second.

To demonstrate CRASH, we implemented the spectrum decision in software and offloaded spectrum sensing to the FPGA fabric using our framework. For comparison, we also created a version with both algorithms in software. We determined the performance of each configuration by measuring the latency in sensing unoccupied spectrum and then transmitting in the spectrum. Compared to the purely software implementation, CRASH's improved processing performance reduced the total system latency (i.e. turnaround time) by 50%.

CRASH creates a low latency, high performance cognitive radio platform that simplifies offloading algorithms to programmable logic. This research shows that heterogeneous computing systems, such as CRASH, can provide cognitive radios substantial processing gains without sacrificing programmability.

Interfacing Hardware and Software in a Software Defined Radio System

Raquel Guerreiro Machado, Alexander M. Wyglinski, Worcester Polytechnic Institute
Robin Getz, Analog Devices

Abstract – To resolve the issue of continuously installing and maintaining the telecommunications infrastructure required by the fast-evolving radio standards, configurable radio technologies such as software defined radio exhibit significant potential to accommodate the current and future needs of society with respect to agile wireless connectivity and cost-effective deployment. Recently, Analog Device developed a radio frequency (RF) front-end (RFFE), the FMCOMMS1 board, that can potentially decrease the barrier between wireless communications and networking research and development and actual prototype implementations using SDR technology. In this work, we present a novel interface architecture designed to enable software connectivity and support for the FMCOMMS1 board via an open source software suite for SDR development called GNU Radio.

Reverse Polarity Optical OFDM for Visible Light Communications

Hany Elgala, Michael Rahaim, Boston University

Abstract – The visible light communication (VLC) technology permits the exploitation of light-emitting diode (LED) based luminaries for simultaneous illumination and wireless data transmission. Optical orthogonal frequency-division multiplexing (OFDM) is a promising modulation technique for direct intensity modulation with direct detection (IM/DD) VLC systems, where the real-valued OFDM signal is used to modulate the instantaneous power of the optical carrier.

A major design challenge that limits the commercialization of VLC is how to incorporate the industry-preferred pulse width modulation (PWM) light dimming technique while maintaining a broadband and reliable communication link.

The proposed reverse polarity optical OFDM (RPO-OFDM) scheme combines the industry-standard dimming technique (PWM) with the highly efficient modulation widely implemented in various communication standards (OFDM). By supporting the PWM dimming format, the new scheme has promise for speeding the adoption of the VLC technology into LED based luminaires.

The RPO-OFDM maps the OFDM signals onto the on and the off periods of the PWM signal through a polarity inversion process. In this case, the data rate and the bit-error performance are maintained with in a wide dimming range of operation. The advantages of using RPO-OFDM include, (1) the data rate is not limited by the frequency of the PWM signal, (2) the LED dynamic-range of operation is fully utilized to minimize the nonlinear distortion of the OFDM signal, and (3) the bit-error performance is sustained over a large fraction of the luminaire dimming range. In addition, RPO-OFDM offers a practical approach to utilize off-the-shelf LED drivers.

A software defined VLC (SDVLC) testbed is realized. Matlab is used to build the RPO-OFDM system model, while Simulink is used to interface with the digital-to-analog conversion (DAC) and analog-to-digital conversion (ADC) cards. The universal software radio peripheral (USRP) from Ettus Research is used. The transmitter frontend incorporates an illumination grade luminaire from Cree Lighting. We realized a real-time SDVLC implementation of the RPO-OFDM modulation techniques for dynamic adaptation to lighting conditions such that the average optical output power is varied to meet illumination requirements. The Matlab based GUI shows in almost real-time, for example, the number of bits in error per OFDM symbol and the estimated complex quadrature amplitude modulation (QAM) symbols.

Multi-Node Software Defined Radio Test-Bed

Travis Collins, Alexander Wyglinski, Worcester Polytechnic Institute

Abstract – Software-defined radio has become a massively growing part of communication systems experimentation and development. To provide development environments for such devices, several software packages have been either extended or written for the sole purpose of SDR development. Unfortunately these tools can be both difficult to master and/or limited in their functionality. To help bridge this gap, our research has utilized the common well known computing environment MATLAB, known to all in the engineering community. This presentation will outline several development paths for software-defined radio development with MATLAB, with the goal of enabling multi-node network level communications. Demonstrations will be provided of multi-radio network level examples, along side cognitive radio research, both utilizing MATLAB with an array of USRP devices. Overall this work presents MATLAB as a simple entry point for those new to SDR, but with enough flexibility to create complex implementations.

Poster Technical Presentations

Next Generation Satellite Communications: Automated Doppler Shift Compensation of PSK-31 via Software-defined Radio

Christopher Anderson, Matthew Lanoue, Jennie Wood, United States Naval Academy

Abstract – Satellite communication systems fall into two broad categories: Amplify and Forward (AF), and Regenerative. AF systems operate as a "bent-pipe" where the information received at the satellite is simply amplified and retransmitted with no alteration of the original signal. In a regenerative repeater, circuitry is designed to demodulate the signal, recover the original information, re-modulate the signal and transmit a new version. Limitations exist in both of these categories: AF systems are unable to compensate for distortion and hardware-defined regenerative repeaters cannot be updated over time.

Software-defined radio (SDR) leverages the processing power of computers to create communications systems that run as flexible software applications, where the radio operating parameters can be set or altered by software. SDR satellite communications systems developed today can run on future hardware platforms and update the applications already running on the satellite. GNU Radio, a framework for creating SDR applications, has recently matured to the point where it can be utilized to develop satellite communications systems.

This project implemented PSK-31, a terrestrial narrowband form of multi-user amateur radio communications for text and simple data messaging, in GNU Radio as part of a as a regenerative satellite repeater. One of the major issues with satellite communications is the Doppler shift experienced as the satellite passes overhead. Demodulating signals affected by Doppler shift requires ground stations with circuits dedicated to track and synchronize with the satellite in order to compensate for the Doppler shift. For the PSK-31 waveform, the amount of Doppler shift exhibited by the satellite would prevent communications using standard receivers.

This project estimates the satellite-to-ground Doppler shift and pre-compensates onboard the satellite to alleviate processing requirements at the ground station. For a particular orbit, the satellite generates a family of possible Doppler shift curves that correspond to all the possible overhead passes the satellite could make with respect to a user. By monitoring communications between users on a particular sub-channel, the software can estimate which curve best matches the Doppler shift experienced by the satellite. The SDR transmitter then uses that information to pre-compensate for the Doppler shift. As a result, the Doppler shift observed at the ground station can be reduced from 10 kHz to less than 10 Hz.

Reconfigurable MAC protocol for GEO Satellite Mobile Communication Systems using Software-Defined Radio

Paulo Victor Ferreira, Alexander M. Wyglinski, Worcester Polytechnic Institute

Abstract – The communication channel for satellite communications systems is a very hostile and dynamic environment for propagating RF signals. The channel covers most part of the Ionosphere including the atmosphere as well and its characteristics vary within some minutes during a day to several weeks. The signal losses are due to the Atmosphere and Ionosphere weather under the form of rain, sand storms, solar storms and by the fluctuation of the total electron content within the Ionosphere according to the interactions between the solar wind and Earth's magnetosphere. Thus, based on the modeling of this channel, weather database and prediction algorithms a MAC protocol for reconfigurable radios operating in GEO satellites can be developed in order to adapt according to the current status of the link and might be able to respond in advance to some adverse events in the near future in an automated way. The importance of this research relies mainly on its wide field of application after reaching a mature level. Examples go beyond GEO satellites, being capable of implementations embedded in space shuttles vehicles, space exploration and probes, civil and military aircrafts making a best effort to keep a stable reconfigurable link given the current attenuation levels imposed by the communication channel.

This work is supported in part by the Brazilian government through the Science without Borders scholarship program.

Spectrally Agile, Affordable, Commercially Derived Network Communication Research Platform

Steven Taylor, William Watson, Raytheon BBN Technologies

Abstract – The new military handheld communications paradigm is shifting from specialized military communications devices to the notion of an inexpensive, moderately capable, almost disposable devices. This shift has been largely fed from the cell phone community in which individuals, to include field grade and general officers, are used to having a very capable communications/computing system "in their pocket".

Raytheon BBN Technologies has recently been involved with several DARPA research programs exploring this new device paradigm. In WNaN, the research has centered on dynamic spectrum operation for voice, data and video, using cooperating multi-transceiver radios. On the DARPA CommEx program, we studied the use of cooperating multi-transceiver architectures for Cognitive radio applications where spectrum agility is a basic requirement.

These programs (and others) led us to the realization that a new genre of SDR platform was needed to support the researchers. We have developed a hardware platform (Hydra) that embraces the cell phone paradigm for handheld communications community while supporting the need for a multi-transceiver research/development platform. The device is designed to use the latest COTS hardware components and has a cost target well below the current generation of "specialized" military hardware. At the same time, it is built to be an industrial grade product suitable for customer delivery and not just suitable for a lab environment.
Raytheon BBN Technologies has built the first version of the product building on the Xilinx Zynq SoC family and the ADI 9361 RFIC radios:

- 4 "soft radio" transceivers that can operate independently
- Full-Duplex operation between transceivers with frequency agility between 70MHz – 6GHz
- Low power requirements to support battery operated target environments
- Small enough to support handheld packaging (2.5"x4"x1" circuit card)
- Minimization of connectors and IO to eliminate cost, e.g. displays and buttons
- Extensive RF front-end features to allow for very selective tuning, including simultaneous transmit and receive and power output in the 1-2w range.

Our poster describes the changing military communications and research environment, the use of cooperating multi-transceiver technology, the methodology we have used to "adjust" to the new environment and the technical capabilities of our new soft radio platform. Actual hardware devices will be available for view.

Detection and defense of reactive jamming attacks against wireless tactical ad hoc systems

Aleksi Marttinen, Riku Jantti, Aalto University
Alexander M. Wyglinski, Worcester Polytechnic Institute

Abstract – Mobile Ad hoc NETworking (MANET) is the infrastructure-free wireless networking technology. Lack of fixed infrastructure makes MANET-technologies very interesting for tactical networks, because in the tactical operations fixed networking infrastructure may be completely absence or destroyed. Wireless tactical communication systems are prone to jamming attacks. Jamming means a denial-of-service attack where the enemy's radio transmission is blocked by transmitting an interfering RF-signal on the same channel simultaneously. Thus, the receiving node can't decode the received packet. Due to critical characteristics of the tactical communications, the jammer should be detected, located and defensed as quickly as possible to secure reliable communication in the network. Jamming strategies are divided into four categories: constant, random, deceptive and reactive jammers. Constant jammers are transmitting random bits on the channel continuously, and thus preventing the transmissions on the channel. Random jammers transmit randomly interfering signal on the channel. If the used jamming technique bases on the transmission of real MAC-packets, it is called the deceptive jamming. Reactive jamming is referred to the attacks where the jammer triggers the transmission of the interfering signal only after it senses an ongoing data transmission.
In this study, we are addressing the problem of selective jamming attacks by reactive jammers in the tactical wireless ad hoc networks. In the selective jamming mechanism, the attack is aligned on the specified node or the group of nodes. We will also discuss how such attacks can be reliably detected and defended.

PHY and Link Layer SDR Implementation Using MATLAB®

Benjamin Drozdenko, Jingzhi Yu, Kaushik Chowdhury, Miriam Leeser, Northeastern University

Abstract – Our project involves building a physical (PHY) and link layer of the network protocol stack in MATLAB® for software defined radios. We are working with the 802.11b standard to realize these aims. Our current work involves an offline version, which uses MATLAB to transmit and receive data frames that correspond to this standard, and an online version, which uses Ettus Research USRP N210 devices as a front end and runs MATLAB on two host computers to perform all the processing.

In this poster, we describe the functional software blocks that comprise the PHY layer of a full transmit-receive chain. On the transmitter side, we implement functionality for scrambling, modulation, spreading, padding, framing, and spectrum shaping using the raised cosine transmit filter. Our design uses differential binary phase shift keying (DBPSK) modulation and direct sequence spread spectrum (DSSS). We implement a receiver front end to counter the adverse channel effects and signal distortions introduced by the hardware. It consists of a raised cosine receive filter, automatic gain control (AGC), carrier recovery, preamble detection, and synchronization. The receiver also incorporates the steps of despreading, demodulation, and descrambling the incoming signal, followed by the cyclic redundancy check to verify the correctness of the received bits.

In this poster, we also discuss some of the practical considerations that need to be taken into account when implementing the receiver front end online, connected to the USRP devices. These considerations include issues that arise with data rate resampling, AGC, DC offset, and frequency drift. Another issue is the ability to process signals in real-time. To do this, we explore some options for parallelism that we implement in an offline version, disconnected from the USRP devices. To potentially speed up the receiver functions, we use MathWorks™ Parallel Computing Toolbox™ and MATLAB® Distributed Computing Server™. Then, using MATLAB® Coder™ to successfully convert from MATLAB to C code, we also experiment using OpenMP and MPI.

In the future, we plan to implement Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA), and spectrum sensing. We plan to use the PHY layer as a basis for building the CSMA/CA MAC protocol based on the 802.11 Distributed Coordination Function. As part of the broader Cognitive Radio project, we plan to add functionality to quickly detect available spectrum so that the radio can communicate on any available channel with flexible bandwidth.

Mapping the Spectrum Consumption Model Modeling Language (SCMML) to the Web Ontology Language (OWL) for Automatic Inference

Suresh Durga, Yanji Chen, Mieczyslaw Kokar, Northeastern University

Abstract – Model-Based Spectrum Management (MBSM) is a new Spectrum Management (SM) approach based on the creation and exchange of spectrum consumption models (SCMs). The objectives of modelling are 1) understanding spectrum use with models, 2) providing methods for computing compatibility of spectrum uses 3) using the models to assess how much of the spectrum is available and how it is consumed. One of the ideas of MBSM is to use SCM's to convey spectrum management (SM) decisions and support the reuse of the spectrum.

SCM's include transmitter models, receiver models, and a combination of transmitter and receiver models to form a system model (collection of transmitter and receiver models) as well as collections that are comprised of groups of system models.

The conventions for combining the data structures of the constructs and combining the constructs to form models are described by the eXtensible Markup Language (XML) schema for spectrum consumption modeling, known as Spectrum Consumption Modeling Markup Language (SCMML). SCMML is used for communicating system models and collections. SCMML is a hierarchy of data types that build upon each other.

While SCM's expressed in SCMML are a very good step towards the formalization of the data models and data exchange, they are not amenable to automatic inference. This is true of XML representations in general since the semantics of XML is carried by them only in case the interoperating systems have procedural code for interpreting the tags defined in the XSD's. The implication of this fact is that any modification in the XSD would require new procedures for interpreting the newly introduced tags. Our goal is to avoid this kind of situation via the use of a language with formal, computer processable semantics. Toward this aim, we map SCMML to the Web Ontology Language (OWL), or more specifically, to the concepts defined in Cogntive Radio Ontology.

This poster shows the work of mapping the SCMML schema for communicating system models and collections written in XML to Web Ontology Language (OWL). Use cases will be based on stochastic process such as fading on a channel, user operational process like the radios will move to some location, or a system behavior such as power control adjustments or antenna adaptation.

The demonstrated use cases will include querying reported antenna movements based on the latitude and longitude values -whether they are legally permissible by the policy as represented by the SCM. An inference engine will be used to demonstrate the value and the usefulness of the OWL semantics, as opposed to just XML.

Tracking Airplanes Using RTL-SDR Radio with MATLAB

Ethem Sozer, Mike Donovan, Debanjana Mukherjee, Mike McLernon, MathWorks

Abstract – RTL-SDR is a low-cost ($18), USB-based software-defined radio (SDR) receiver that you can use to capture and process radio signals in MATLAB and Simulink. The RTL-SDR radio can cover the spectrum between 30 MHz to 1.8 GHz. One of the interesting signals defined within this band is the Automatic Dependent Surveillance-Broadcast (ADS-B) standard. ADS-B is a surveillance standard for aircraft tracking where aircraft determine their own location and heading using GPS and automatically transmit the data. In this example, we demonstrate how to capture ADS-B signals using the RTL-SDR radio, demodulate the received packets in MATLAB, and show the tracked planes on a map, in real-time.

Emulated RF Environment Using Software Defined Radios

Billy Zhong, Collin Hockey, Ryan Moniz, Patrick M. Howard, Chris Niessen, The MITRE Corporation

Abstract – Presented in this research is a method to emulate the RF environment to evaluate tactical radios in a laboratory setting. Our approach involves converting an RF signal to baseband and applying digital emulation to mimic RF propagation, such as path loss, delay, and Doppler. The advantage of using a digital system as opposed to an analog system is cost, scalability, flexibility, and fidelity. By leveraging the low-cost, high quality Ettus USRP2 N210 as the RF front end, we implemented a separate board to perform the actual emulation. Communication between the front end and the board is achieved through high speed transceivers over a serial link. There are many obstacles with implementing a system with various platforms. This research explores the architecture of the system, the reasoning behind some of the design decisions, and the challenges that we faced in the development.

Data Mining–Informed Cognitive Radio Networks

Sven Bilén, Khashayar Kotobi, Conrad Tucker, Penn State

Abstract – Current and projected future demands on wireless bandwidth require that the limited available frequency spectrum be utilized much more efficiently. Cognitive radio (CR) systems are proposed as a viable solution to address the efficiency issue. One can define the CR's "cognitive ability" as that of capturing and gathering information regarding its radio environment, processing this information, and then acting based on that information. Simple CRs might monitor the power level in a specific frequency band or channel to determine if it is in use; more complex CRs might also include information on the spatial and temporal variations in the radio environment deriving from node mobility and time transmission dependency of most wireless devices. Reconfigurability empowers the CR to dynamically adapt to a dynamic radio environment, making decisions on what waveform parameters to use (including modulation, protocol, operating frequency, networking layer, etc.).

Now consider yet other sources that go beyond radio-environment parameters to include information from other data sources. Data used in current cognitive radio systems typically involve the radio environment, might include information such as location, but generally include little to no information from other sources, and certainly are not ones that have learned what data are relevant. The emergence of low cost mobile communication devices and digital storage technologies is enabling the rapid creation and dissemination of information on a global scale. Digital information, ranging from user-generated data (e.g., captured through social media such as Twitter®, Facebook®, and Google +®, etc.), to data generated through industry and government efforts, is establishing a new dimension of social-driven knowledge discovery. These data, fed through the appropriate cognitive engines, might inform CR beyond what radio parameters alone can do, and in the process expand bandwidth. The challenge facing us is not the lack of digital information, but rather the synthesis of large scale, multi-domain data and its transformation into actionable information by CR systems.

This poster presentation will discuss a framework for a Data Mining–Informed Cognitive Radio (DMICR) network and some preliminary investigations into such a system.

Notes

Notes

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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.