Award # 2128628 : Ultra Wideband Flexible MIMO Radios for Energy Efficient Secure Spectrum Sharing

John Volakis (PI)[1],Satheesh Bojja Venkatakrishnan (Co-PI)[1], and Kannan Srinivasan (Co-PI)[2]
[1] Florida International University, Miami, FI-33172, USA
[2] The Ohio State University, Columbus, OH-43210, USA

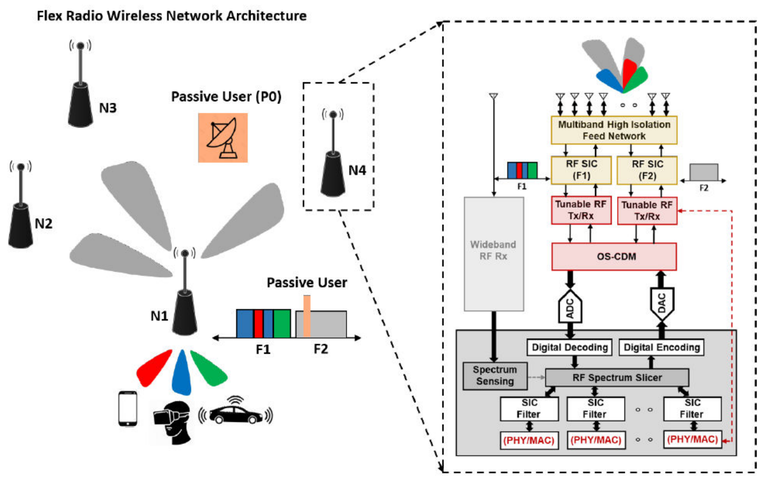
Spectrum and Wireless Innovation enabled by Future Technologies (SWIFT)

INTRODUCTION

- Increased use of spectrum due to worldwide growth in W/L applications. Spectrum becoming a basic community resource.
- Rapid advances in AR/VR, V2V & Data Rates requiring large swaths if BW and high data rate
- Security protocols to avoid eavesdropping and man-in-the-middle (MitM) attacks
- Low-cost versatile hardware to serve as multi-mode broker to autonomously reconfigure and optimize W/L resources

OBJECTIVES

- T-1: RF reconfigurability and spectrum aggregation to support active & passive users
- T-2: Achieving improved RF self-interference cancellation for spectrum co-existence of the
- T-3: AI-based models for security and privacy by detecting malicious (MitM and eavesdroppers) attacks



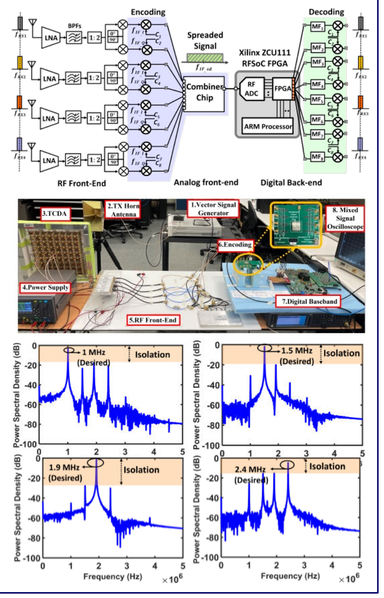
Challenges being Addressed:

- Synergic Spectrum Aggregation
- Supporting Key Passive users
- Robust Wireless Networking
- Reconfigurable and Power Efficient Radios

T-1: Reduced Hardware Adaptive MIMO[1]

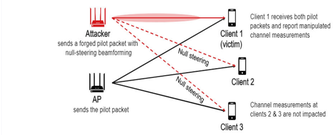
- mmWave 4-channel code-multiplexed digital receiver for MIMO
- Overcomes bottleneck of hardware complexity, cost and power consumption
- Requires one ADC for every 16 RF chains
- Achieves ~87% and ~78% reduction in power and cost

Measurements show ACI > 20 dB and NMSE = -24.5 dB with no SNR degradation

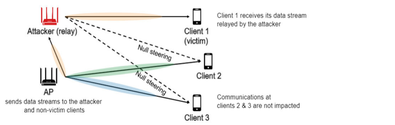


T-3: Man-in-the-Middle Attack Detection[2]

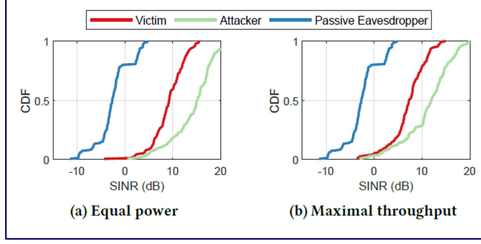
- Goal is to detect the full-duplex Mitm relay attacker without any previously-collected signatures.
- Proposed approach increases the eavesdropping opportunity to 100%.



Channel measurement injection during NDP transmission

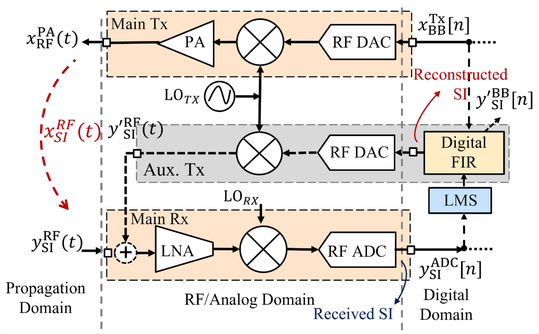


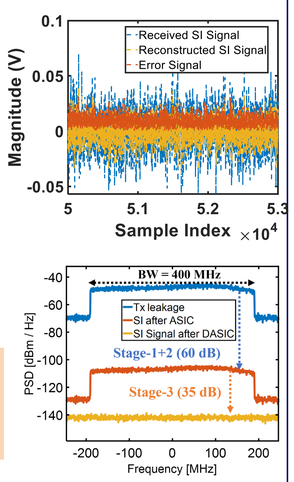
Data Stream Relaying



- Real-time null-steering beamforming
- Attacker's SINR > victim's SINR

T-2: Improved SIC STAR System[1]





Objective:
Reconstructed SI ≈ Received SI

- Reconstruction of self-interference channel at the RF/analog and digital baseband
- Digital adaptive FIR filter implementation on RF-SoC FPGA for digital SIC

- Cancellation bandwidths of **200** and **400 MHz**
- Linear SI Cancellation of **38 dB** and **35 dB**

Intellectual Merit and Boarder Impact

- Next-G flexible, secure and adaptive RF front end development. COTS prototype was demonstrated at FIU engineering expo to high school students and at 2 graduate-level workshops highlighting the need for effective spectrum utilization.
- Malicious relay detection has deep implications to attacks in IoT and communication systems. A Ph.D. student trained on this project is a woman student.
- Publications: 2-journal submissions and 5- conference presentations.

NEXT STEPS

- Integration of multi-stage cancellation techniques
- Optimize RF cancellers (stage1+stage2) to provide > 70 dB total analog SI suppression
- Realize multi-stage STAR front in reduced footprint
- Our next step is to investigate how to employ multiple wireless nodes so that secrecy capacity is zero. We will also propose countermeasures.