Software/Hardware Efficient Extensible Protocols (SHEEP)

Program: US-EU Internet Core & Edge Technologies (ICE-T)

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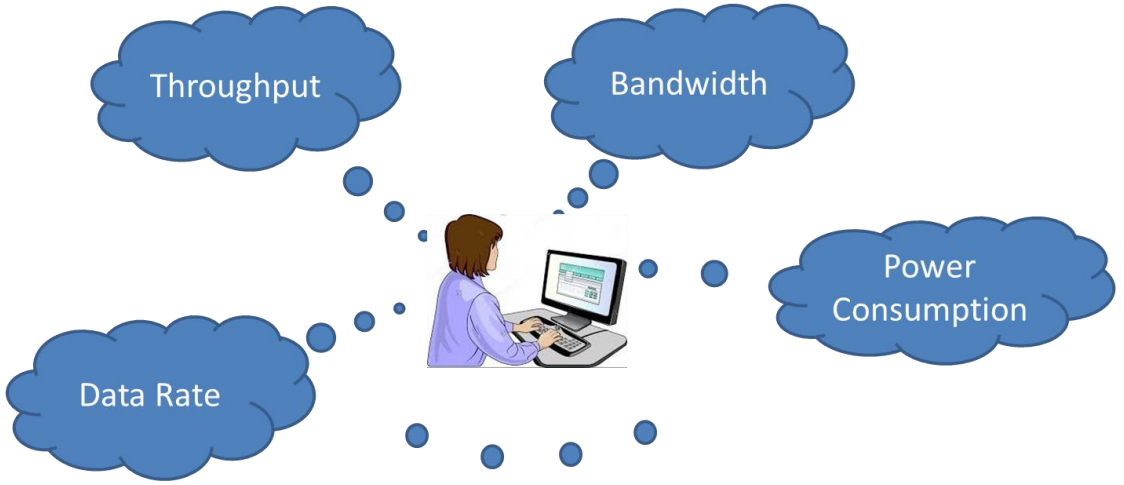
NSF CSR/NeTS program

Goals and Challenges



- Push the edge of what can be designed
- Ease the design process to make platforms:
  - more flexible
  - easier to customize
- Addressing versatility and adaptability in mobile systems:
  - Flexible radio access technologies and dynamic management of resources at the edge of wireless networks
  - Prototyping new protocols as well as developing an agile approach to support existing protocols

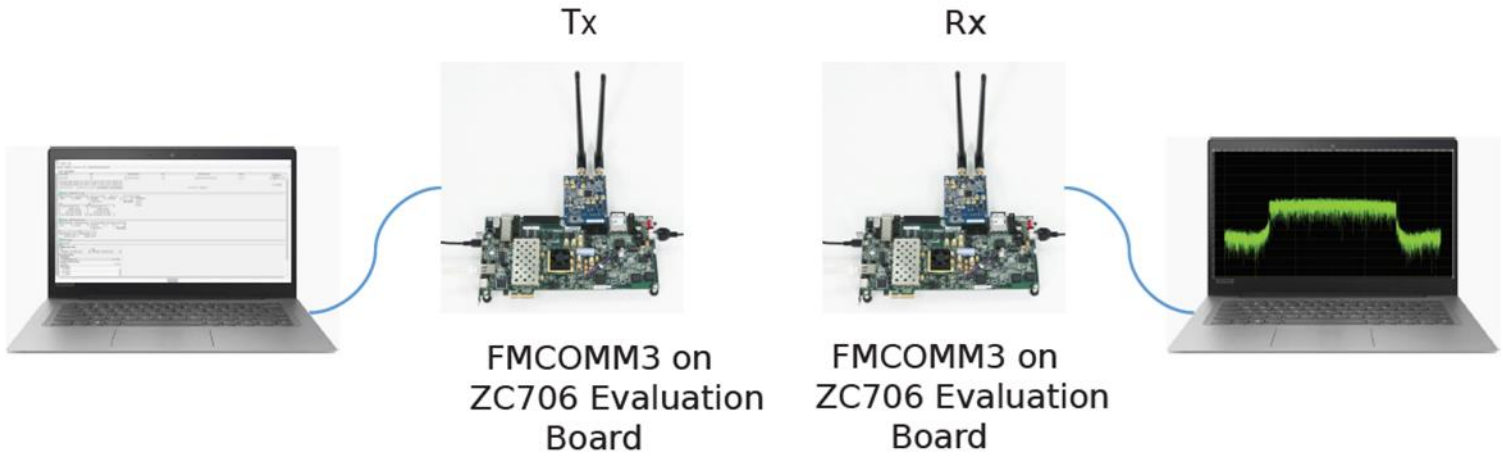
Joint Hardware/Software setup:

Hardware:

- Xilinx SoC (Zynq)
  ARM processor +FPGA
- ADI RF front ends
- Latest: Xilinx RF SoC

Software:

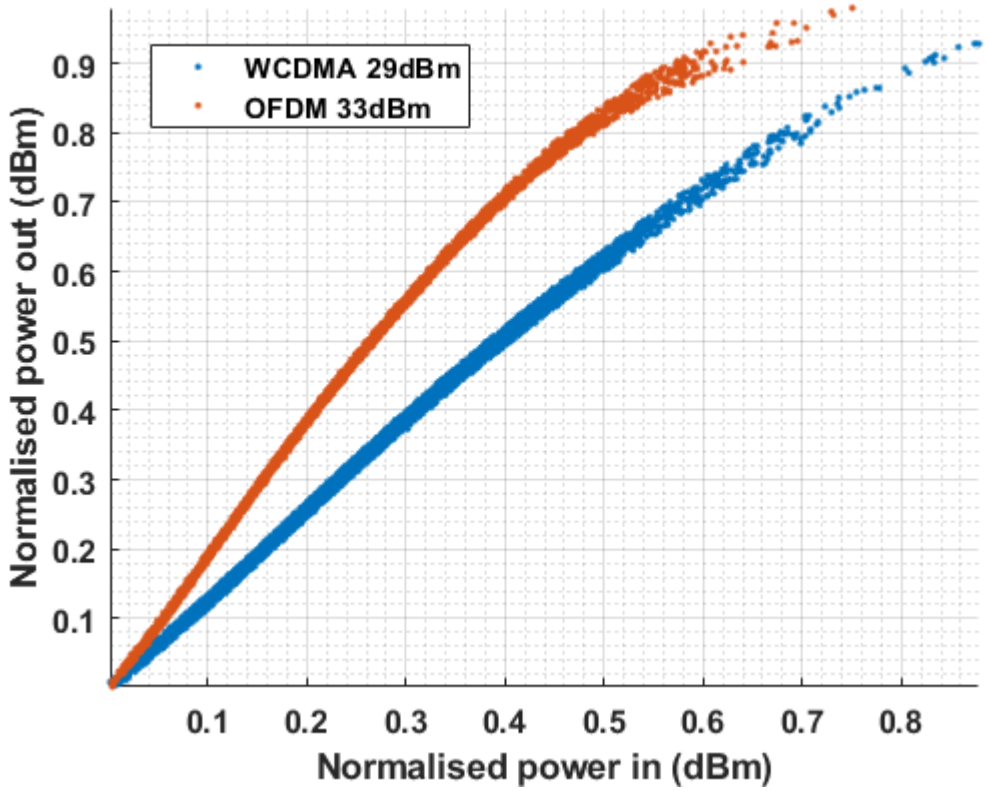
- Mathworks communications and hardware tools
- Xilinx Vivado when needed



Coexistence: Adaptable signal processing, multiple protocols with the same RF front end

Previous Experiments:

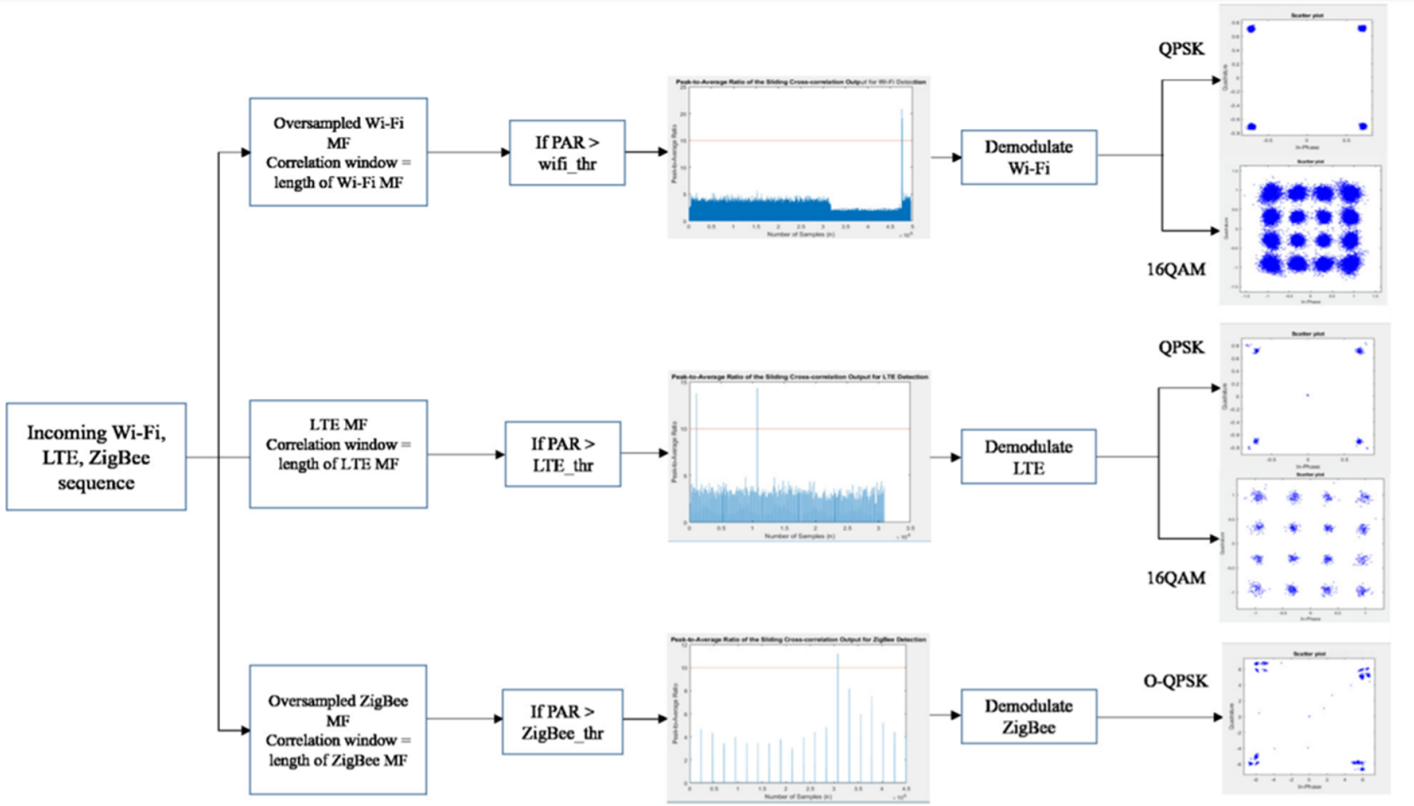
- Coexistence of WCDMA, LTE, DVB-S2X
- Determine common operating conditions
- Different signals transmitted on same hardware -- advanced agility
- Experiments in end-to-end connected testbench



Coexistence: Identifying multiple protocols with the same front end

Previous Experiments:

- Coexistence of Zigbee, Wifi, LTE
- All signals received at same frequency
- Resample matched filter rather than incoming signal
- Different signals detected on *same* hardware -- advanced agility
- Experiments in noisy lab environment



Future Directions – New 5G Waveforms

- Focus on PHY layer implementations
  - CP-OFDM, F-OFDM, UFMC, WOLA

	CP-OFDM (Unfiltered)	CP-OFDM (Filtered)	F-OFDM	UFMC	WOLA
Spectral efficiency	Poor	Good	Excellent	Excellent	Excellent
Implementation Complexity	Low	Medium	Medium	High	Medium
OOB leakage	High	Low	Very Low	Very Low	Very Low

Goals and Future Directions

- Goals:
  - Ease design process
  - Enable exploration of PHY layer implementations
  - Support flexibility
  - Same HW for multiple protocols
  - Truly flexible cognitive radio
- Next steps:
  - Demonstrate designs using our toolflow and Xilinx RFSoC.
- Target 5G:
  - MIMO
  - Beamforming
  - Digital predistortion

Publications

1. Leeser, M., Handagala, S., Mohamed, M., Xu, J. and Onabajo, M. "An FPGA Design Technique to Receive Multiple Wireless Protocols with the Same RF Front End." In *Wireless Days,* IEEE, April 2019.
2. Handagala, S., Mohamed, M., Xu, J., Onabajo, M. and Leeser, M. "Detection of different wireless protocols on an FPGA with the same analog/RF front end." In *International Conference on Cognitive Radio Oriented Wireless Networks (CROWNCOM), September, 2018.*
3. Ramabadran, P., Afanasyev, P., Malone, D., Leeser, M., McCarthy, D., O'Brien, B., Farrell, R. and Dooley, J. "A Novel Physical Layer Authentication with PAPR Reduction based on Channel and Hardware Frequency Responses." in IEEE Transactions on Circuits and Systems I. To appear.