FPGA ACCELERATED BASEBAND FOR WIRELESS SYSTEMS

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Abstract

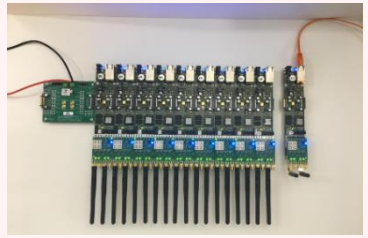
FPGA-based System on Chip Education and Research
- Rice developed Wireless open Access Research Platform (WARP) is in wide use in academia and industry for wireless system design and research
- Next generation RENEW platform will support large scale multi-user multiple antenna MIMO research

Educational Objectives:
- Embedded systems and wireless systems architecture design with open access example repositories - WARP

Research Objectives:
- Baseband algorithm acceleration for high efficiency

Introduction

RENEW
Reconfigurable Ecosystem for Next-gen End-to-end Wireless



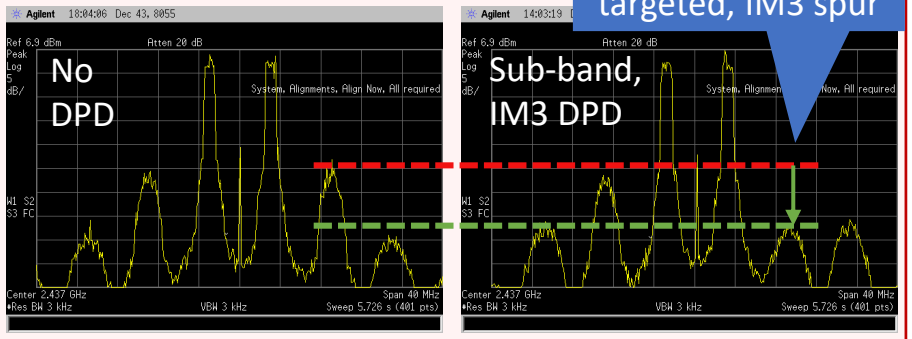
- New fully programmable and observable Massive MIMO wireless network.
- Builds on new Argos v3 Massive MIMO base-station
  - Programmable wide-band radios, including 5G bands of 2.5 and 3.5 GHz
  - SDR boards use Xilinx Zynq FPGA
- RENEW testbed allows for evaluating high-performance, FPGA-based signal processing designs for next generation wireless systems
- 2018 NSF PAWR Powder-Renew initiative with U. Utah
- At Rice: A. Sabharwal, E. Knightly, L. Zhong, J. Cavallaro

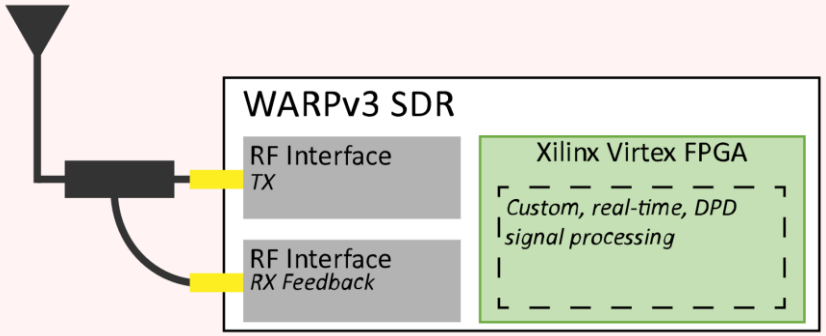
Case Study I: Real-time Digital Predistortion

Power Amplifier Nonlinearities
- Cause spurious emissions and spectral regrowth
- Intermodulation distortion is major problem in carrier aggregation

Digital Predistortion (DPD)
- Computationally complex at high sampling rates found in 5G NR
- Need low-complexity method for real-time learning and correction
- Sub-band DPD solution for flexible, low-complexity suppression in carrier aggregation scenarios

13 dB reduction in targeted, IM3 spur



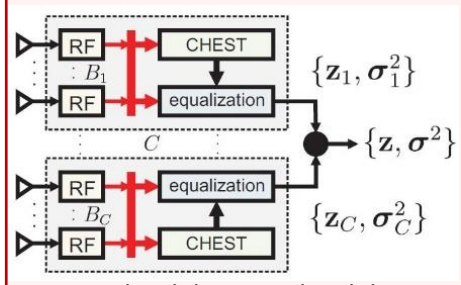


Case Study II: MU-MIMO Detection

Massive multi-user MIMO systems
- 5G key technology: high spectral efficiency
- Hundreds of BS antennas to serve tens of users

Uplink data detection at base-station
- Core baseband component to recover user data
- Centralized detectors are hardly scalable

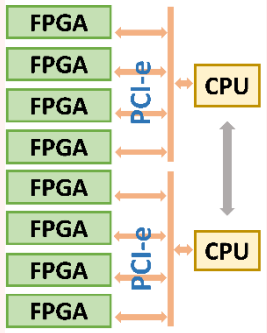
Decentralized data detection
- Resolve computation and interconnection issues
- High scalability for thousands of antennas



Optimal fusion of local equalization output z_i and noise variance σ_i with minimum message passing

Decentralized detector: local detection & centralized fusion

Implementation on multi-FPGA systems



Hardware: AWS EC2 F1 system
Toolkit: SDAccel & Vivado HLS
Language: C++ & OpenCL
Deployment:
- Control processes on CPU
- Local detection on FPGA
- Message passing via PCI-e