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Software Defined Radios for Teaching & Research

<Name>

SDRs Shorten the Transition from Design to Deploy

Design → Prototype → Deploy

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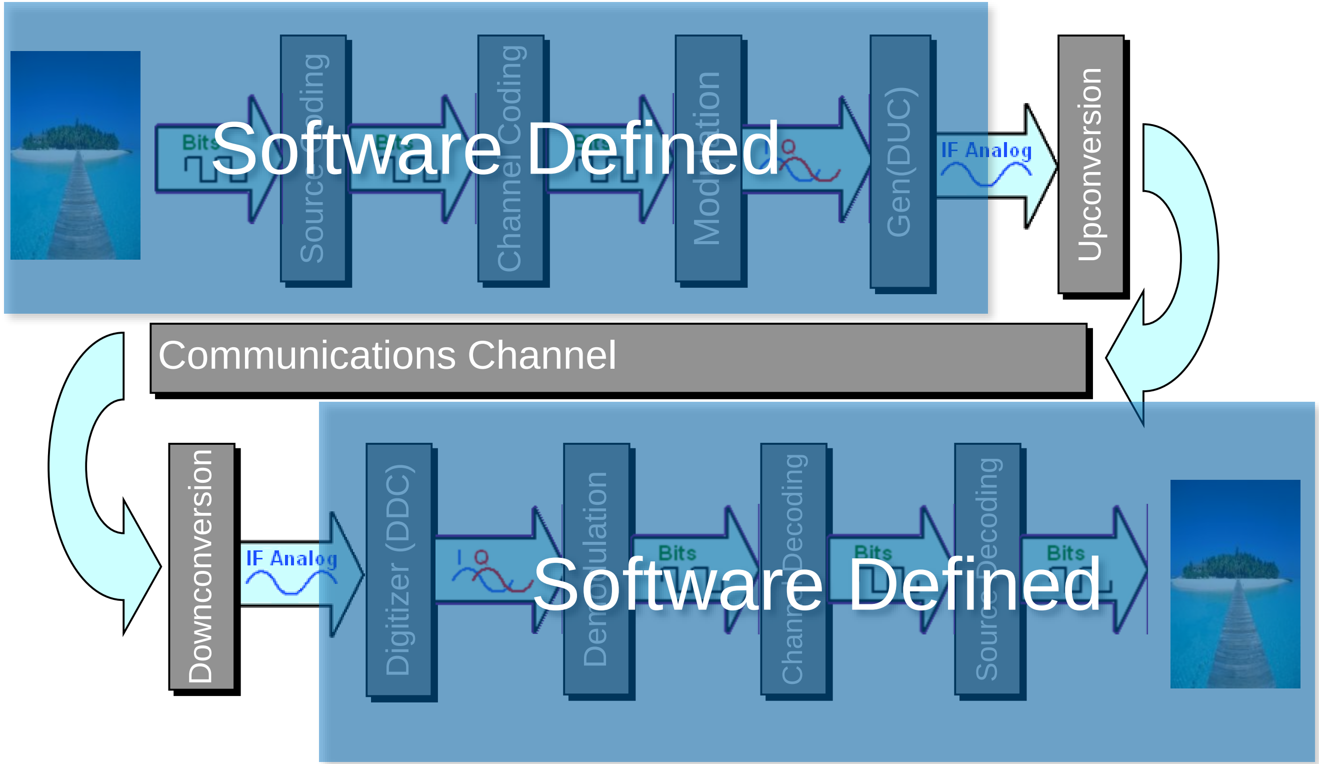
Modern Digital Communication System



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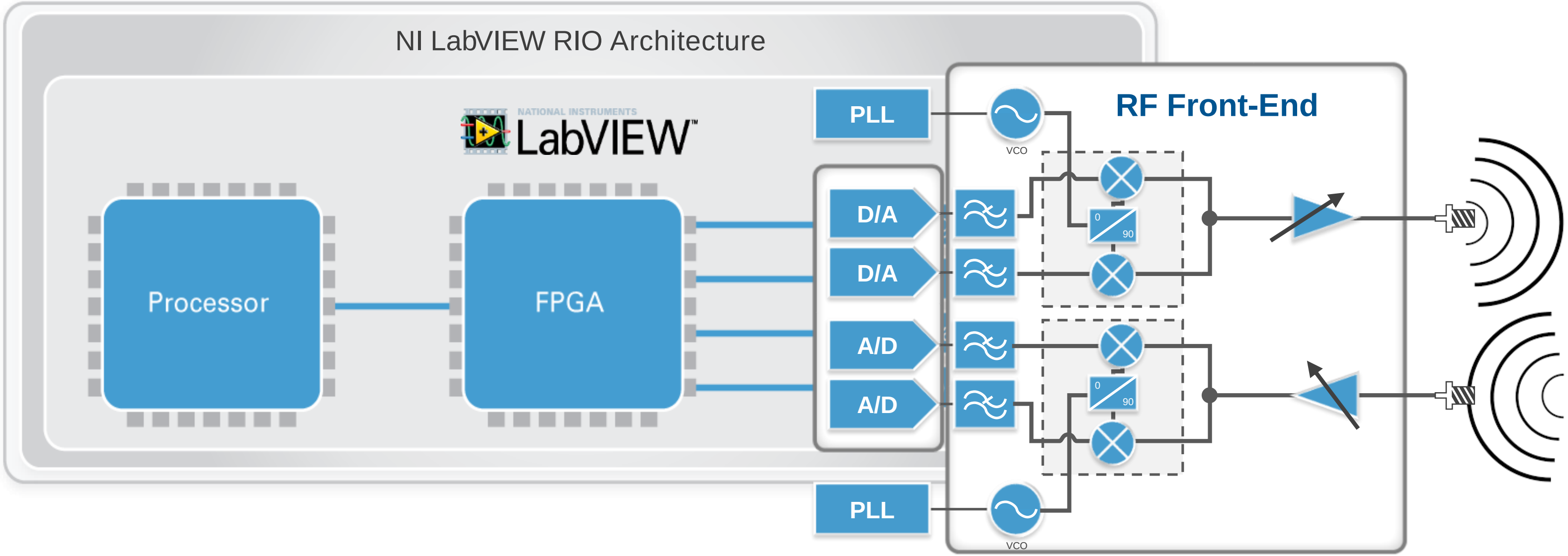
LabVIEW RIO Architecture in SDR



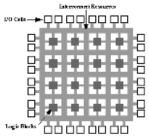
Today's Development Challenge

Tools

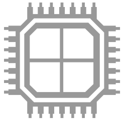
- Math (.m files)
- Simulation (Hybrid)
- User Interface (HTML)
- FPGA (VHDL, Verilog)

- Host Control (C, C++, .NET)
- DSP (Fixed Point C, Assembly)
- H/W Driver (C, Assembly)
- System Debug

Targets



FPGAs



Multicore Processors

- SDR development requires multiple, disparate software tools
- Software tools don't address system design

- Long learning curves
- Limited reuse
- Need for "specialists"

- Increased costs
- Increased time-to-result

NI SDR Platform

Open Ecosystem of Software Toolflows

LabVIEW

GNU Radio
the gnu software radio

XILINX ALL PROGRAMMABLE
VIVADO

python

C / C++

The Largest Breadth and Depth of HW in the Industry

Proven Customer Success

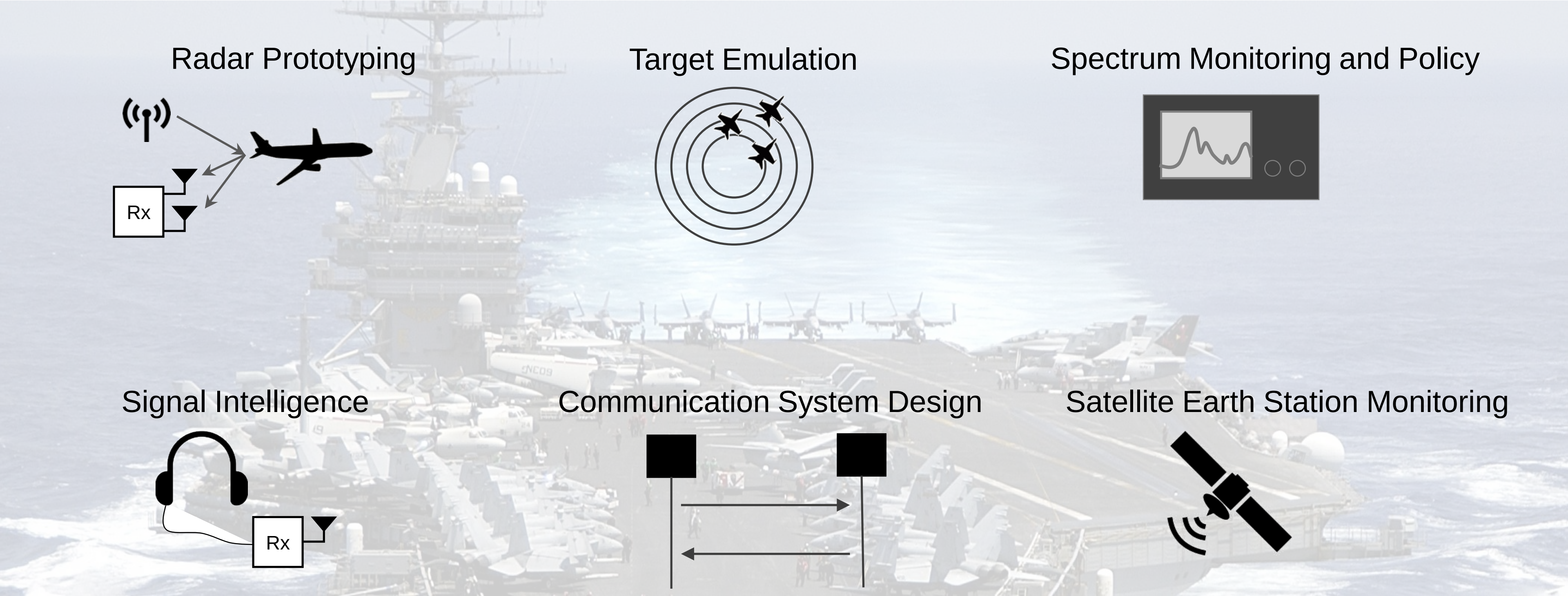
First 28GHz mm-wave 5G transceiver demoed in US -Electronics Weekly

Massive MIMO gets a boost from National Instruments -RCR Wireless

Bristol and Lund set a new world record in 5G wireless spectrum efficiency -Bristol University

World's Most Powerful Emulator of Radio-Signal Traffic Opens for Business -DARPA

SDR Technology Solves a Wide Range of Applications



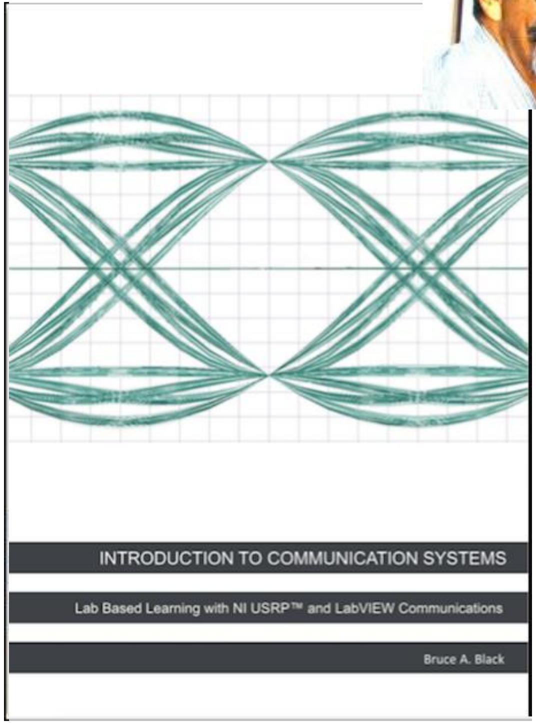
Using SDRs as Teaching tools

Ready to Use Courseware

- Introductory Communications Systems

  By Dr. Bruce Black, Rose-Hulman Institute of Technology

  - Lab 1 : Introduction to the USRP
  - Lab 2 : Amplitude Modulation
  - Lab 3: Frequency-Division Multiplexing
  - Lab 4: Image Rejection
  - Lab 5: Double-Sideband Suppressed Carrier
  - Lab 6: Frequency Modulation
  - Lab 7: Amplitude-Shift Keying
  - Lab 8: Frequency-Shift Keying
  - Lab 9: Binary Phase-Shift Keying
  - Lab 10: The Eye Diagram
  - Lab 11: Equalization
  - Lab 12: Quadrature Phase-Shift Keying

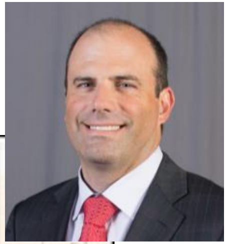


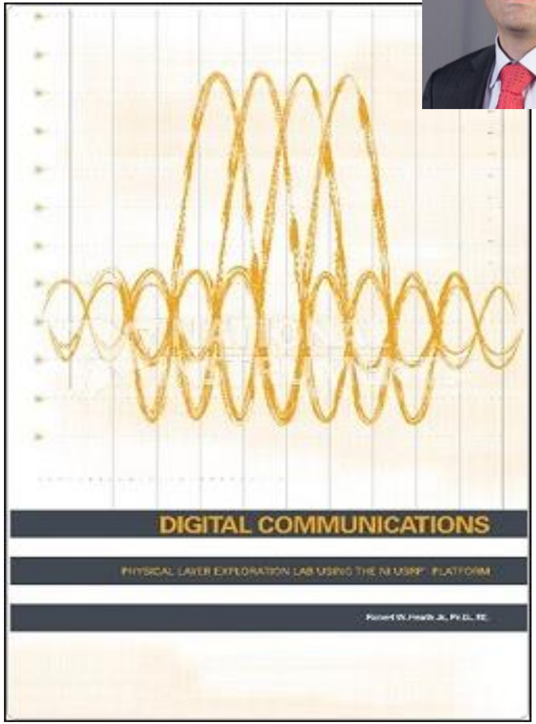
Ready to Use Courseware (contd….)

- Digital Communications

  By Dr. Robert Heath, University of Texas, Austin

  - Lab 1 :
    - Part 1: Introduction to NI LabVIEW
    - Part 2: Introduction to NI RF Hardware
  - Lab 2 :
    - Part 1: Modulation and Detection
    - Part 2: Pulse Shaping and Matched Filtering
  - Lab 3: Synchronization
  - Lab 4: Channel Estimation & Equalization
  - Lab 5: Frame Detection & Frequency Offset Correction
  - Lab 6: OFDM Modulation & Frequency Domain Equalization
  - Lab 7: Synchronization in OFDM Systems
  - Lab 8: Channel Coding in OFDM System





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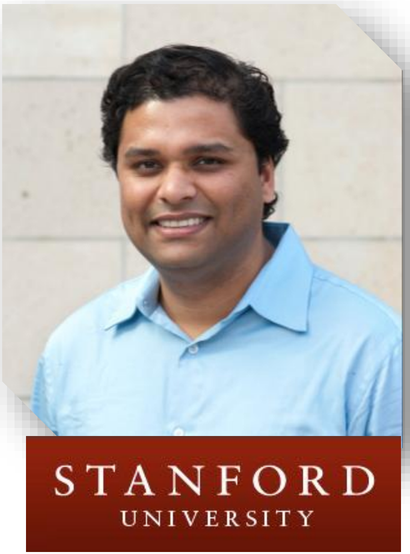
Demos

NI USRP at Stanford University



… “We want to expose students to real-world signals early in their academic careers. With the NI USRP and LabVIEW, we’re able to provide this exposure in introductory courses for the first time, which adds depth to both teaching and learning of communications concepts.”.

Students rated the class **4.94/5.0**, likely making it one of the **highest ratings among all classes** in the School of Engineering at Stanford.

Dr. Sachin Katti

[Electrical and Computer Engineering]

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Research Applications enabled by SDRs

NI's Platform-Based Approach to Software Defined Radio

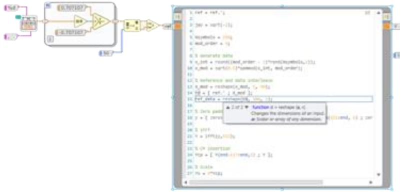
NI's Software Integrates all Aspects of System Design

Hardware Integration

- Integrated support for wide range NI RF hardware
- Deployment platforms from highly-portable to high-performance

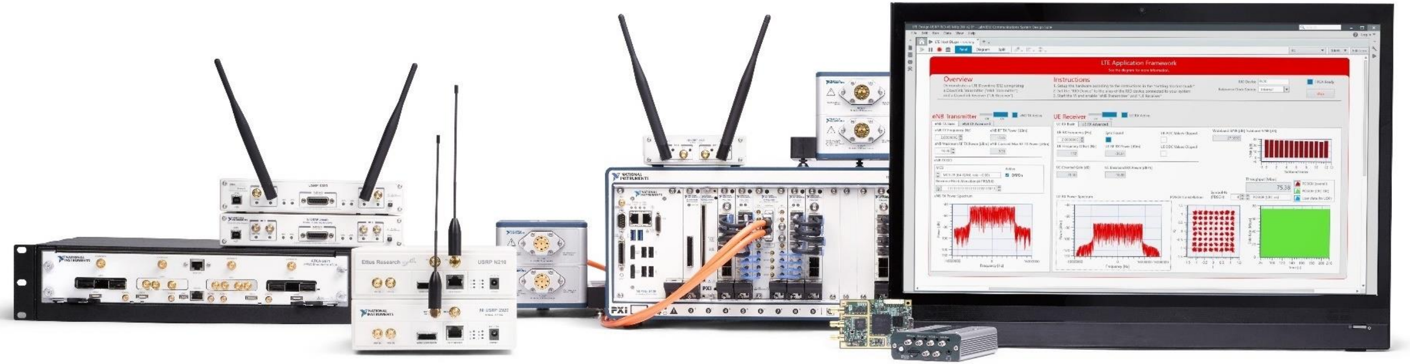
Algorithm Development

- Deep LabVIEW signal processing libraries
- RFNoC and GNU radio toolchain support
- C, C++, .M, and VHDL integration



System Completion

- An ecosystem of partners and developers
- Better usability with native GUI and built-in remote access
- Hardware synchronization and data storage



Design → Prototype → Deploy

For more information, please visit ni.com/sdr

Applications

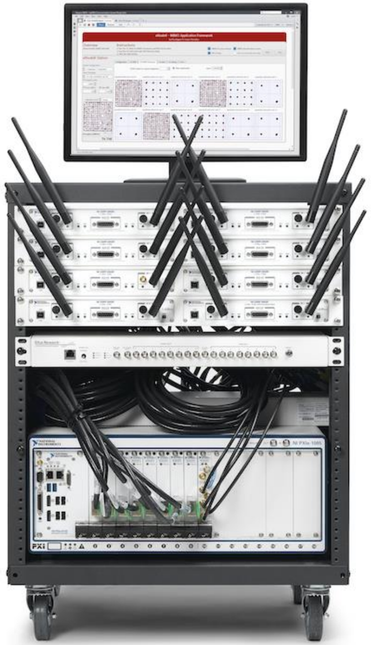
MIMO

The NI MIMO Platform for Phased Arrays

Featuring the MIMO Application Framework

The world's first real-time Massive MIMO testbed with software reference design and hardware that scales from 4-128 antennas.

- Real-time over-the-air transmission
- 50 MHz – 6 GHz
- 20 MHz bandwidth TDD UL & DL
- Scalable number of channels from 4 – 128
- Fully reconfigurable frame structure
- 128x128 MMSE, ZF, and MRC MIMO decoder FPGA IP
- Supports QAM, 16 QAM, 64 QAM, 256 QAM
- Channel reciprocity compensation per RF channel
- Open loop power control
- Over the air synchronization & calibration



16 Channel
Mini-Massive MIMO System

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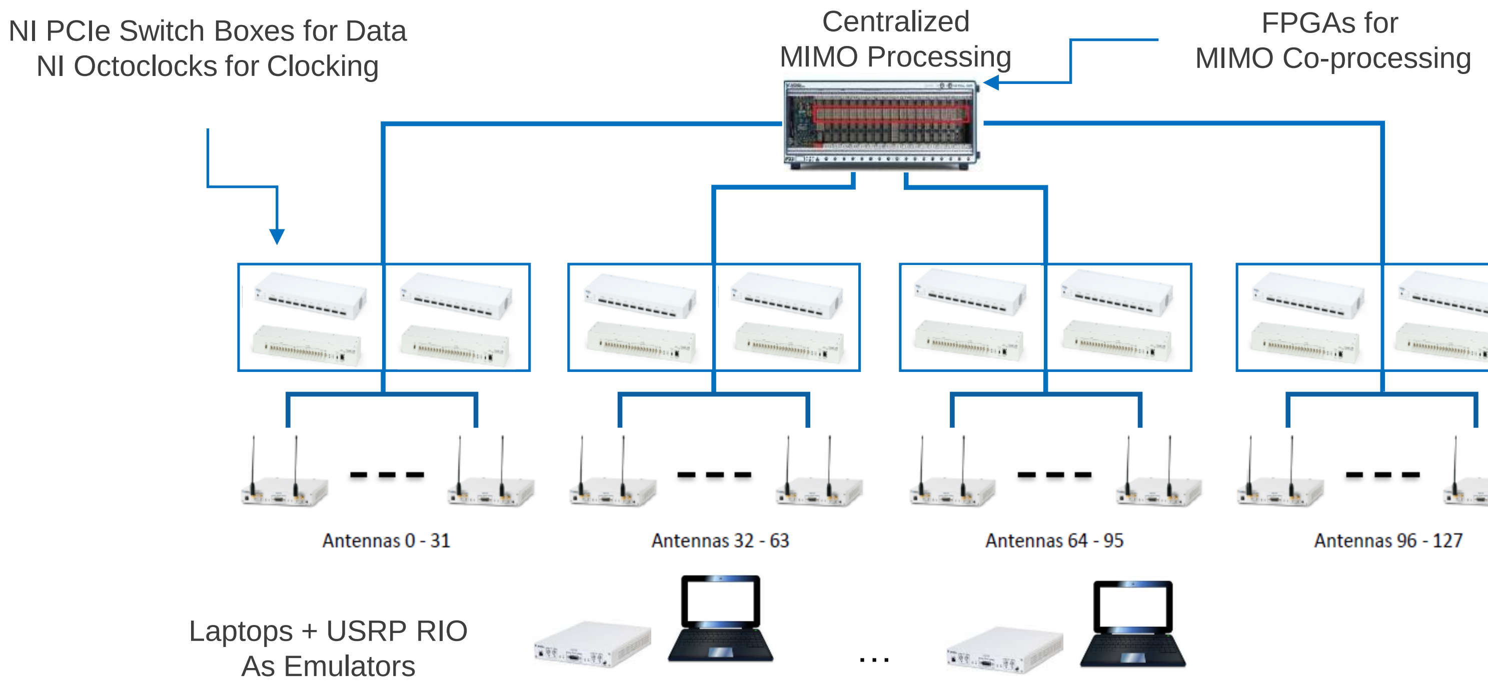
Hardware Architecture:
Scalable from 16 to 128 Antennas @ 20 MHz



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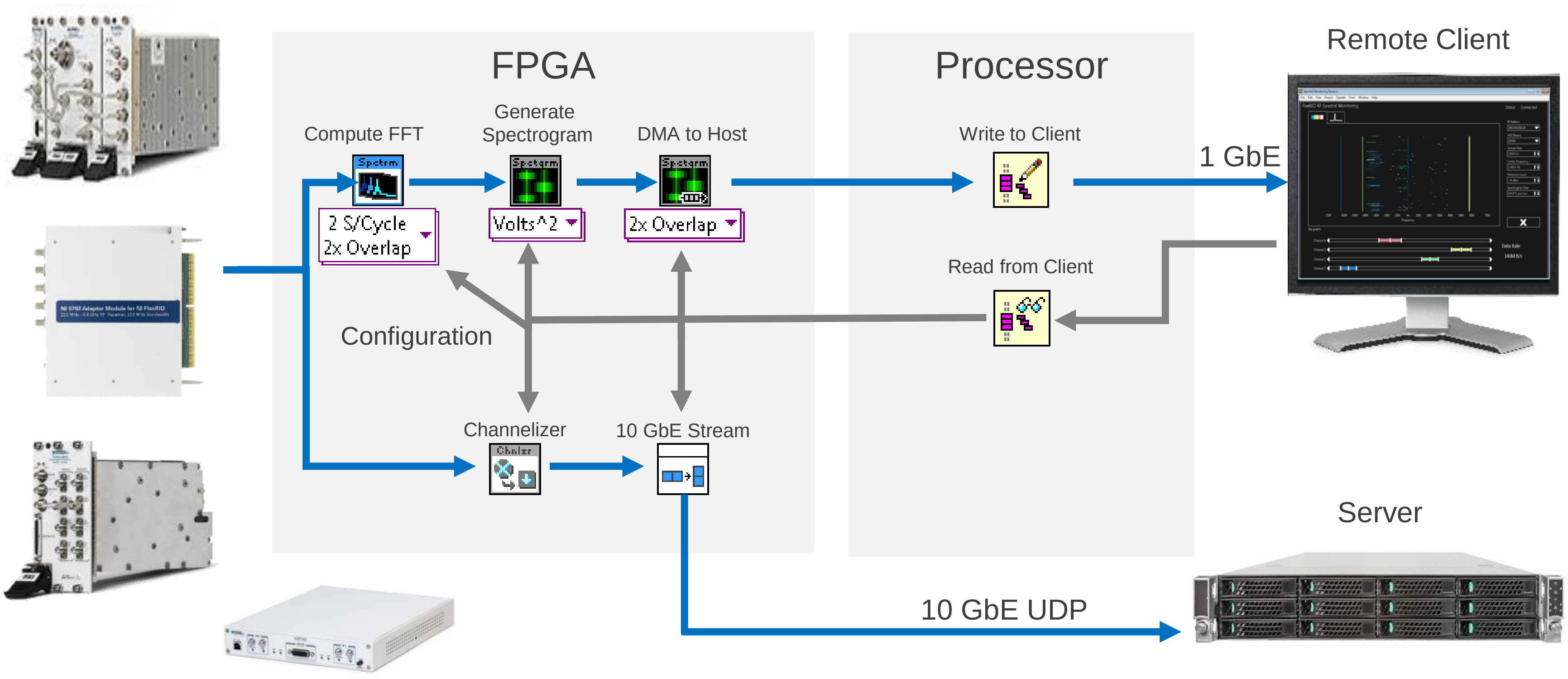
Cognitive Radio

Full Duplex Radio

Spectrum Monitoring

Example Application: Spectrum Monitoring



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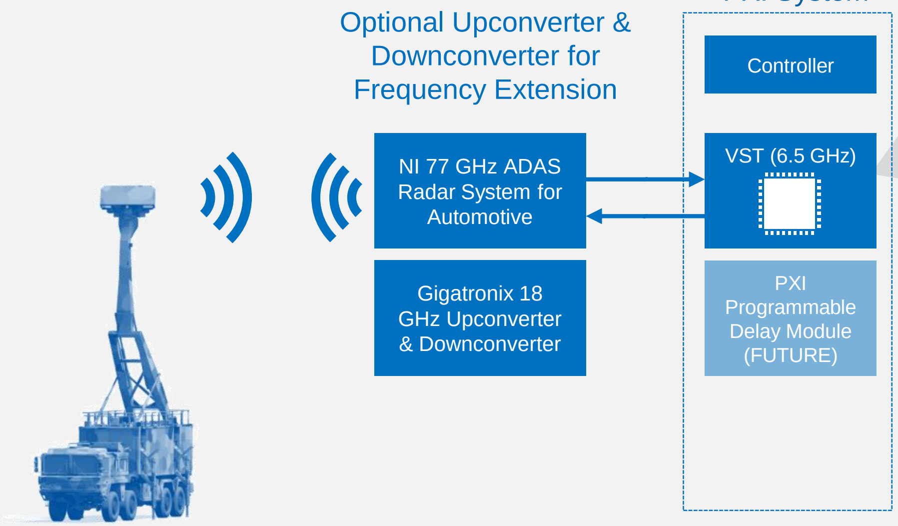
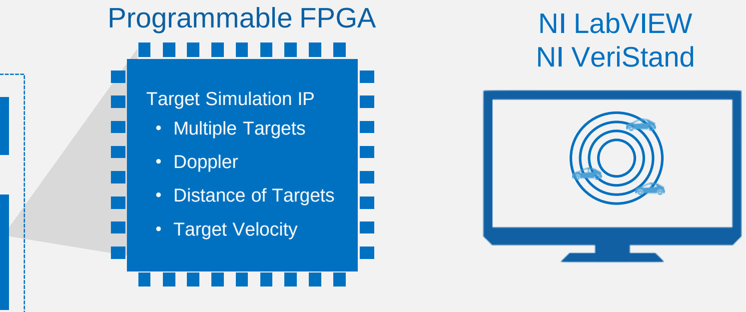
Radar Target Emulation

Radar Target Emulation





- In-line FPGA processing
- RCS: Constant, Swirling
- Path: Moving, Clutter
- Variable: Speed, Gain, Range, Doppler, Angle

Passive Radar System

Digital beam forming to determine the direction of arrival of signals

Adaptive filtering to cancel any unwanted direct signal returns

Cross-correlation of the reference channel with the surveillance channels

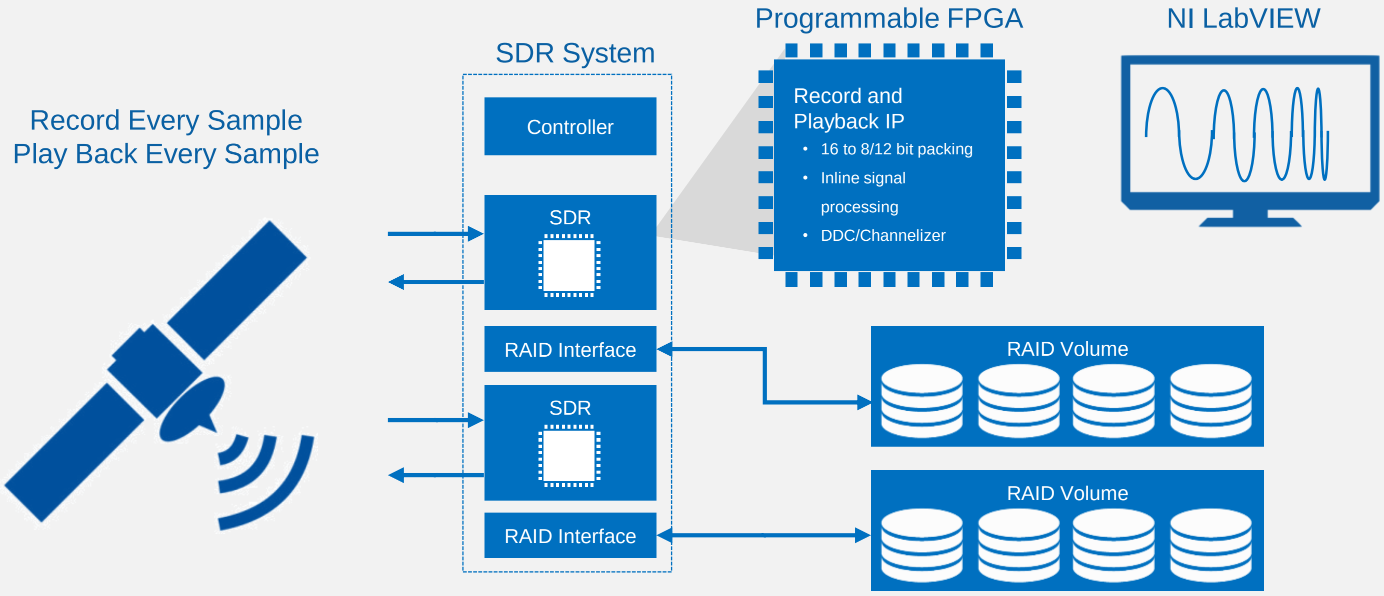
"We chose NI products is because of the user-friendly environment to develop the software"

- Dr. Riccardo Mancinelli,
Selex Sistemi Integrati

SELEX Sistemi Integrati

Record & Playback

Technology Example: 1 GHz RF Record & Playback to Disk



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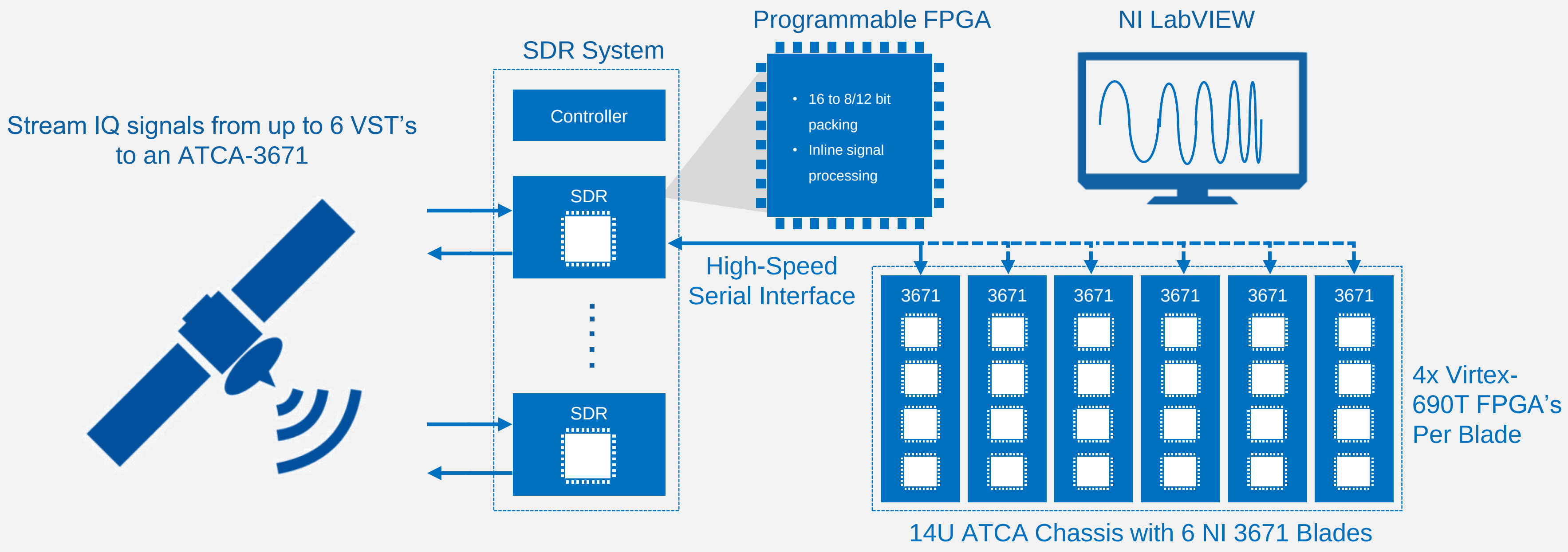
Technology Example 2: Streaming 1.1 Tbps

Algorithm Exploration, Development, Real-Time Verification, Field Trials



Questions