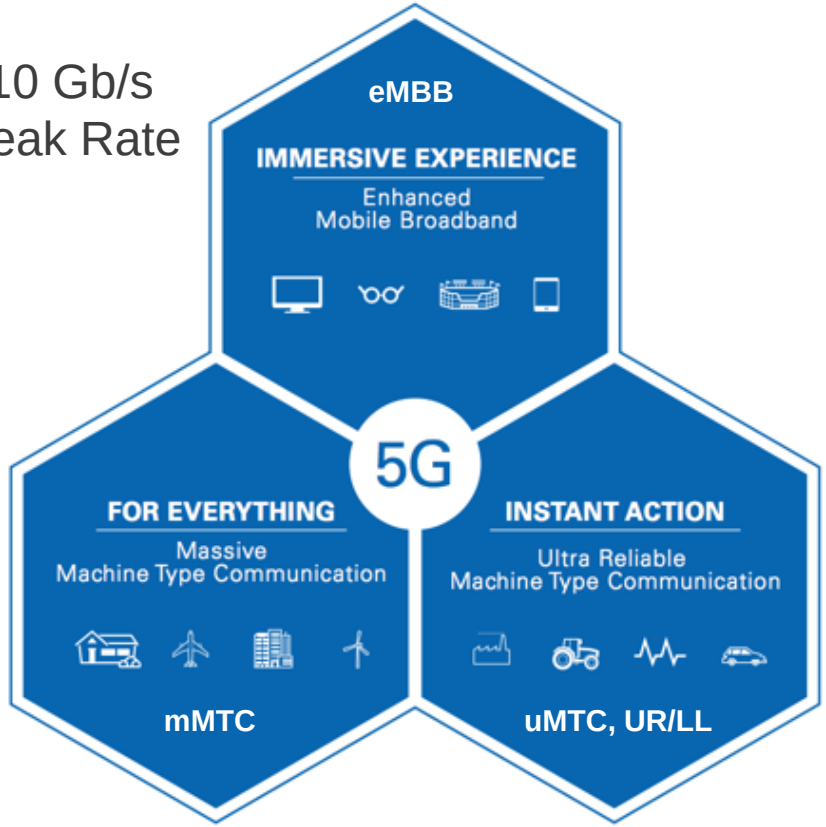
Building Complex Systems with COTS Software Defined Radios

Sarah Yost

Product Marketing Manager, National Instruments

ITU-R Vision for 5G

>10 Gb/s
Peak Rate



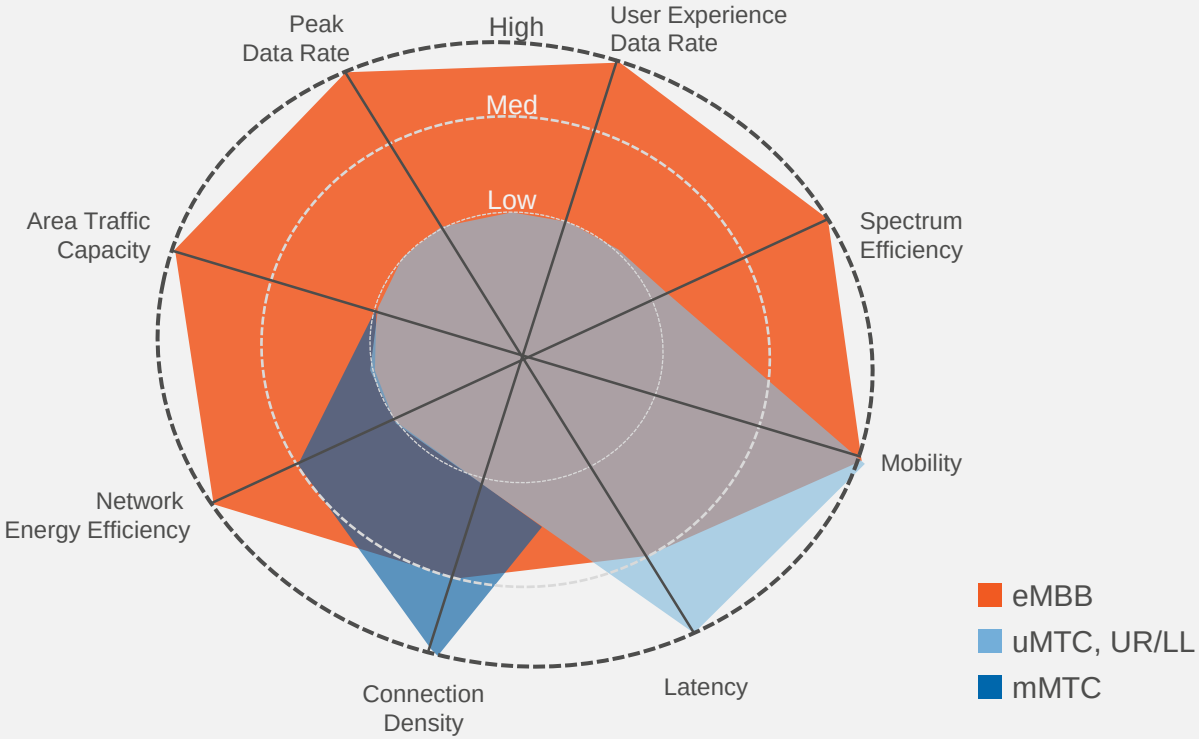
100X More Devices

< 1mS Latency

NATIONAL INSTRUMENTS

ITU-R Vision for IMT-2020 and Beyond

8 Capabilities



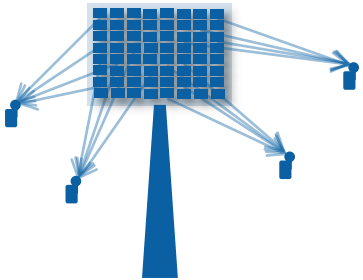
Source – ITU-R M.[IMT.VISION]

NATIONAL INSTRUMENTS

Prototyping Key Technologies to Drive 5G Standards

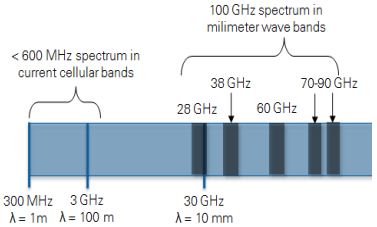
Massive MIMO

Dramatically increases number of antenna elements on base station to enable beamforming



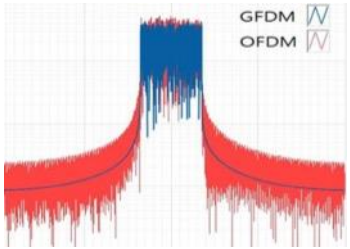
mmWave

Utilizes the potential of extremely wide bandwidths at frequency ranges once thought impractical for commercial wireless



Multi Radio Access Technologies (RAT)

Improve bandwidth utilization through evolving PHY Level and flexible numerology



Wireless Networks

Offer consistent connectivity to meet the 1000X increase in traffic demand for 5G

- Densification
- NFV
- SDN
- CRAN

NATIONAL INSTRUMENTS

5G Testbed Examples

University of Bristol and Lund University

128-Antenna Massive MIMO

AT&T

28 GHz Channel Sounder

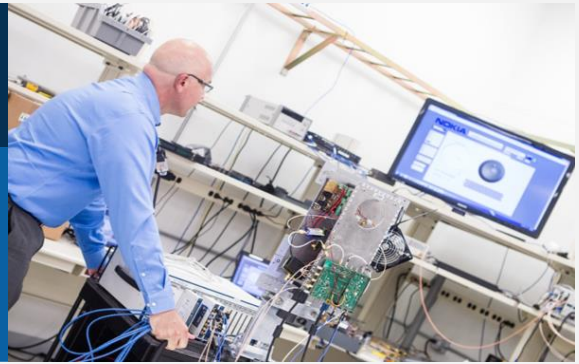
DARPA

Spectrum Collaboration Challenge

Nokia

First mmWave Prototypes

14.5 Gbps

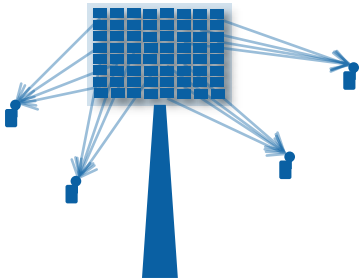


NATIONAL INSTRUMENTS

Prototyping Key Technologies to Drive 5G Standards

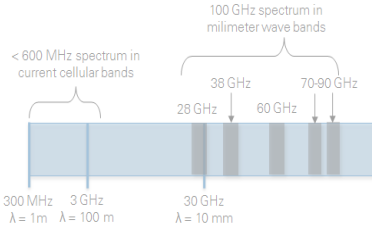
Massive MIMO

Dramatically increases number of antenna elements on base station to enable beamforming



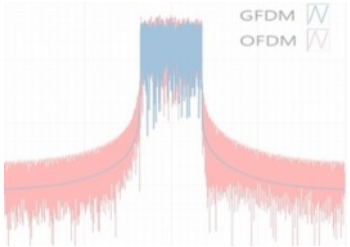
mmWave

Utilizes the potential of extremely wide bandwidths at frequency ranges once thought impractical for commercial wireless



Multi Radio Access Technologies (RAT)

Improve bandwidth utilization through evolving PHY Level and flexible numerology



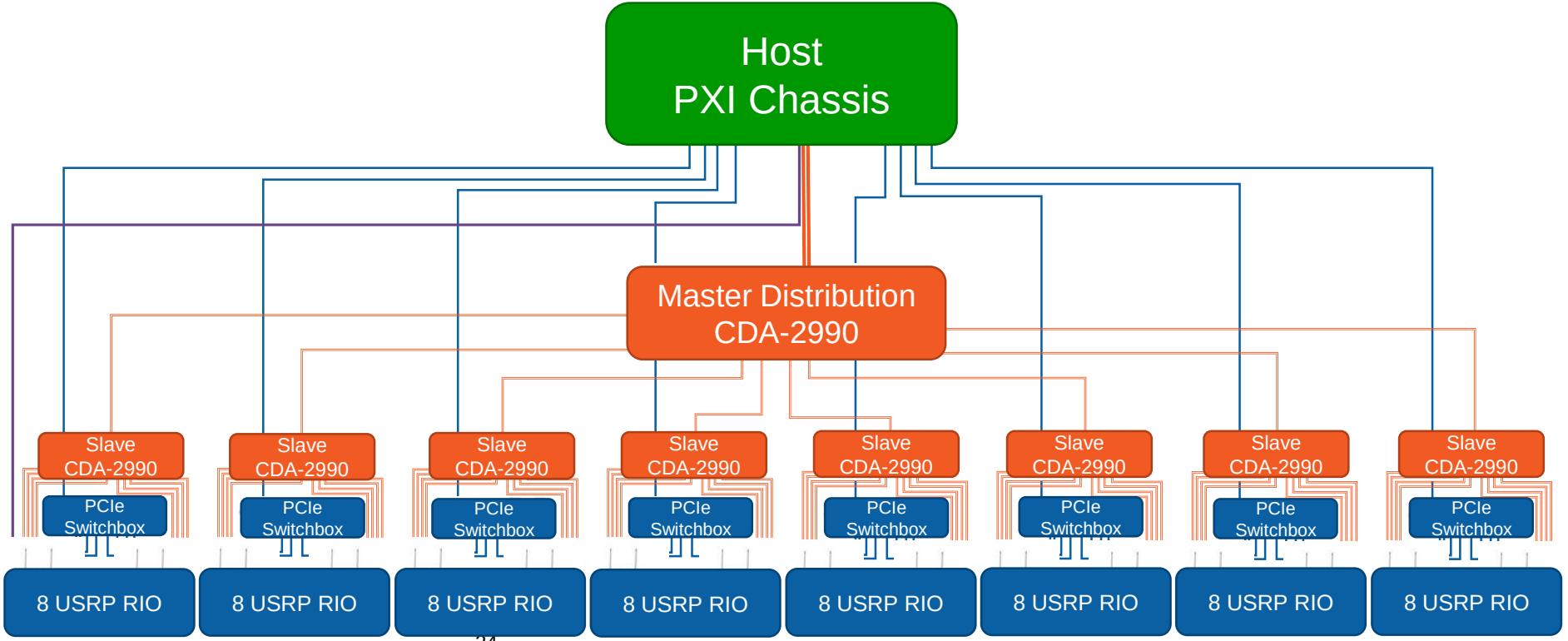
Wireless Networks

Offer consistent connectivity to meet the 1000X increase in traffic demand for 5G

- Densification
- NFV
- SDN
- CRAN

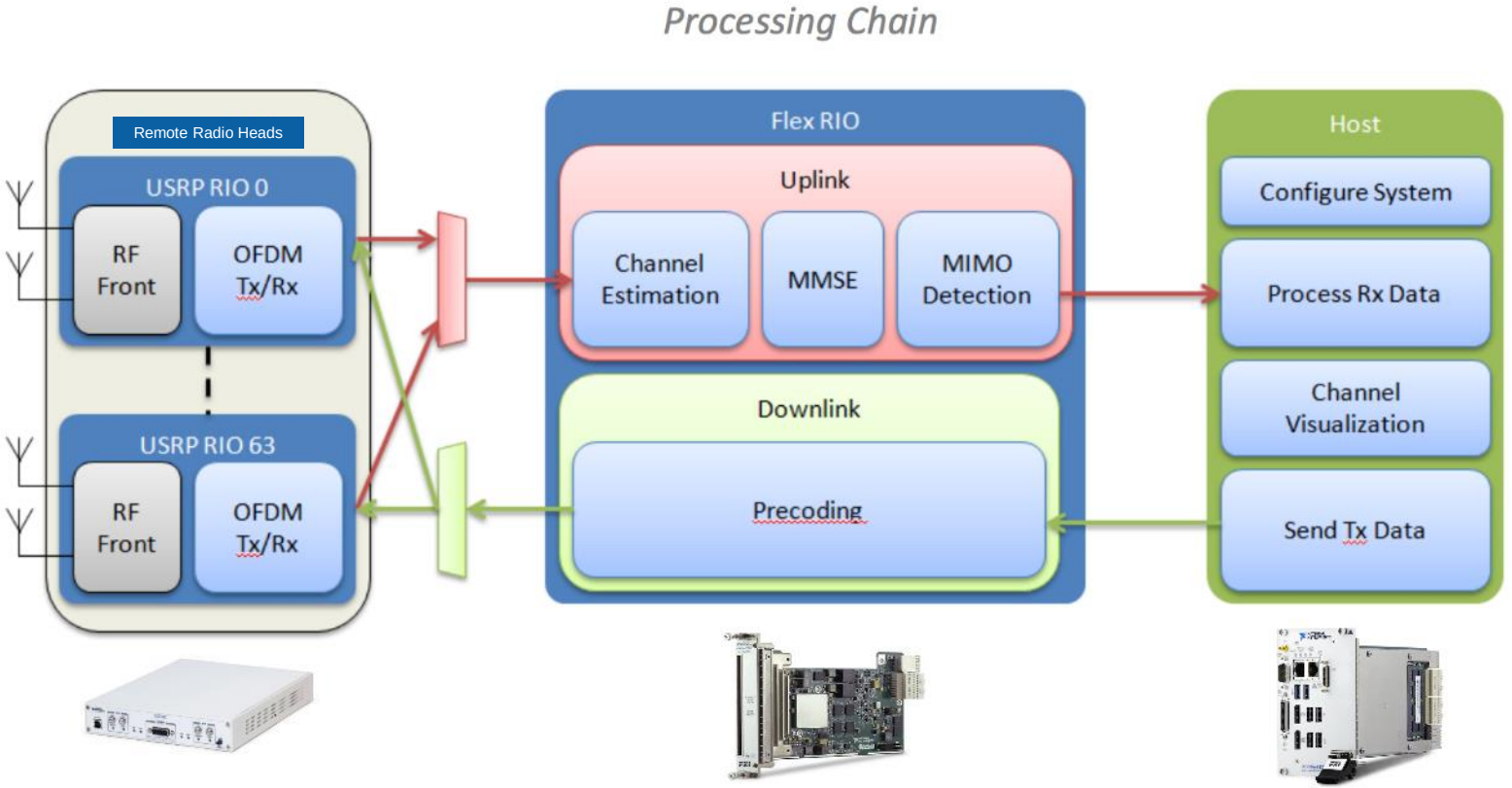
NATIONAL INSTRUMENTS

128 Channel System



NATIONAL INSTRUMENTS

Massive MIMO System Diagram



NATIONAL INSTRUMENTS

Massive MIMO Testbed Results

Facebook announces ARIES Testbed

71 bits/Second/Hz

96 Antennas, 24 Users

(USRP RIO, LV, Custom LV Code Base)

April 2016

Bristol Smashes Record Again

>146.4 bits/Second/Hz

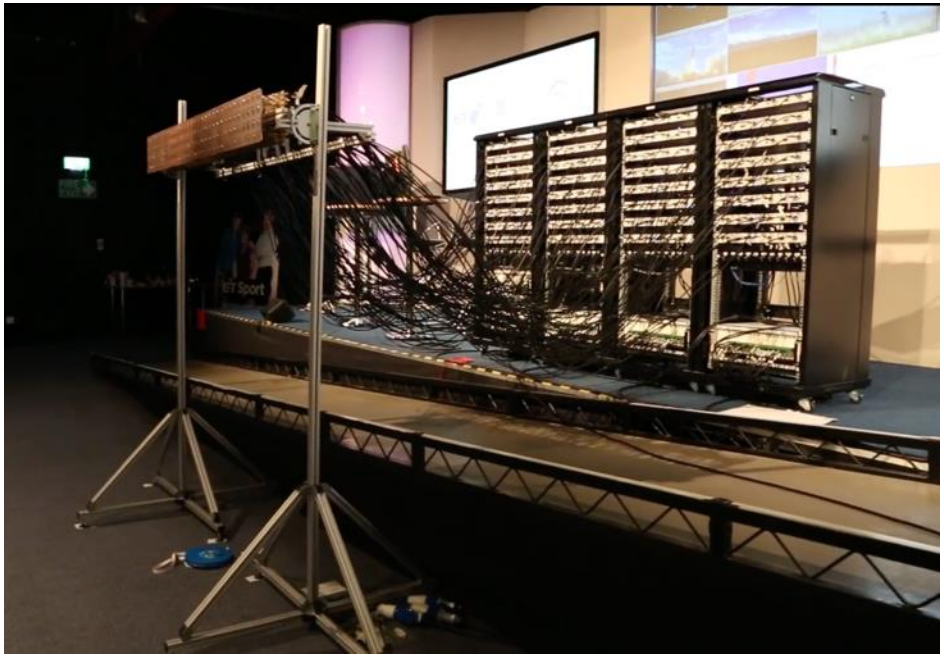
128 Antennas, 22 Users

(USRP RIO, LV, NI LU Code Base)

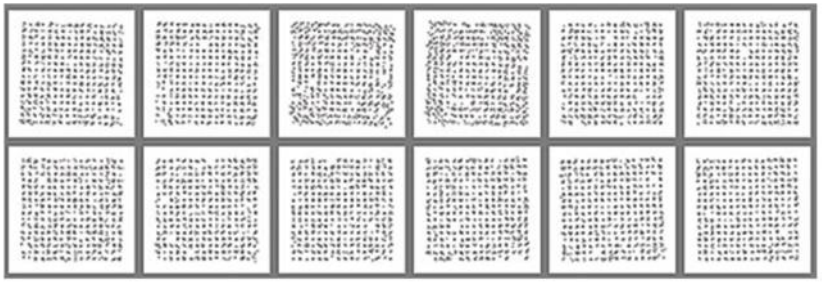
May 2016

NATIONAL INSTRUMENTS

Massive MIMO Testbed Results



Massive MIMO testbed setup for BT trials



Uplink constellation for up to 22 users

Sum rate of 1.59 Gb/s in 20 MHz bandwidth

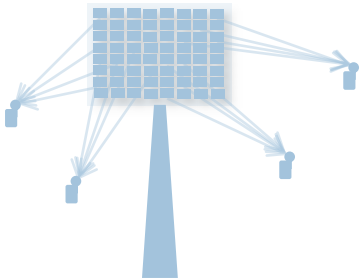
NATIONAL INSTRUMENTS

Full story: http://www.microwavejournal.com/articles/28974-from-mimo-to-massive-mimo

Prototyping Key Technologies to Drive 5G Standards

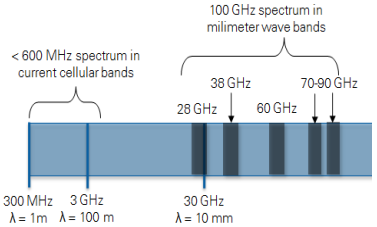
Massive MIMO

Dramatically increases number of antenna elements on base station to enable beamforming



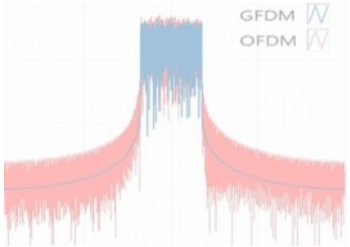
mmWave

Utilizes the potential of extremely wide bandwidths at frequency ranges once thought impractical for commercial wireless



Multi Radio Access Technologies (RAT)

Improve bandwidth utilization through evolving PHY Level and flexible numerology



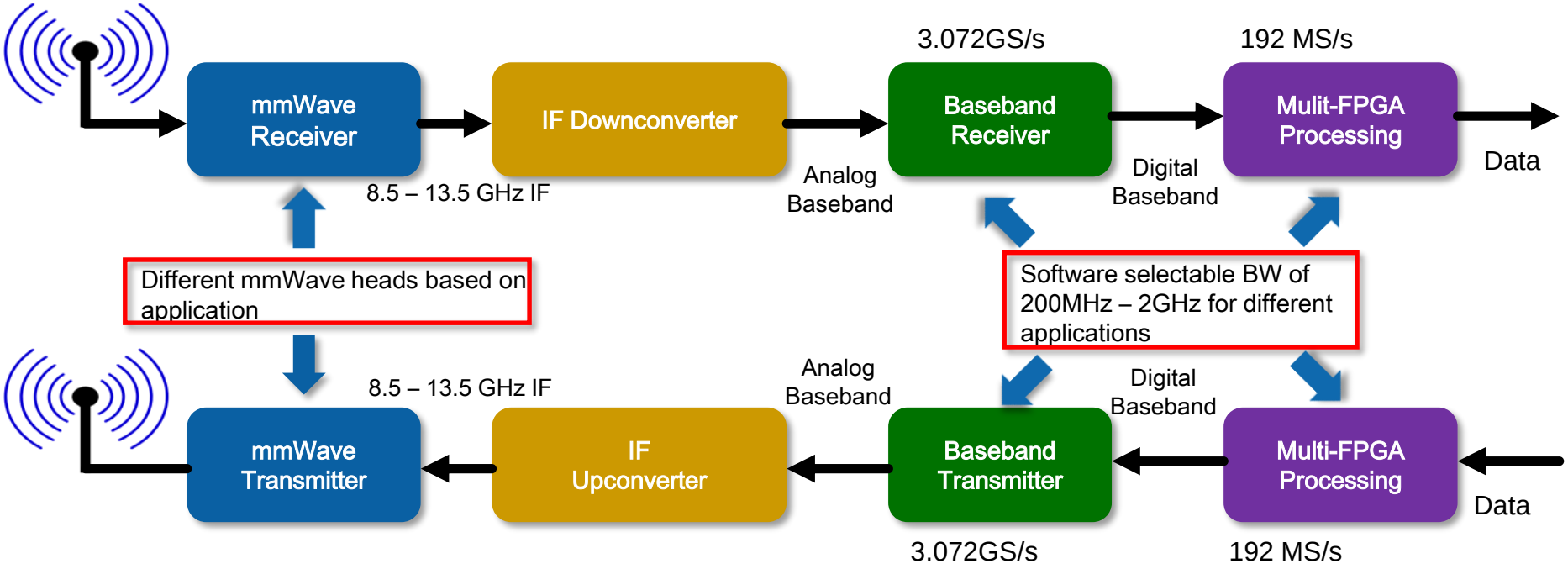
Wireless Networks

Offer consistent connectivity to meet the 1000X increase in traffic demand for 5G

- Densification
- NFV
- SDN
- CRAN

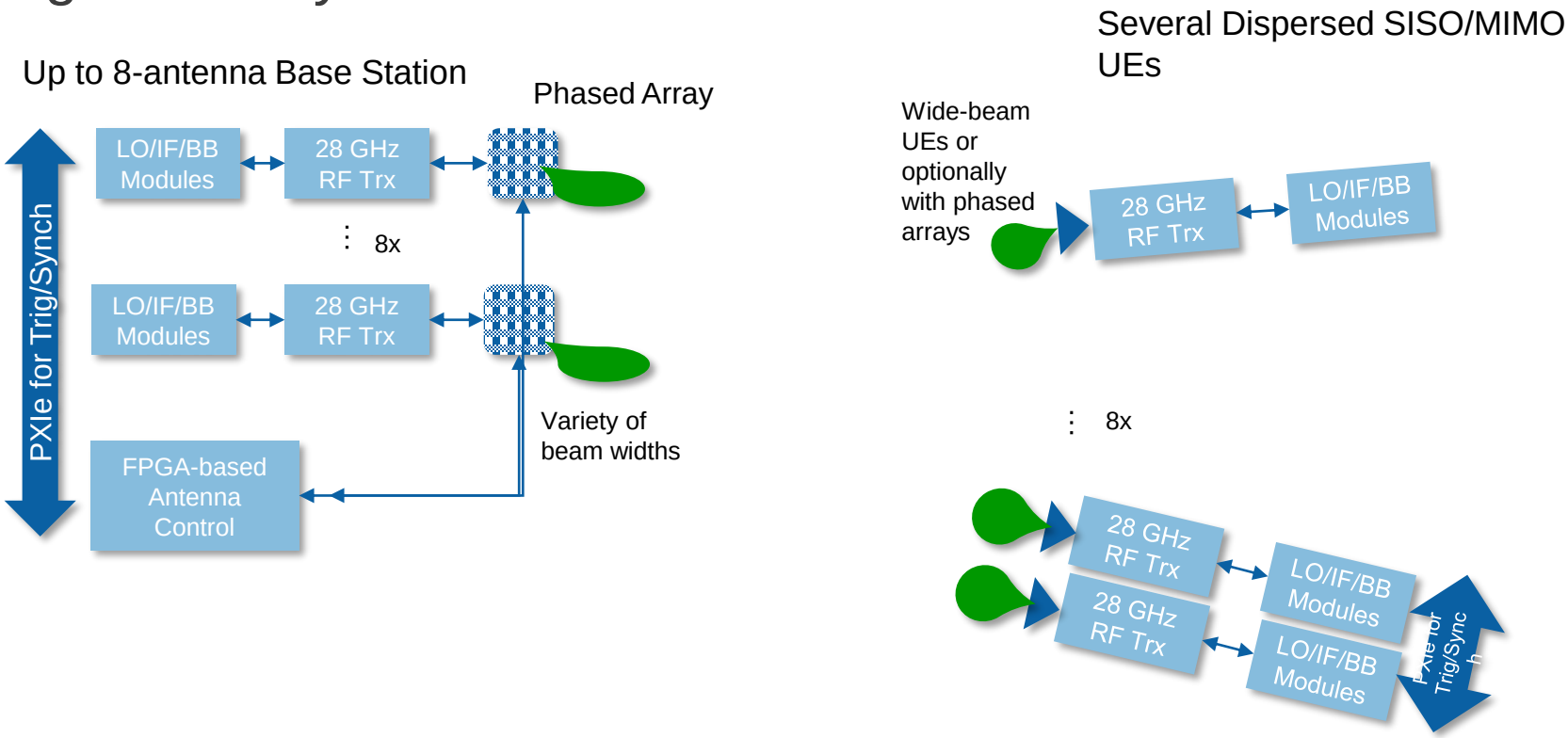
NATIONAL INSTRUMENTS

mmWave Transceiver System Diagram

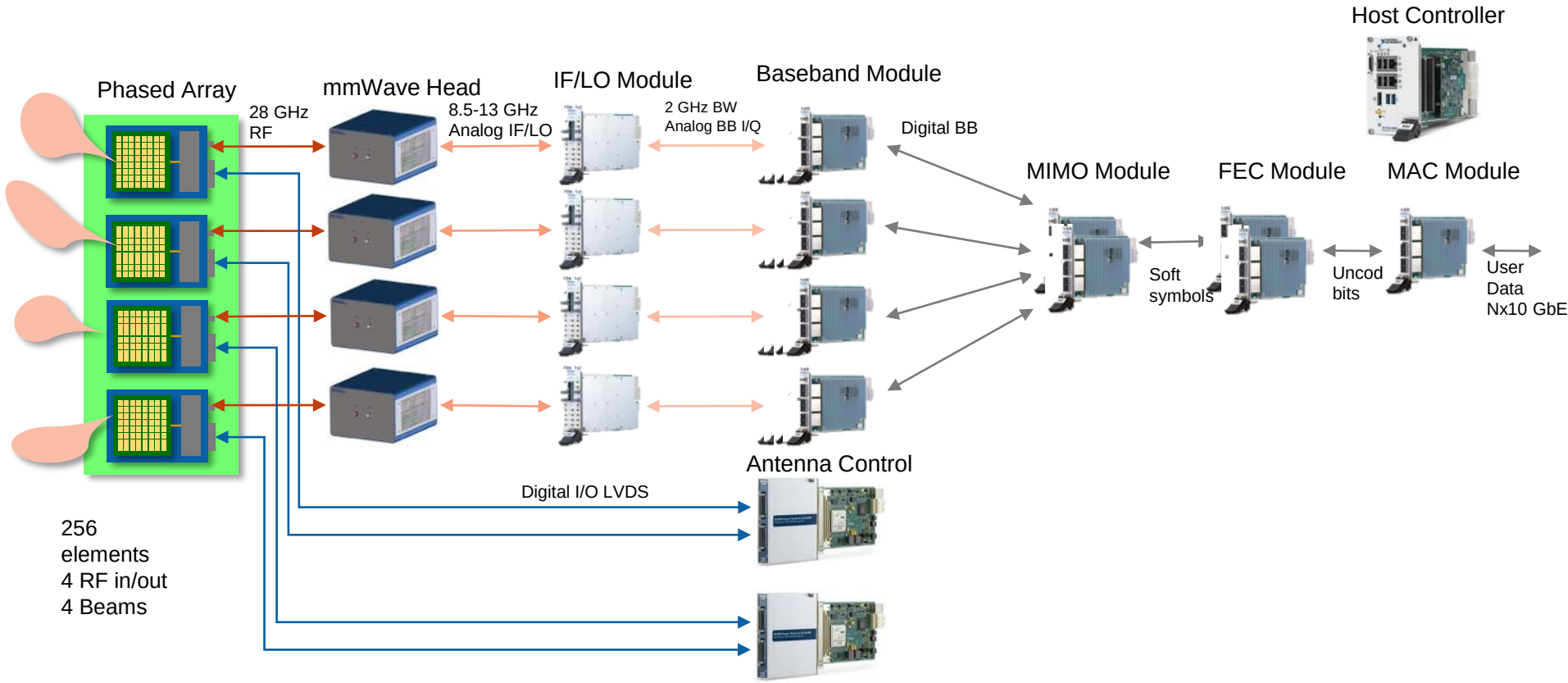


NATIONAL INSTRUMENTS

High-level System Architecture – NR



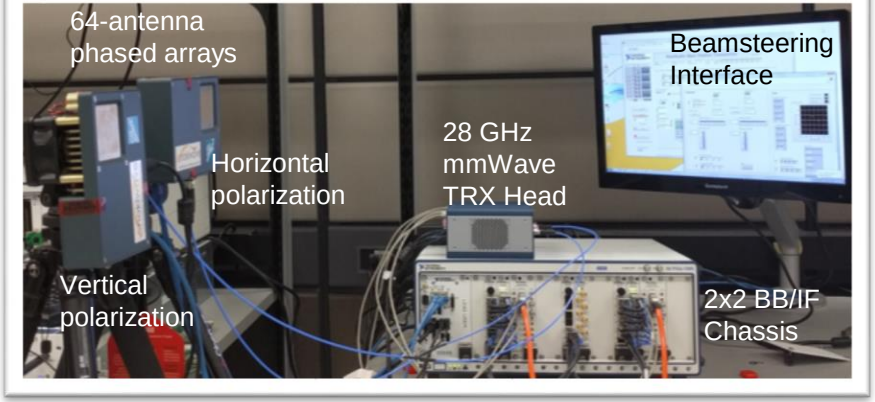
4-TRX mmWave MU-MIMO NR Base Station

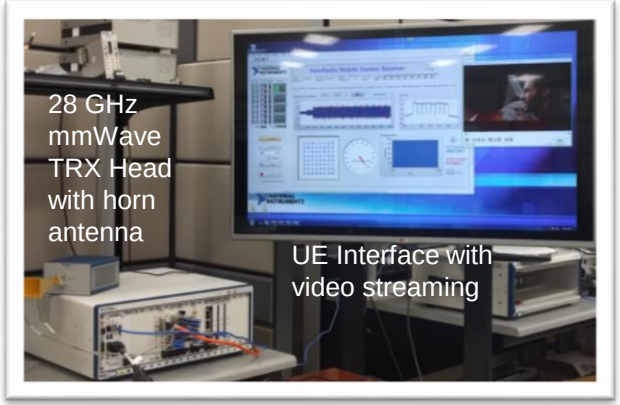


NATIONAL INSTRUMENTS

mmWave Testbed Results

28 GHz, 8x100 MHz OFDM, 2x2 MU-MIMO w/hybrid beamforming
2-Transceiver Base Station

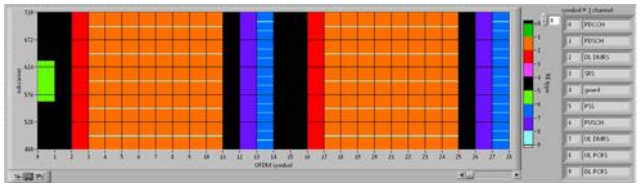




UE0:
64-QAM
2.9 Gbps

UE1:
16-QAM
1.8 Gbps

Dynamic TDD with self-contained subframe



NATIONAL INSTRUMENTS

mmWave Testbed Results

NOKIA Timeline w/ NI Platform

	Brooklyn 5G Summit 2014	NIWeek 2015	MWC 2016
Frequency	73 GHz	73 GHz	73 GHz
Bandwidth	1 GHz	2 GHz	2 GHz
Streams	1x1	2x2	2x2
Modulation	16 QAM	16 QAM	64 QAM
Peak rate	**2.3 Gbps**	**>10 Gbps**	**>14.5 Gbps**

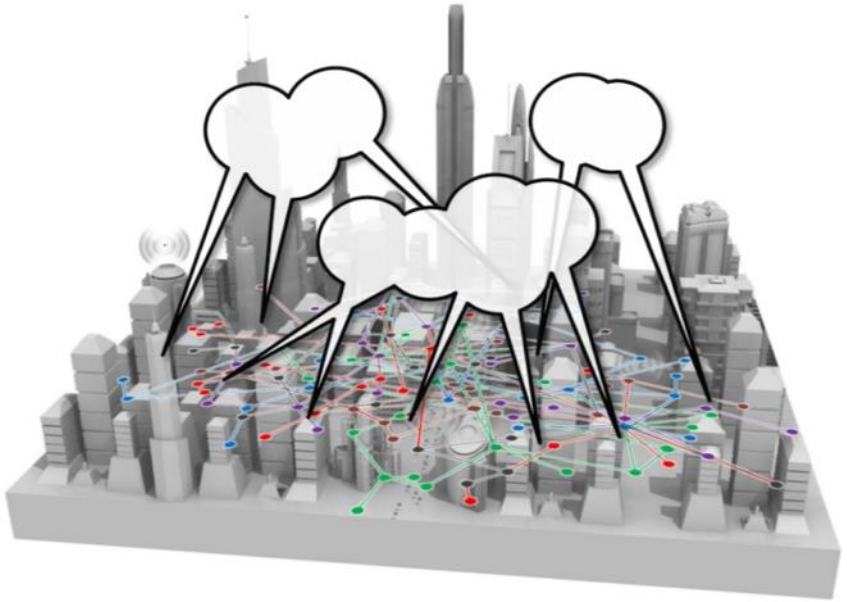
NATIONAL INSTRUMENTS

NATIONAL INSTRUMENTS

Spectrum Collaboration Challenge

The world's first collaborative machine-intelligence competition to overcome spectrum scarcity.

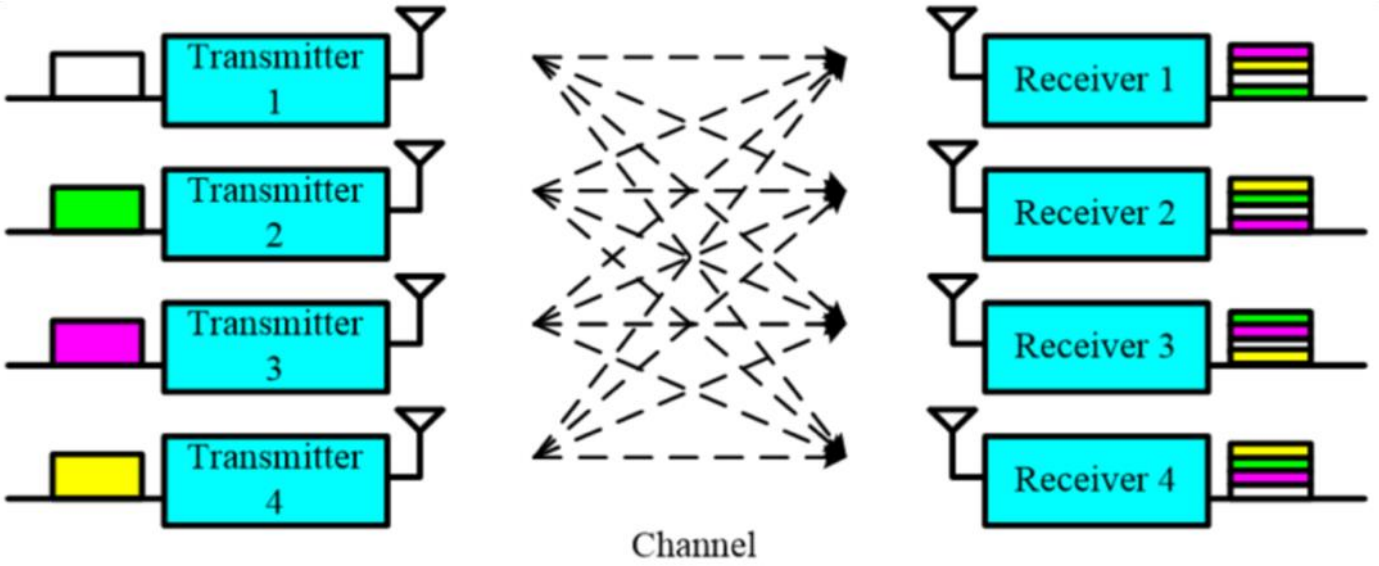
- An open **competition**
- To develop **radio networks**
- Which can thrive in the **spectrum without allocations**
- Which learn how to **adapt** across multiple degrees of freedom
- Which **collaboratively** optimize the total spectrum capacity, moment-to-moment



NATIONAL INSTRUMENTS

Colosseum is a Channel Emulator

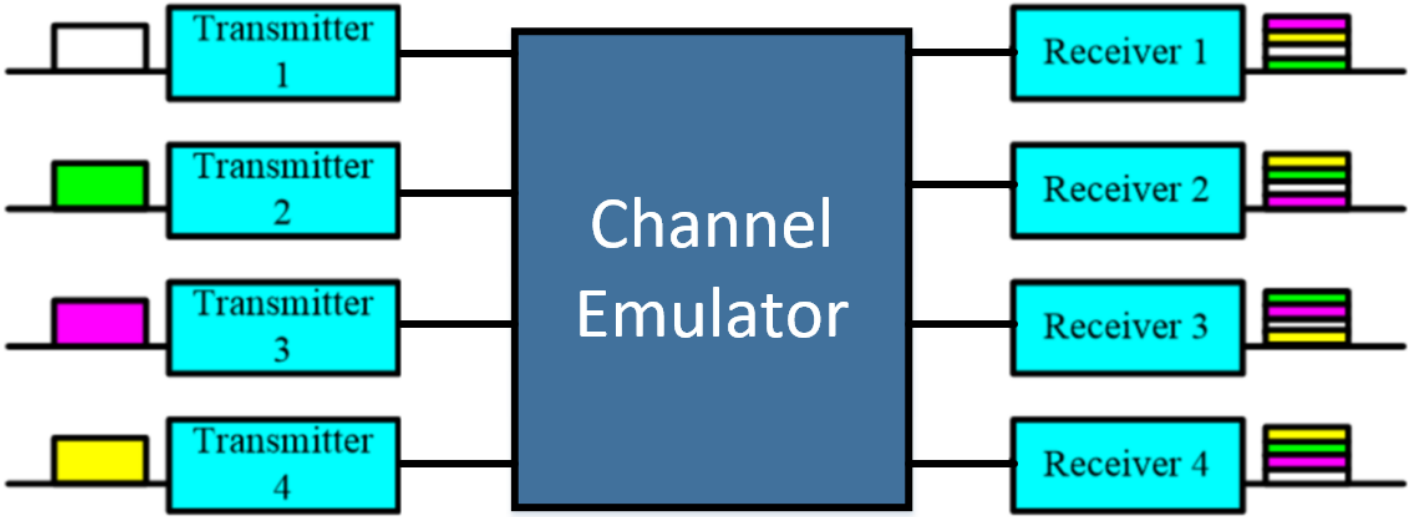
In a test environment, channel emulators replace the real-world radio channel between a radio transmitter and a receiver by providing a faded representation of a transmitted signal to the receiver inputs.



NATIONAL INSTRUMENTS

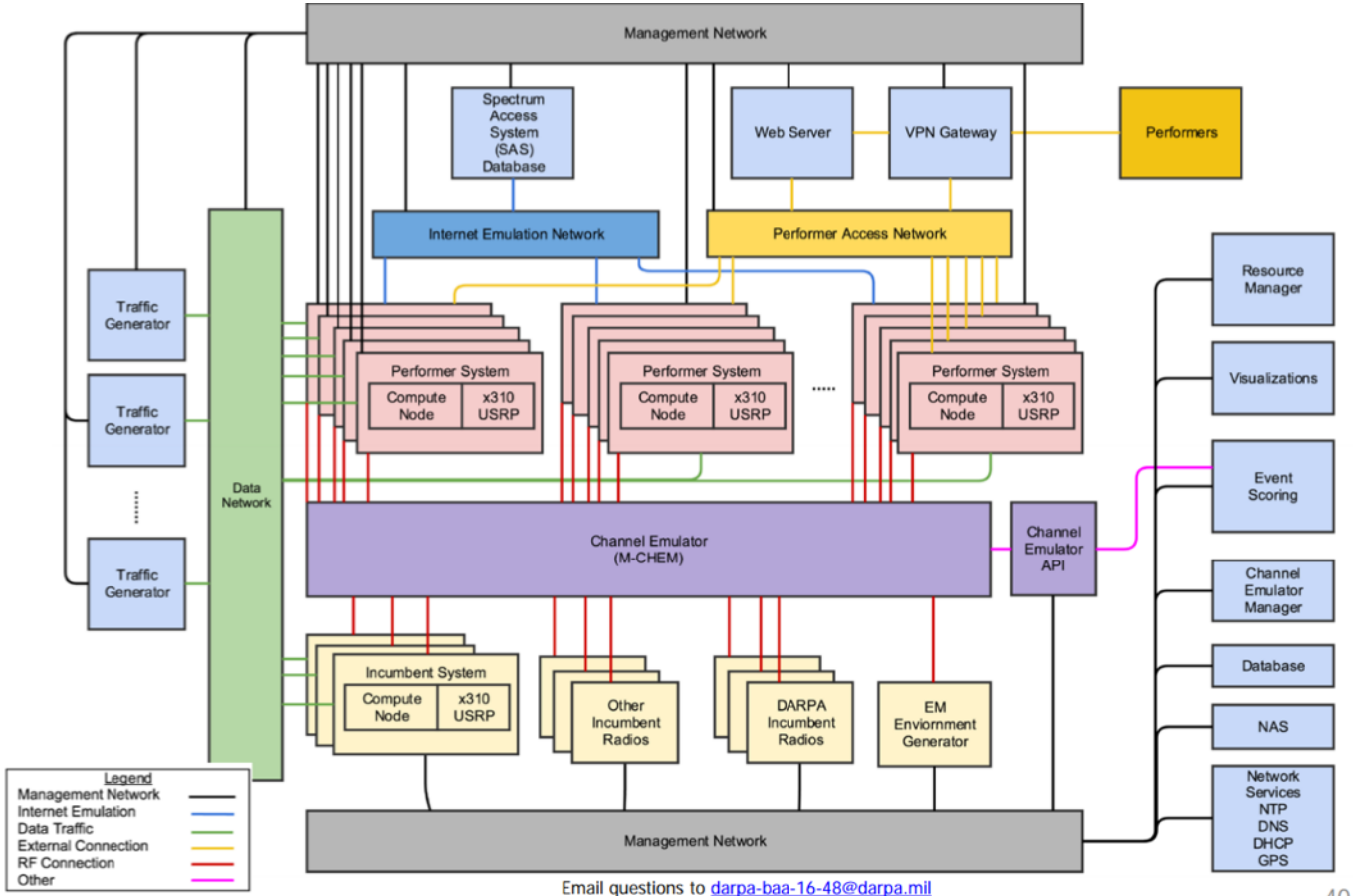
Colosseum is a Channel Emulator

In a test environment, channel emulators replace the real-world radio channel between a radio transmitter and a receiver by providing a faded representation of a transmitted signal to the receiver inputs.



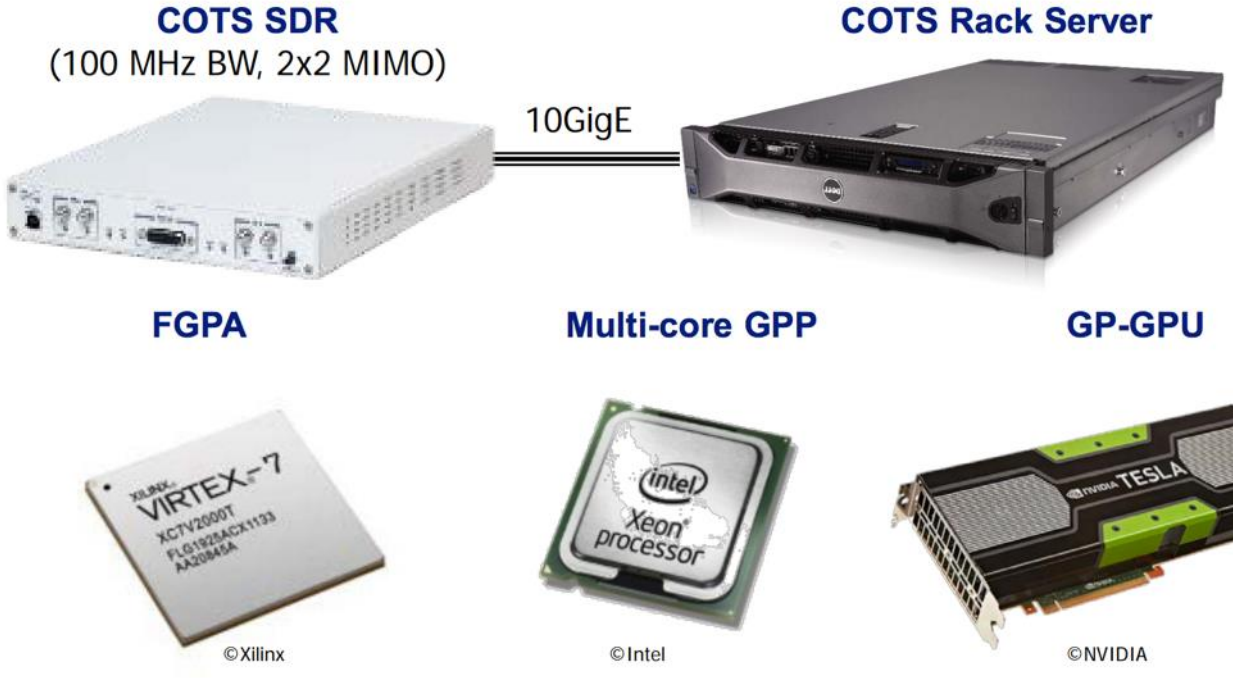
NATIONAL INSTRUMENTS

Colosseum Block Diagram



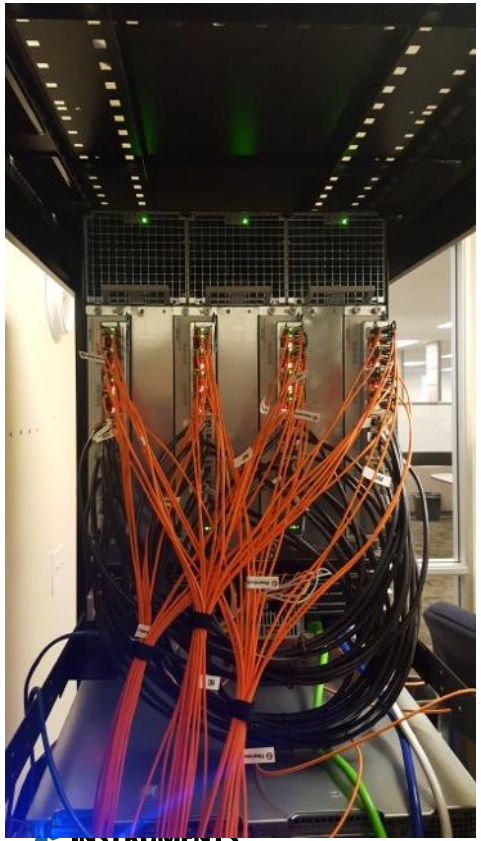
NATIONAL INSTRUMENTS

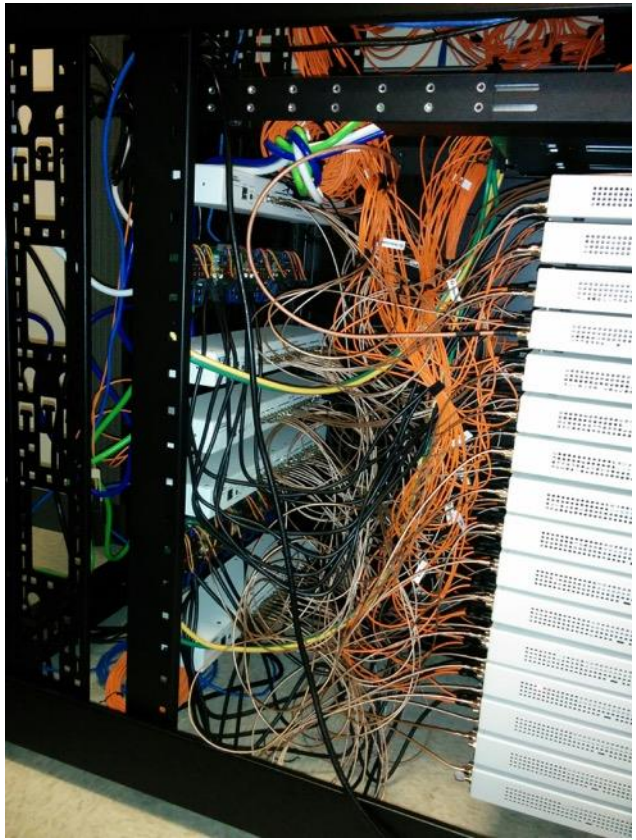
Standard Radio Node in Colosseum

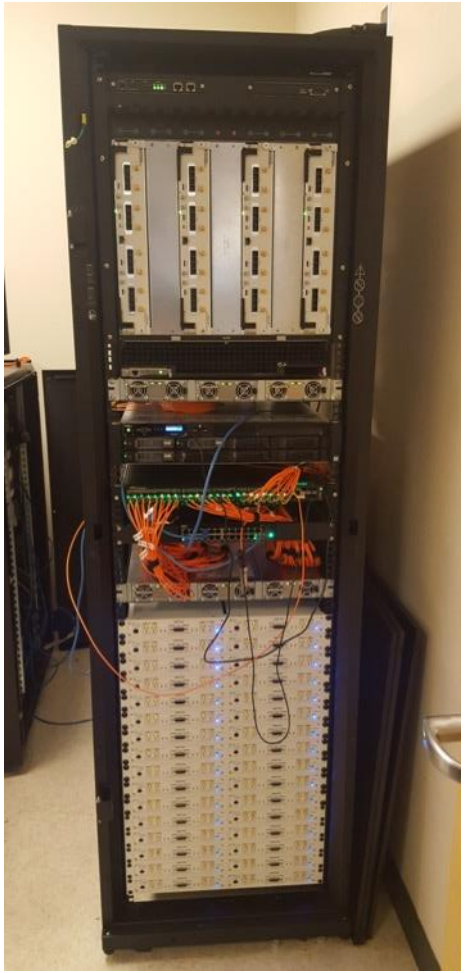


Radio design can take advantage of a heterogeneous processing architecture

Colosseum Hardware







SC2 Update

- Phase 1 hurdles to wrap up in December 2017
- Phase 2 registration is open until January 2018
- Want to learn more about joining?
  - Check out https://spectrumcollaborationchallenge.com

Questions