
NIDays

Richard Roberts
Technical Marketing Engineer
NI

What will the **Internet of Things** look like in five years time?


STANFORD
UNIVERSITY


NOKIA


industrial internet
CONSORTIUM


cisco


IBM


DELL


Ruckus


intel


GoPro


PTC

Wireless Communications

Industrial Systems

Consumer Technology

STANFORD UNIVERSITY

NOKIA

industrial internet CONSORTIUM

CISCO

IBM

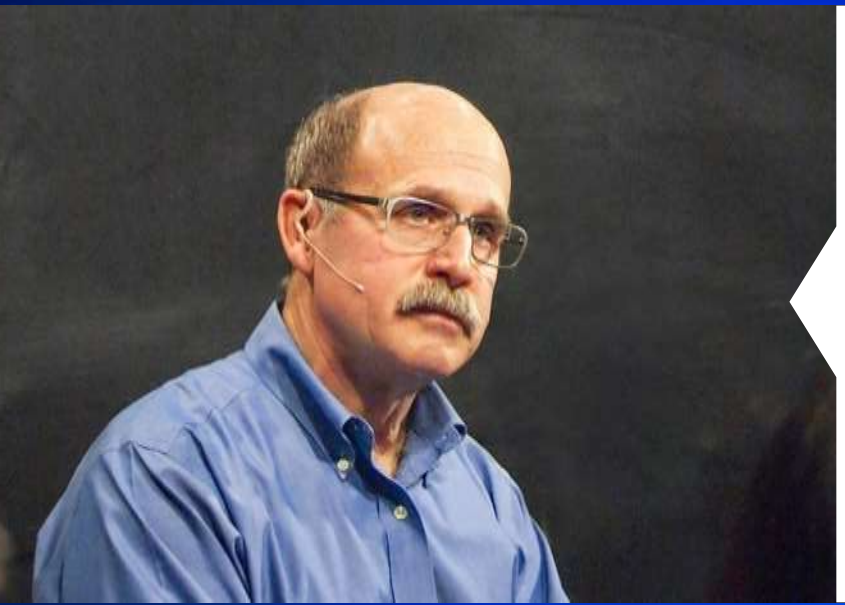
DELL

Ruckus

intel

GoPro

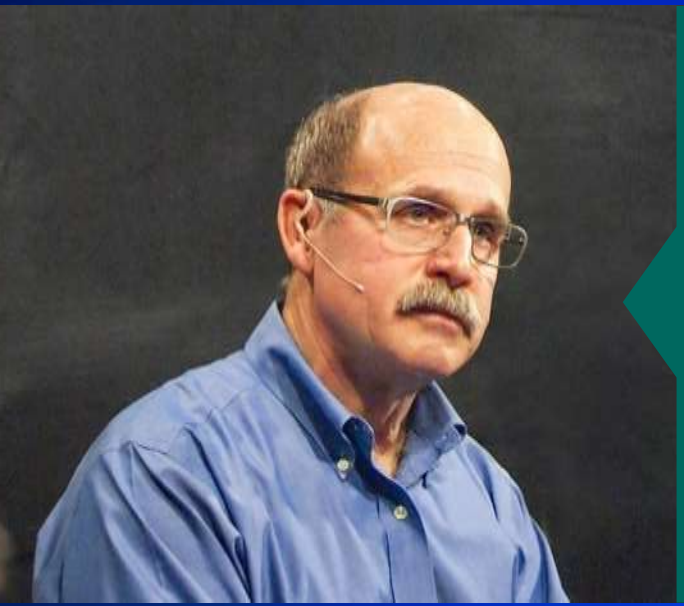
PTC



Paul Saffo

Futurist, Technology Forecaster, Consulting Professor in the School of Engineering at Stanford University

Stanford University



"The NI world is very innovative in that it uses many more sensors, is much more innovative, and is much more sophisticated than the process control. In revolutions like this, edges end up becoming centers of things."

—Paul Saffo, Futurist


nest
21

Smart Edge Device Architecture

SOLUTIONS AND PARTNER IP

NI PLATFORMS

COMMERCIAL TECHNOLOGIES

Kirtesh Mistry
Inside Sales Engineer
NI

ABB
Accenture
Altera Corporation
Analog Devices
Auburn University
Bosch
Dell
Deloitte LLP
Eclipse Foundation
Fujitsu Limited
Hewlett-Packard
Hitachi Ltd.
Honeywell
Huawei
Infineon Technologies
Jabil
Johns Hopkins
Kepware Technologies
LocalGrid Technologies
Micron Technology
Microsoft
MIT
Mitsubishi Electric
Moxa Inc.
NEC Corporation
Oracle
PTC Inc.
Purdue University
Putman Media
Real-Time Innovations
Red Hat
RPI
Rubicon Labs
Samsung
Siemens
Tech Mahindra
ThingWorx
Toshiba
Toyota Motor Sales
TTTech
Tyco
Vanderbilt University
Verisign, Inc

Industry Savings with 1% Efficiency Improvements

Industrial Internet Consortium Activities

Collaboration +

Business Usage Scenarios
Thought Leadership
Best Practices

Interoperability +

Frameworks
Standards
Open Engineering Technology

Testbeds

Experimentation
Real-World Scenarios
Proven Architectures

Products
Architectures
Methodologies

Condition Monitoring and Predictive Maintenance Testbed

industrial internet CONSORTIUM

NATIONAL INSTRUMENTS

IBM

> “IBM will invest $3 billion over the next four years to establish a new Internet of Things (IoT) unit.”
>
> —IBM, March 2015

Evolution of Maintenance Strategy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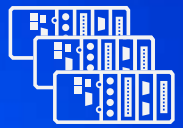
Technical Challenges

Cloud Integration

Interoperability

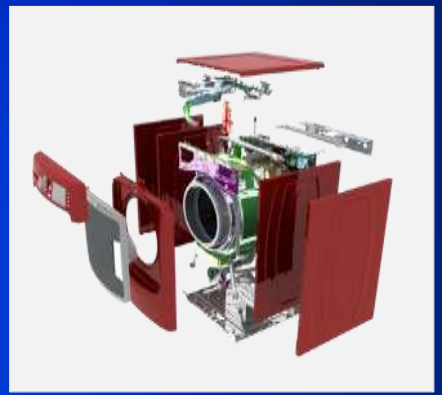
Security



Scalability

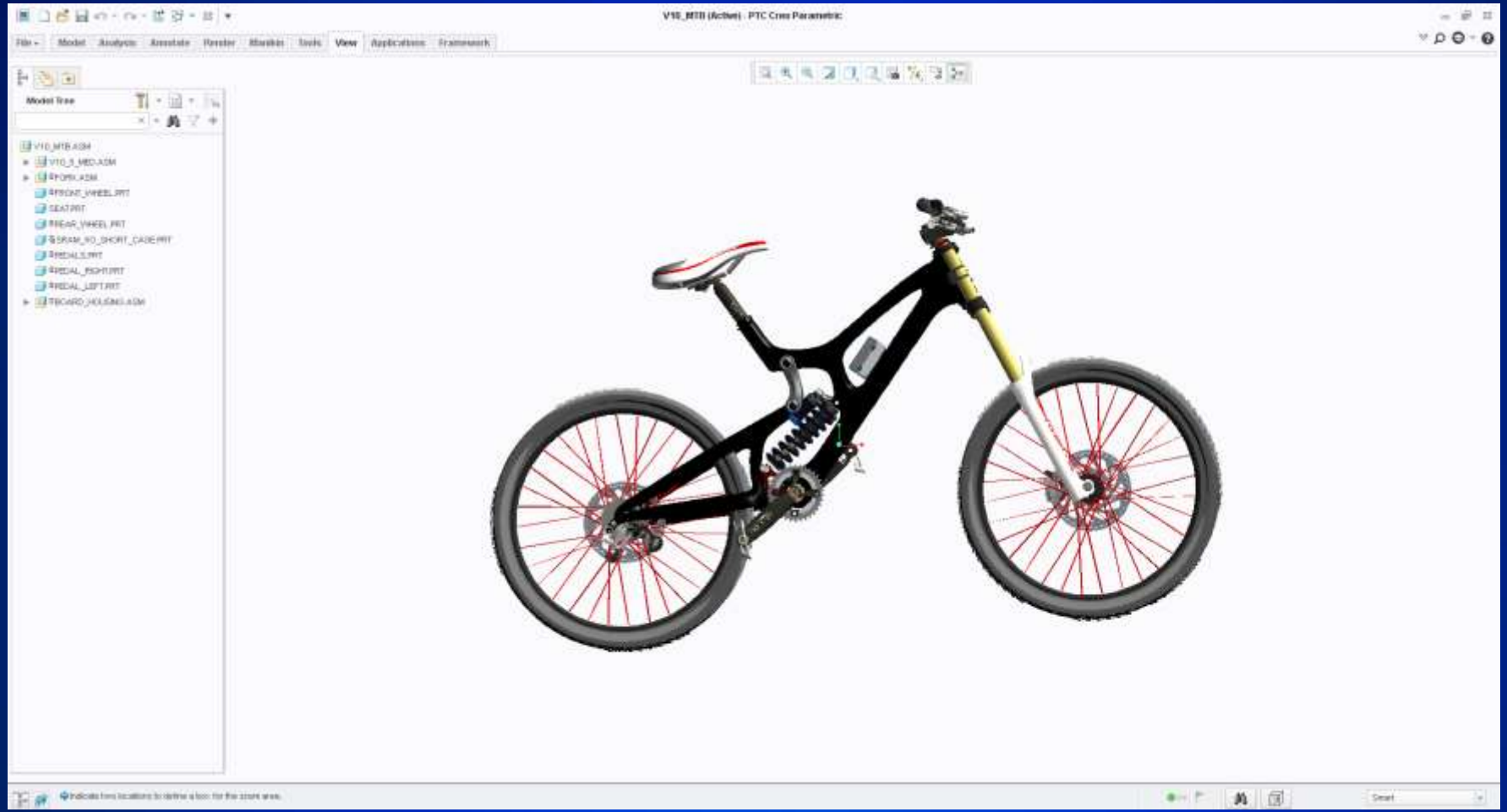
End-to-End Analytics

Matthew Surridge
Applications Engineer Team Leader
NI



NI and PTC End-to-End IoT Solution


6.94
.023


V10_MTB (Active) - PTC Creo Parametric
File
Model
Analysis
Annotate
Render
Manikin
Tools
View
Applications
Framework
Model Tree
V10_MTB.ASM
V10_S_MED.ASM
FORK.ASM
FRONT_WHEEL.PRT
SEAT.PRT
REAR_WHEEL.PRT
SRAM_XO_SHORT_CAGE.PRT
PEDALS.PRT
PEDAL_RIGHT.PRT
PEDAL_LEFT.PRT
TBOARD_HOUSING.ASM
Smart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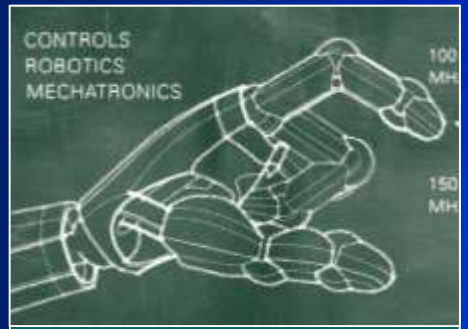
STUDENT DESIGN COMPETITION



System-Level Design

Industry Grade Tools

Raw Creativity

MedSIM

University of Leeds
A Haptic Simulator
for Medical Training

Balancing Bicycle

Tsinghua University
Auto-Balancing
Hybrid Electric Bicycle

Scalevo

ETH Zürich
Stair Climbing
Electric Wheelchair

MedSIM

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A Haptic Simulator
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Auto-Balancing
Hybrid Electric Bicycle

Scalevo

ETH Zürich
Stair Climbing
Electric Wheelchair


DRIVERS WELCOME
7
DIAL 7
7

2000

Rapid Evolution of Standards

Wi-Fi

802.11a/b

Mobile

GSM/GPRS
CDMA2k

Personal Networks

Bluetooth

2005

Rapid Evolution of Standards

Wi-Fi

802.11a/b
802.11g

Mobile

GSM/GPRS
CDMA2k
EDGE
WCDMA
HSPA
EV-DO Rev 0

Personal Networks

Bluetooth
UWB
BT EDR
ZigBee
UWB
Z-Wave
Wireless USB 1.0

2010

Rapid Evolution of Standards

Wi-Fi

802.11a/b
802.11g
802.11n

Mobile

GSM/GPRS
CDMA2k
EDGE
WCDMA
HSPA
EV-DO Rev 0
HSPA+
EV-DO Rev A
LTE

Personal Networks

Bluetooth
UWB
BT EDR
ZigBee
UWB
Z-Wave
Wireless USB 1.0
BT HS
ZigBee Pro
Wireless USB 1.1

2015

Rapid Evolution of Standards

Wi-Fi

802.11a/b
802.11g
802.11n
802.11ac
802.11ax
802.11ad
802.11af

Mobile

GSM/GPRS
CDMA2k
EDGE
WCDMA
HSPA
EV-DO Rev 0
HSPA+
EV-DO Rev A
LTE
Evolved Edge
HSPA+ Advanced
DO-Advanced
LTE-Advanced
5G

Personal Networks

Bluetooth
UWB
BT EDR
ZigBee
UWB
Z-Wave
Wireless USB 1.0
BT HS
ZigBee Pro
Wireless USB 1.1
NFC
BT LE

Joao Vieira
PhD Student
Lund University

Massive MIMO in Practice

- from theory to proof-of-concept

Joao Vieira – PhD student, Lund University, Sweden

MAMMOET Consortium

LUND UNIVERSITY

Project members at Lund University

Wireless Communication ⟷ Circuit design

Fredrik Rusek
Assoc. Professor
Comm. theory and algorithm design

Fredrik Tufvesson
Professor
System design and propagation

Ove Edfors
Professor
System and algorithm design

Viktor Öwall
Professor
Digital circuit design

Liang Liu
Asstn. Professor
Baseband processing and circuit design

Erik Bengtsson
PhD stud.
Propagation and Antenna design

Joao Vieira
PhD stud.
Propagation and radio systems

Hemanth Prabhu
PhD stud.
Precoding and distrib. processing

Steffen Malkowsky
PhD stud.
Digital circuits and processing

Massive MIMO TDD illustration

Let us understand massive MIMO in **2 minutes**!

Massive MIMO theoretical claims

"Technology to handle orders of magnitude more data traffic!"

"Focus energy into ever smaller regions of space to bring huge improvements in throughput and radiated energy efficiency!"

"Linear processing is able to provide near-optimal performance!"

...

We need a testbed to take the next steps towards realizing massive MIMO!

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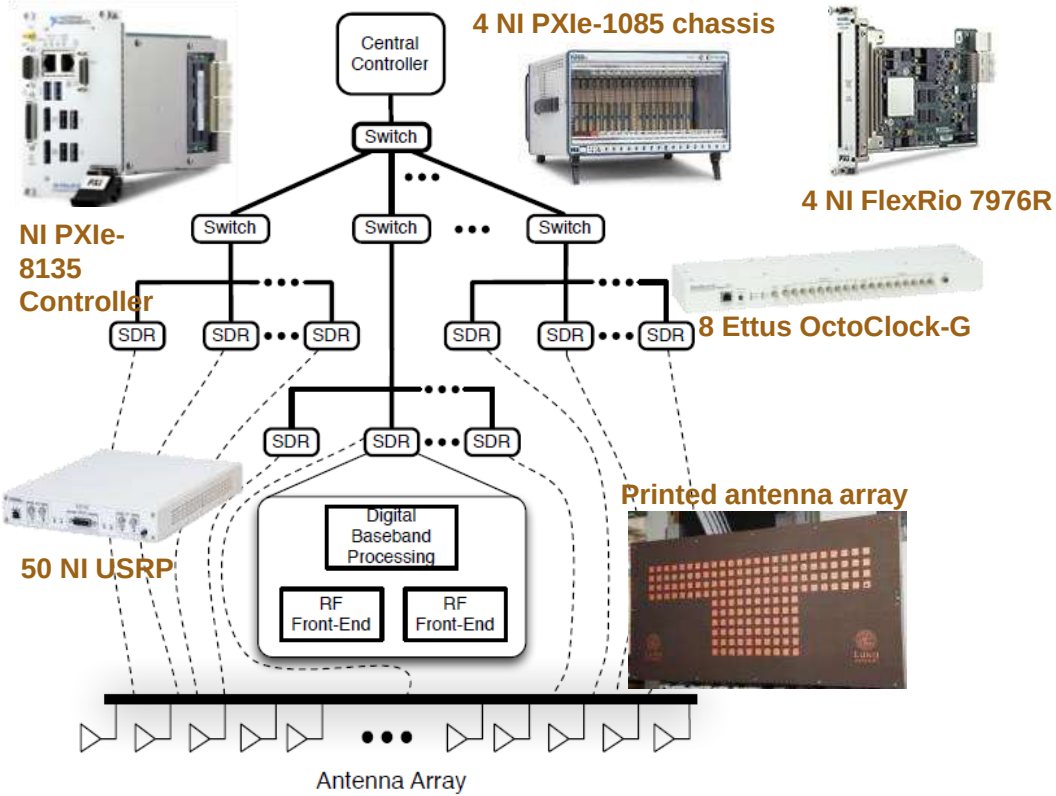
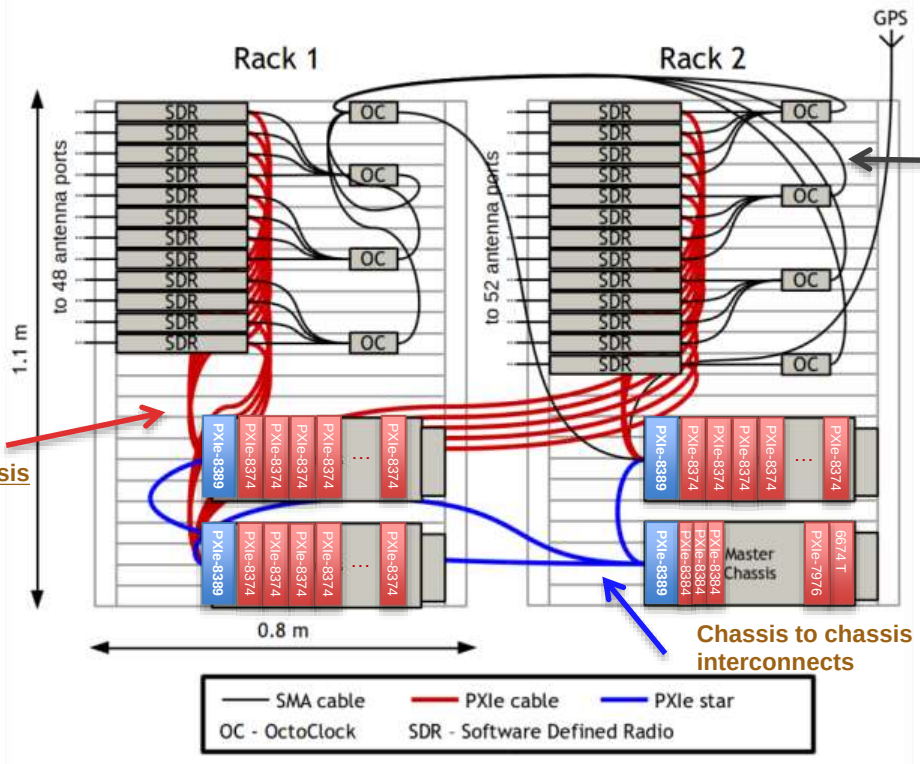
System component & architecture



BS hardware setup: side-view



Base station assembly

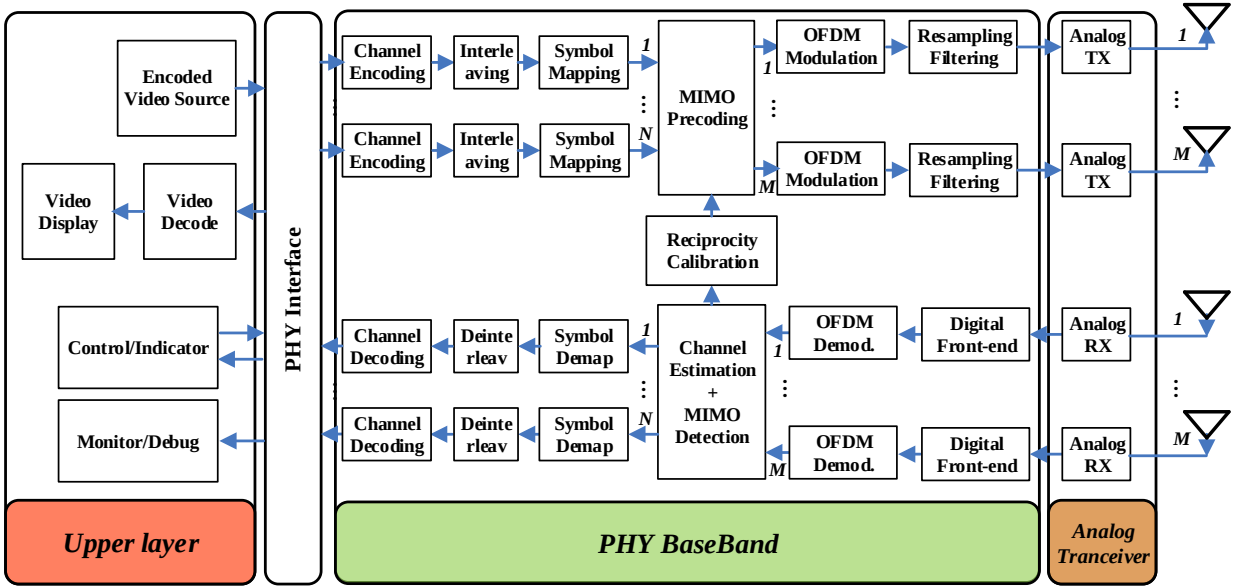
User-equipment

Proof-of-Concept

LTE-like OFDM TDD Massive MIMO

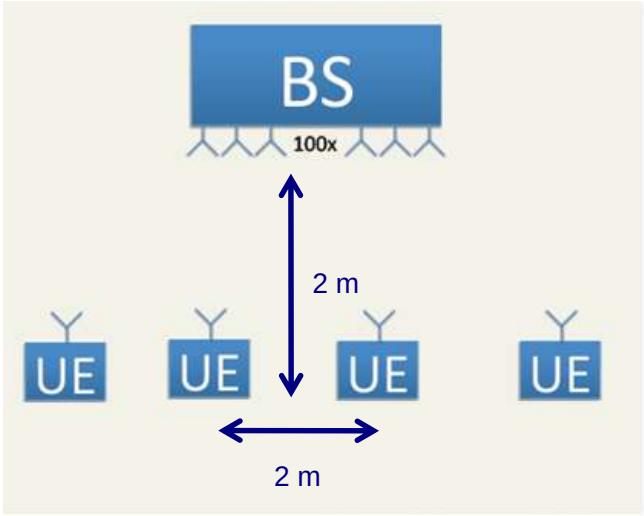
Parameter	Variable	Value
Bandwidth	W	20 MHz
Carrier frequency	f_c	3.7 GHz
Sampling Rate	F_s	30.72 MS/s
FFT Size	N_{FFT}	2048
# Used subcarriers	N_{used}	1200
Slot time	T_S	0.5 ms
Sub-Frame time	T_{sf}	1 ms
Frame time	T_f	10 ms
# UEs	K	10
# BS antennas	M	100

Step1: Uplink with host processing



Some results

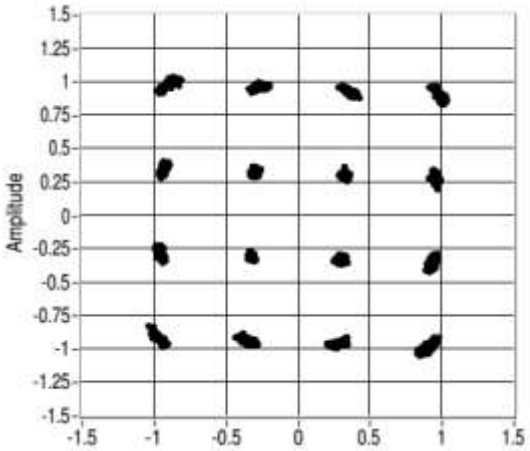
Received signal constellations – LOS & four users 2 m separation



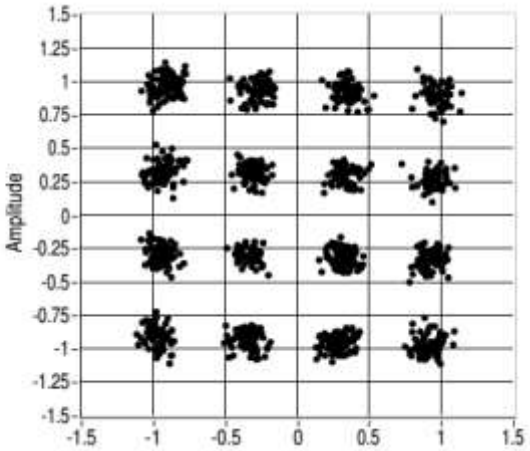
Some results

Received signal constellations – LOS & four users 2 m separation

ZF detector



MRC detector



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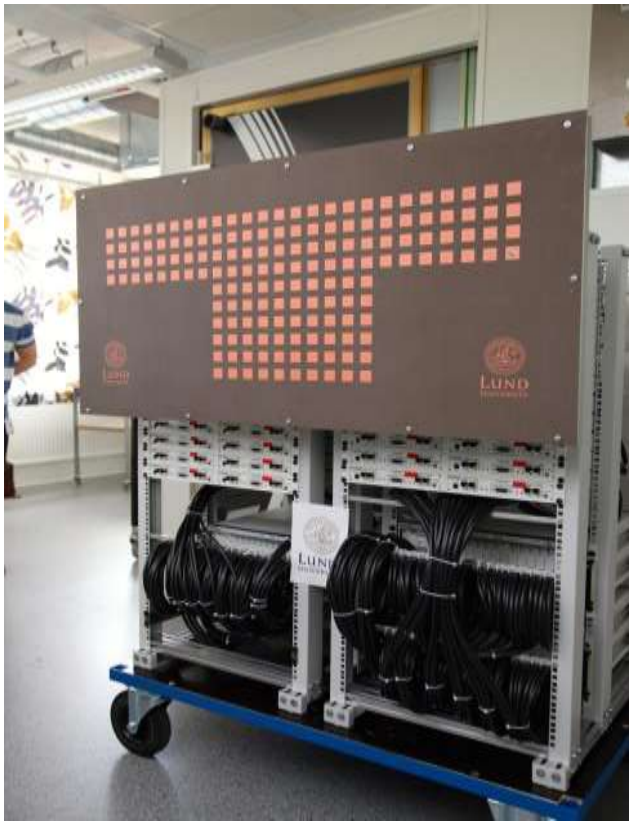
Summary



- Flexible architecture based on NI platform and software radios
- 100 frequency coherent RF chains
- Supports 10 simultaneous single antenna users in the *same* time-frequency resource block
- Real time operation in the 3.7 GHz band, 20 MHz bandwidth
- More at: http://www.eit.lth.se/mamitheme
- Taking Massive MIMO from the lab to reality.

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NOVATOR
SOLUTIONS


NATIONAL
INSTRUMENTS
Gold
Alliance
Partner

Thanks To Our Exhibition Partners

AddQ Consulting
C.A.G. Senseus
Columbia
Etteplan
Novator Solutions
Omniray
Prevas
SEMA-TEC
WireFlow


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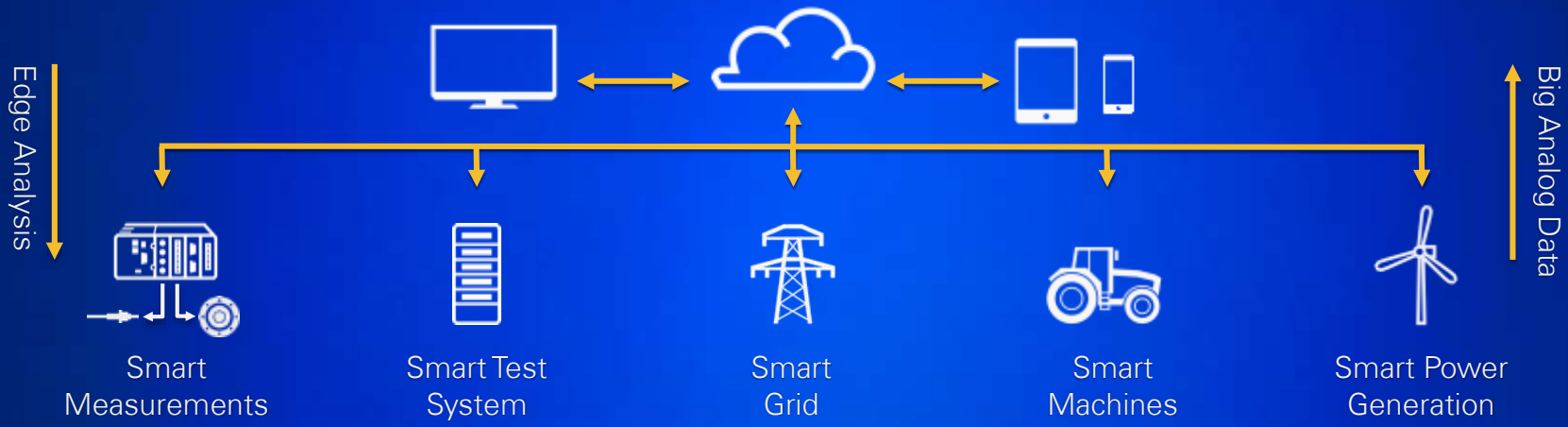
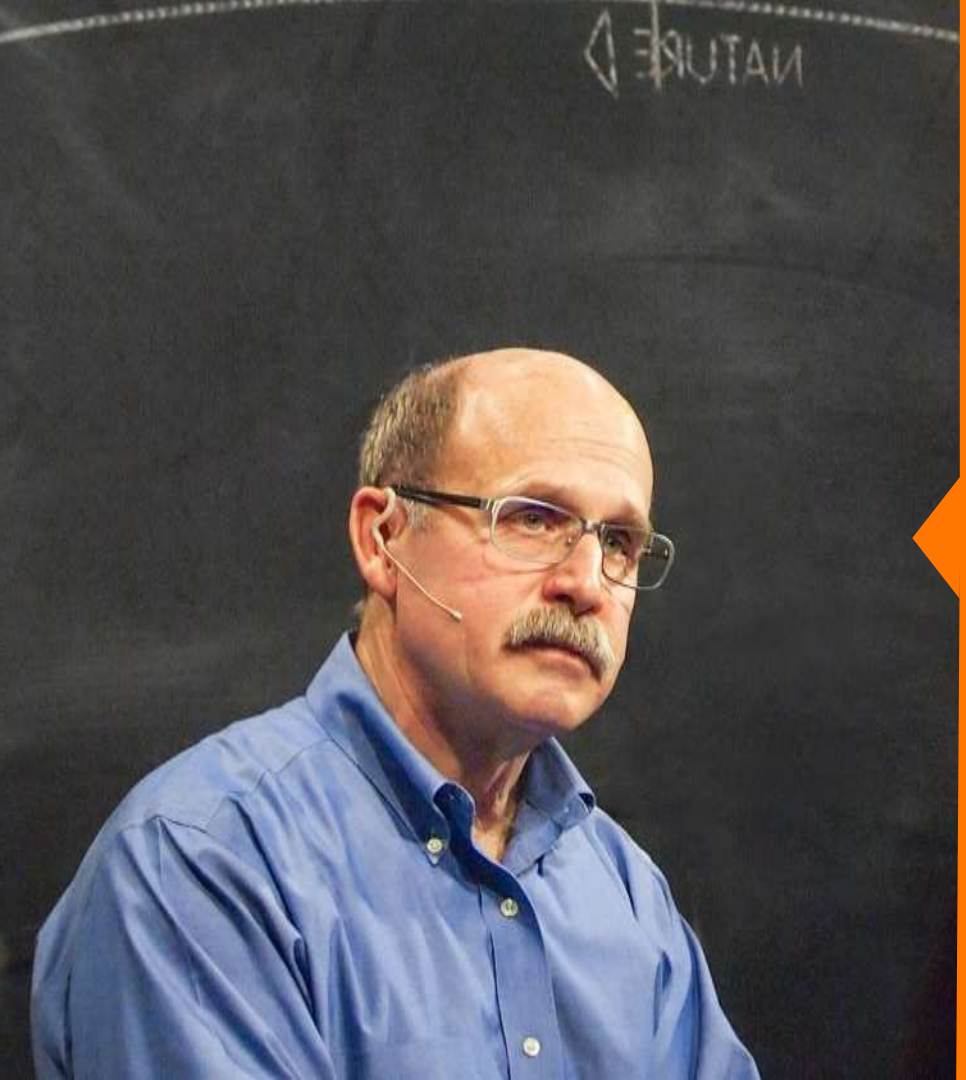
Internet of Things
The New Industrial Revolution





“Uncertainty is going to be as huge as opportunity, and it’s going to take every bit of your visionary skill, your management skill, and your technical vision to take advantage of what is about to happen.”

Paul Saffo, Futurist

> “The Industrial Internet is indeed transformative. It will change the basis of competition, redraw industry boundaries, and create a new wave of disruptive companies”
>
> World Economic Forum

You and NI will create the **Internet of Things**.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