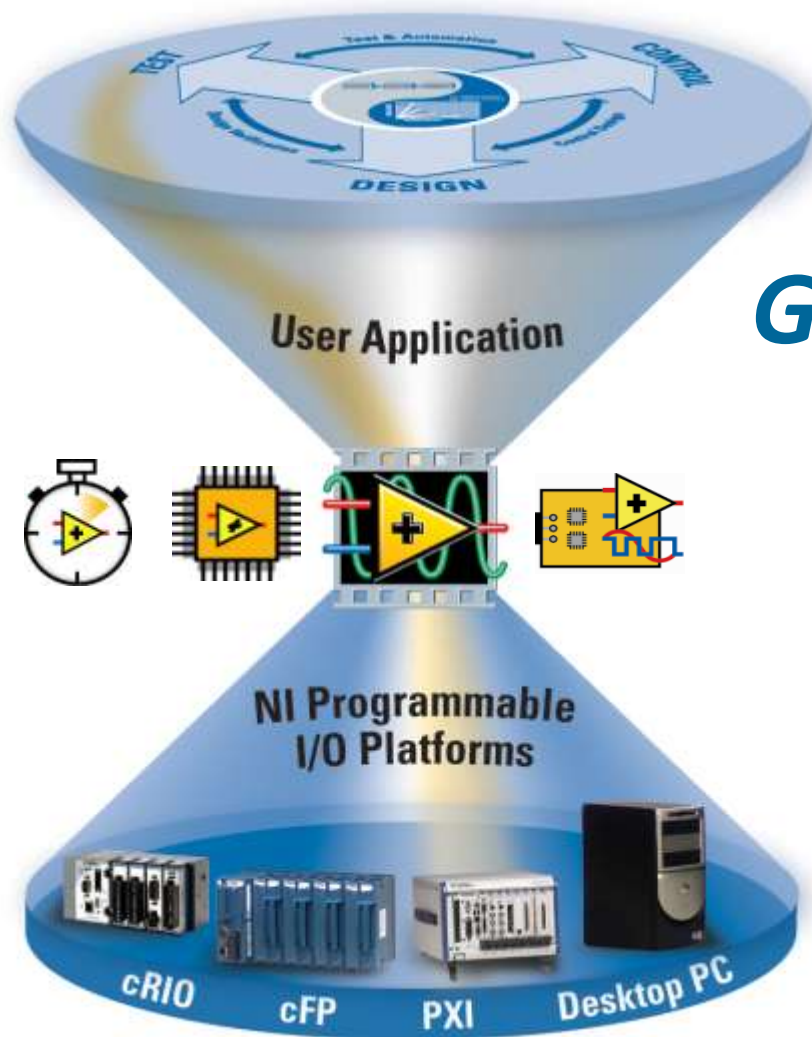


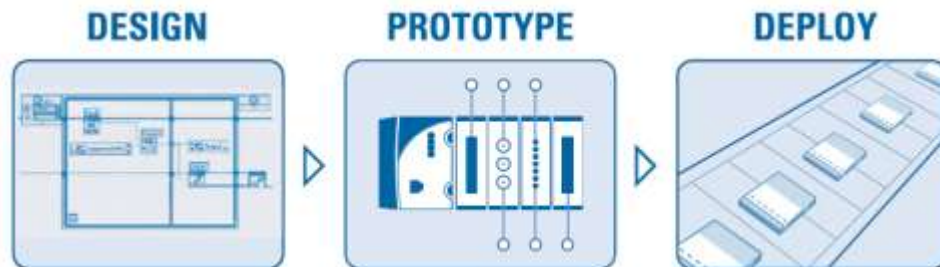
# NI Days 2009

Drammen, Norway

# Virtual Instrumentation *Evolved ...*



## *Graphical System Design*



# Charles Schroeder

## R&D Section Manager, FPGA-based products for Test

- As a section manager in research and development, Charles Schroeder is responsible for the business strategies, architectures, and product development of test products that combine cutting-edge measurement technologies with user programmable FPGAs.
- Schroeder joined NI in 1993 and has held several positions in the company. He began his career as a hardware design engineer and has since held R&D leadership positions in several product areas.
- In his current role, he is working to combine his knowledge of customer applications and needs with his deep understanding of FPGA technologies to re-write the “rules” of the test industry, allowing test customers to define their own measurement hardware through the programming model of LabVIEW FPGA.
- Schroeder is a co-holder of several patents and an author of several technical papers. He has both Bachelor’s and Master’s degrees in Electrical Engineering from Texas A&M University.

# Leveraging Technologies to Solve the Next Generation of Engineering Challenges

Charles Schroeder  
R&D Section Manager

NIDays 2009

# Engineering Grand Challenges



Make solar energy economical



Provide energy from fusion



Develop carbon sequestration methods



Manage the nitrogen cycle



Provide access to clean water



Restore and improve urban infrastructure



Advance health informatics



Engineer better medicines



Reverse-engineer the brain



Prevent nuclear terror



Secure cyberspace



Enhance virtual reality



Advance personalized learning



Engineer the tools of scientific discovery

Source: [www.engineeringchallenges.org](http://www.engineeringchallenges.org)

# Today's Technology: Core Value

Multicore



FPGA



Modular I/O



# Today's Technology Potential

Multicore

Parallel &  
Scalable  
Processing



Desktop  
Supercomputing

FPGA

Re-definable  
Silicon



Rapid  
Embedded  
Development

Modular I/O

Combinable  
Measurements  
& Rapid Data  
Access

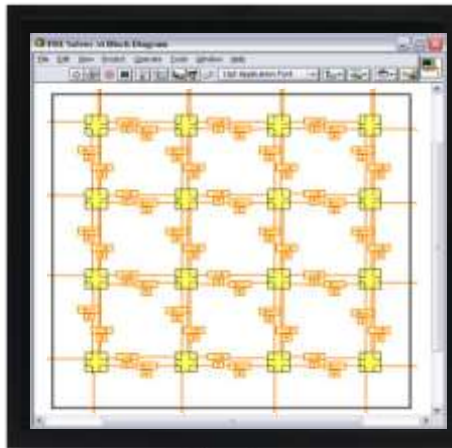


High  
Performance  
Interaction



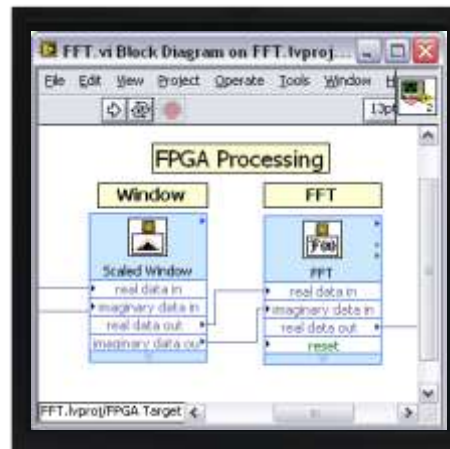
# Access through Graphical Programming

Multicore



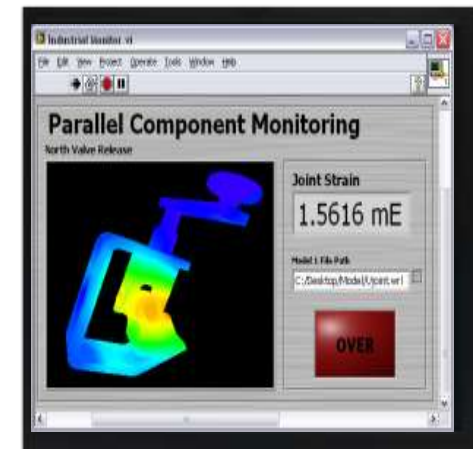
Desktop  
Supercomputing

FPGA



Rapid  
Embedded  
Development

Modular I/O



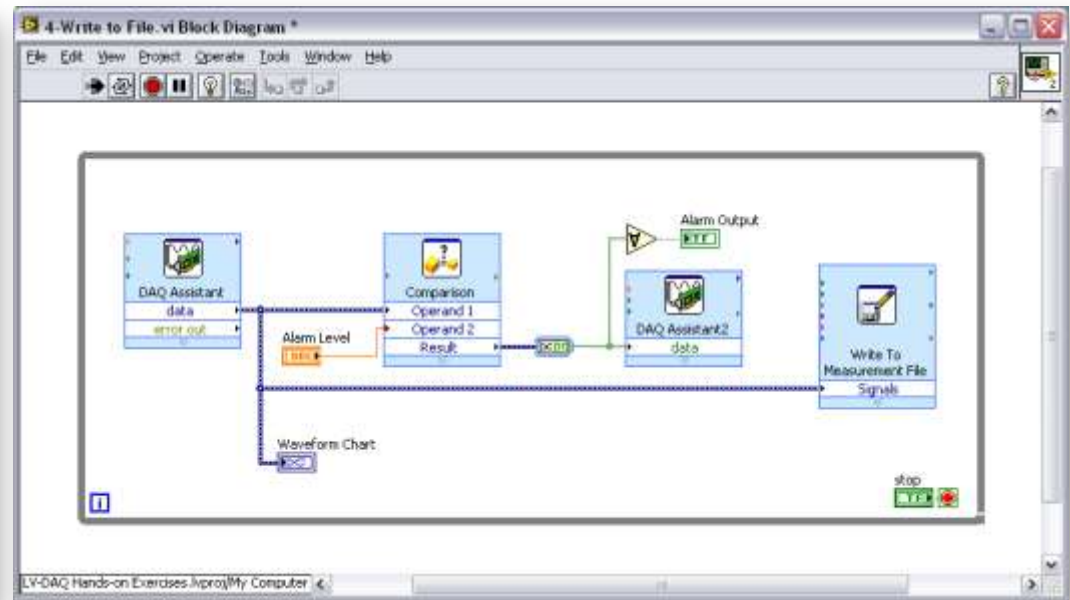
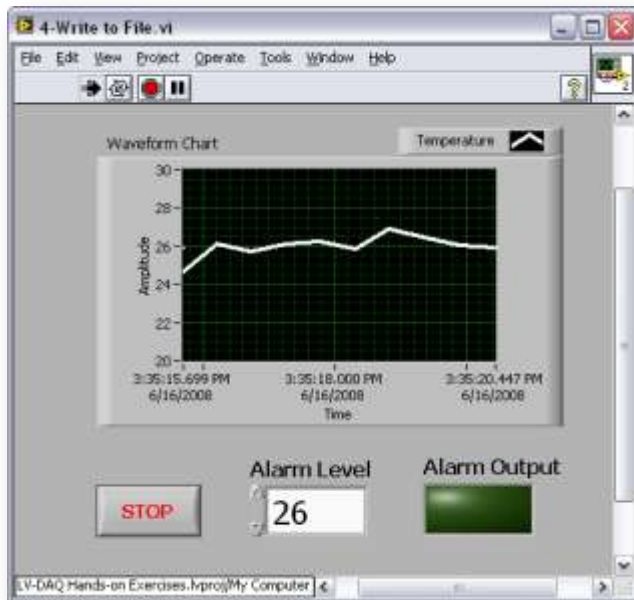
High  
Performance  
Interaction



# Graphical Programming:

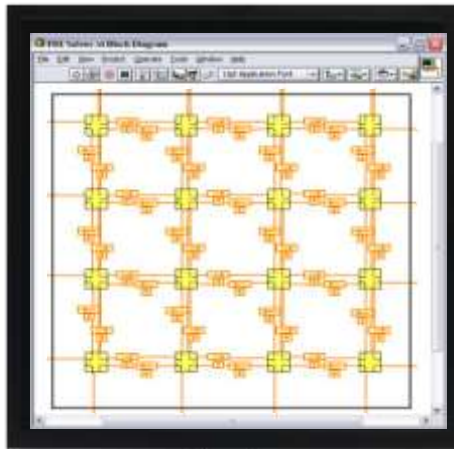
## Simplifying Design of Complex Engineering Systems

- Symbolic
- Dataflow
- Hierarchical
- Interactive
- Inherent User Interface



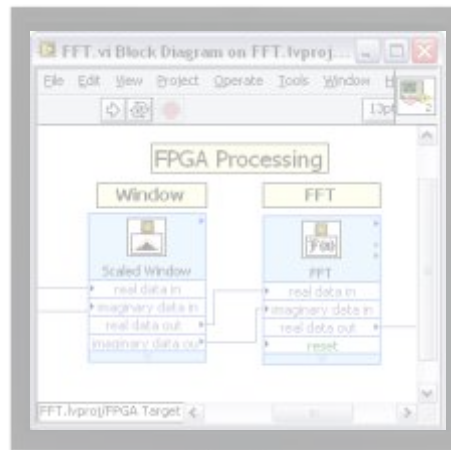
# Access through Graphical Programming

Multicore



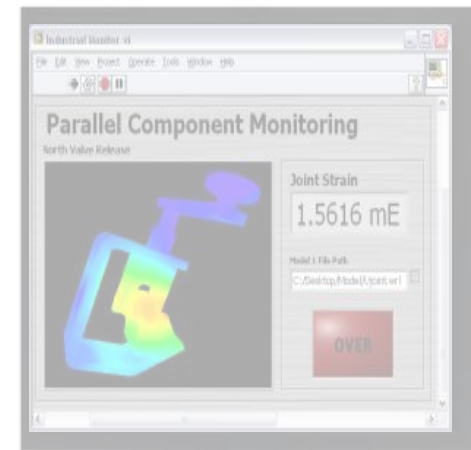
Desktop  
Supercomputing

FPGA



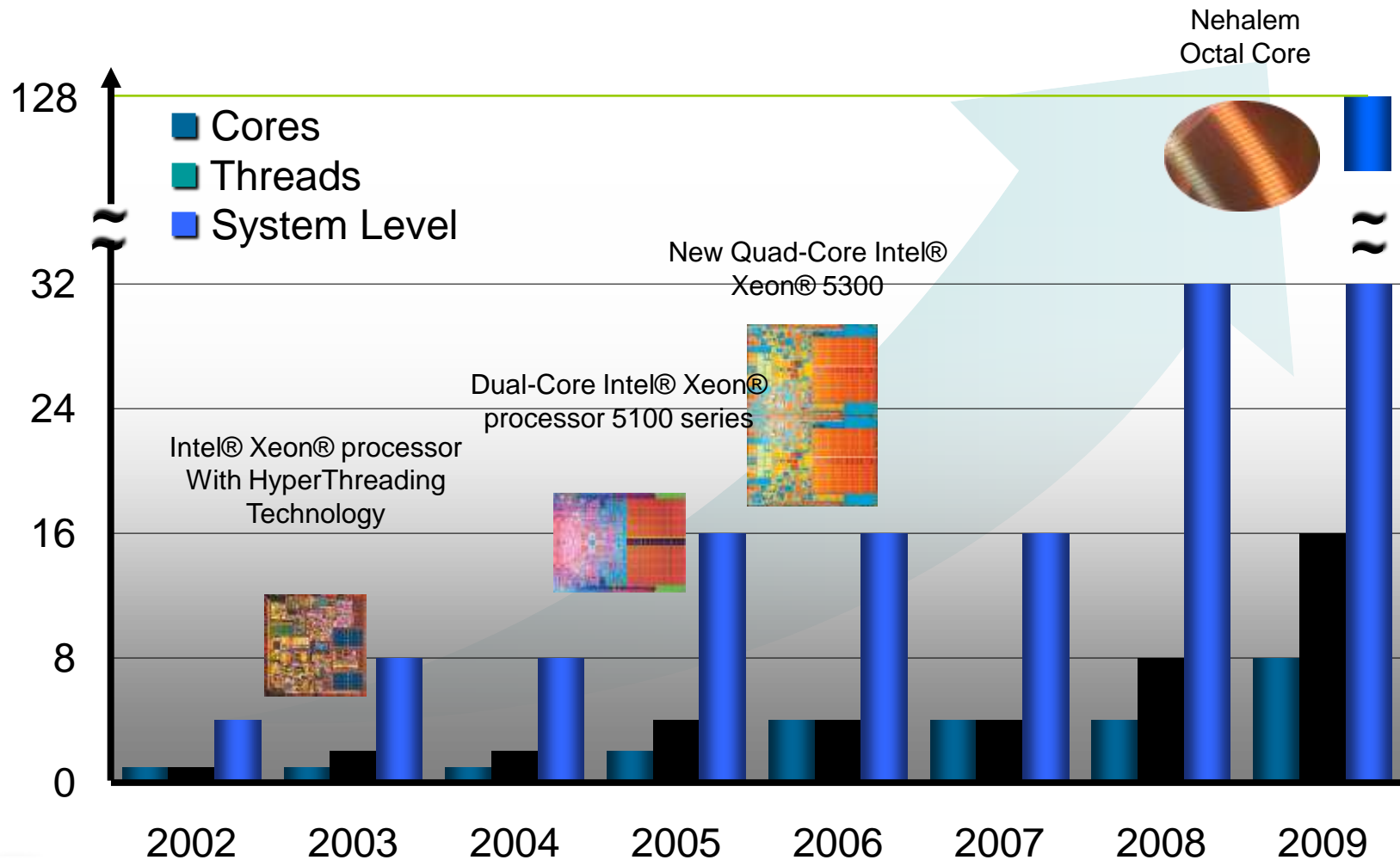
Rapid  
Embedded  
Development

Modular I/O



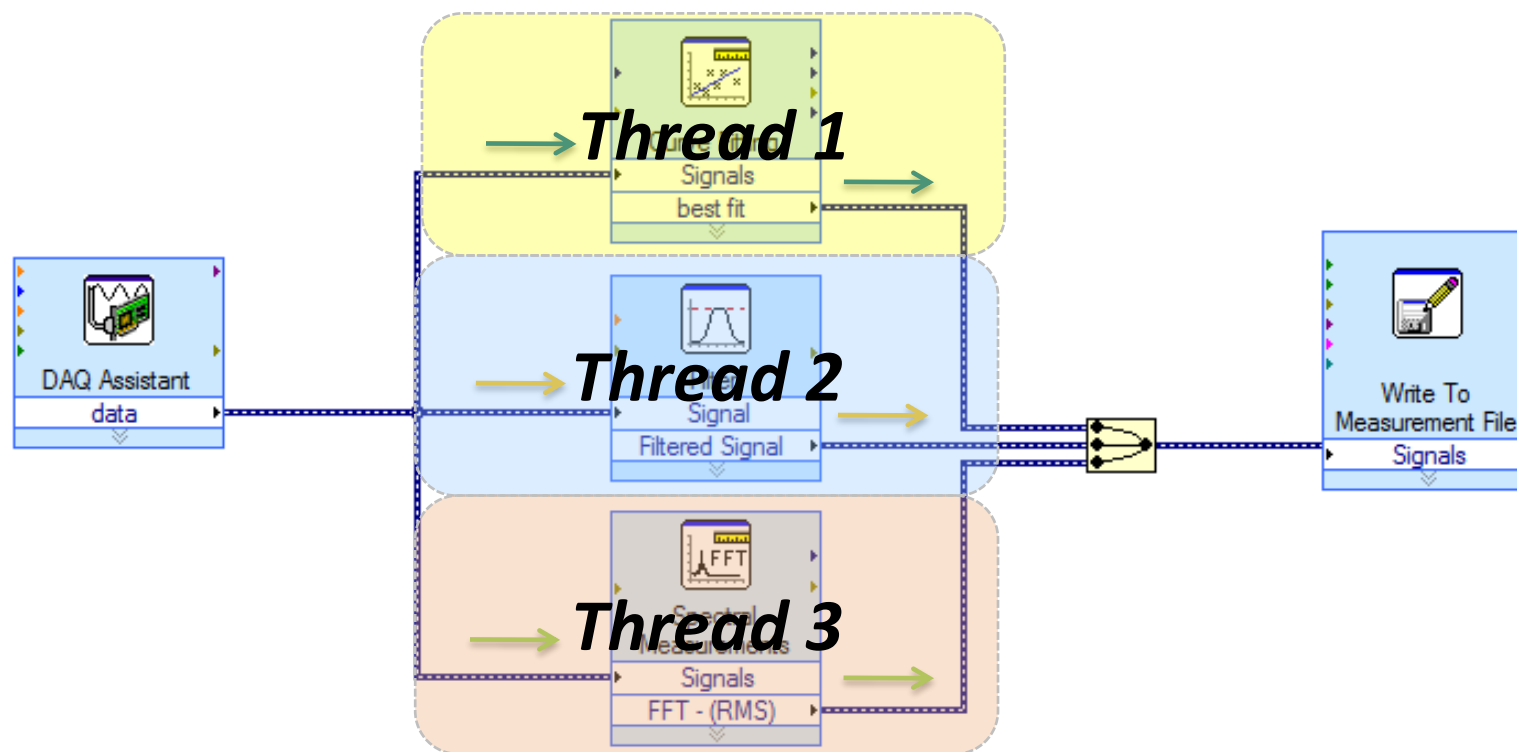
High  
Performance  
Interaction

# Multi-core: Scalable Parallel Processing



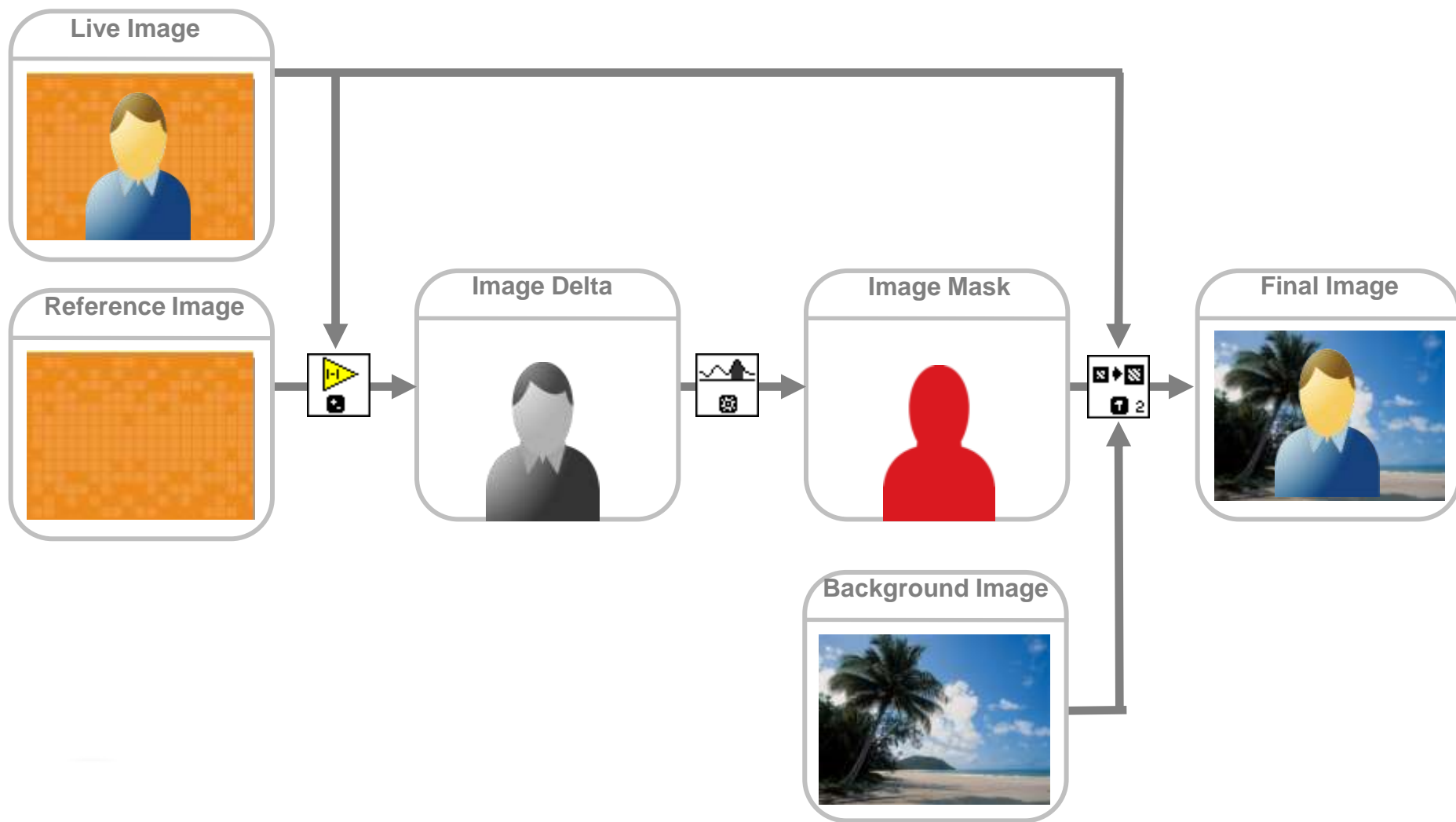
Courtesy: Intel Corporation

# Realizing the Potential: Inherent Access to Automatically Scalable Parallelism

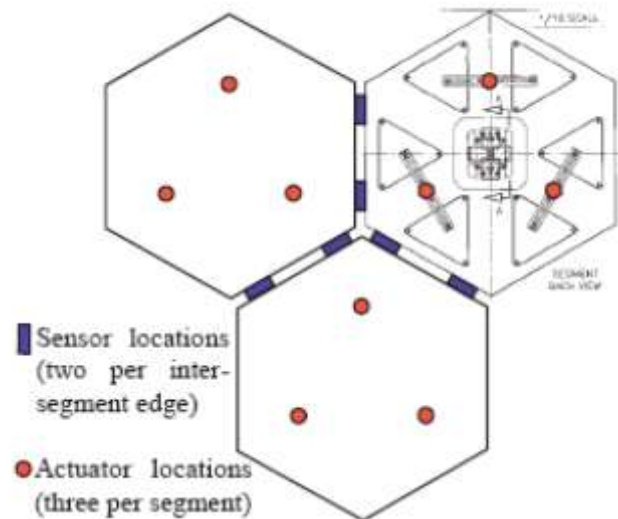


10 Year Anniversary of Multithreading

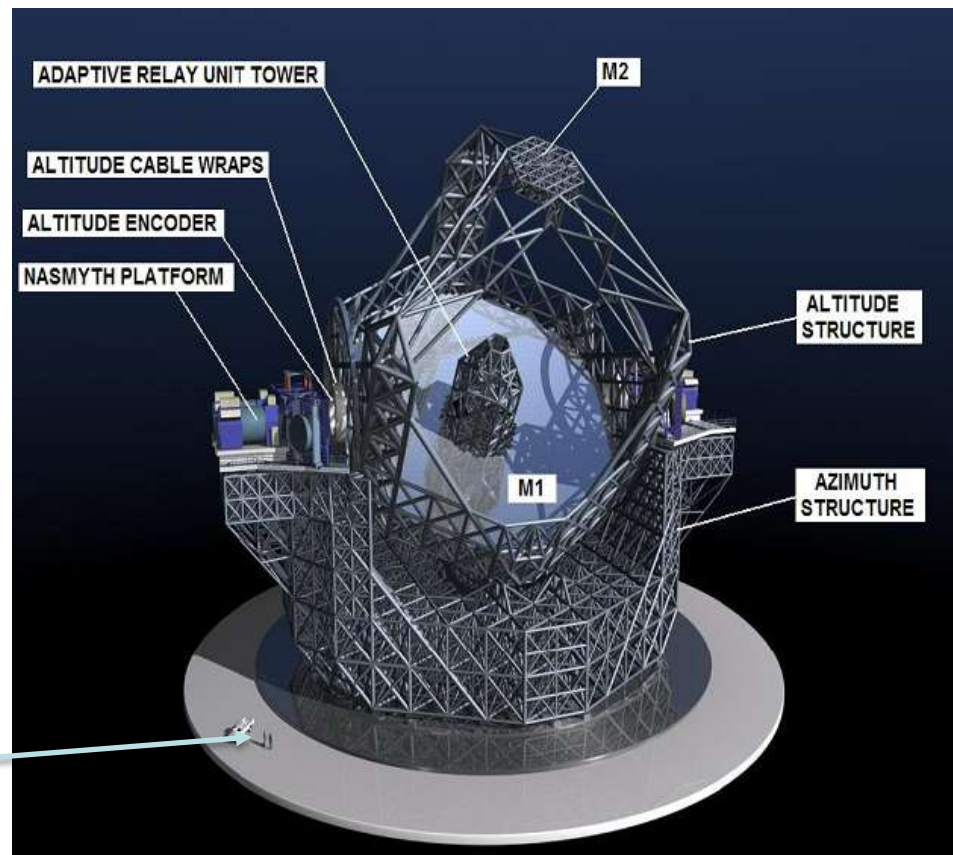
# Demo: The LabVIEW Green Screen



# 1 Case study I – Extremely Large Telescope

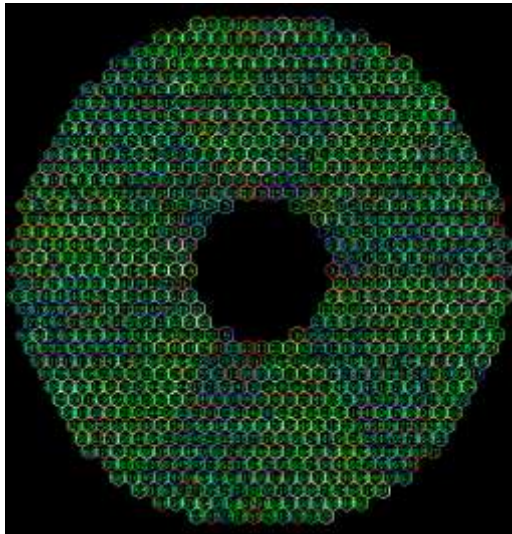


Physicists are getting smaller these days!





# 1 Case study I – Extremely Large Telescope

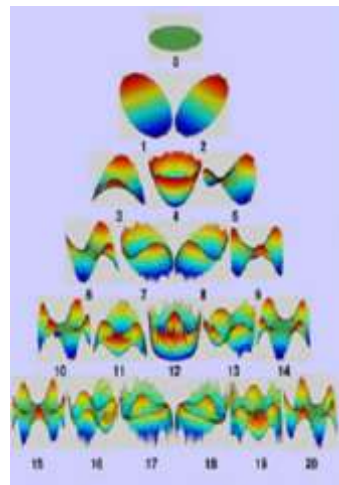


## M1 – mirror

984 hexagonal mirrors

6 sensors/3 actuators each

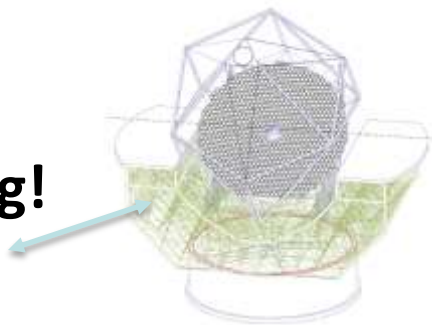
1 ms



## Fight the modes!

Translates into large matrix operations (3K-by-3K)

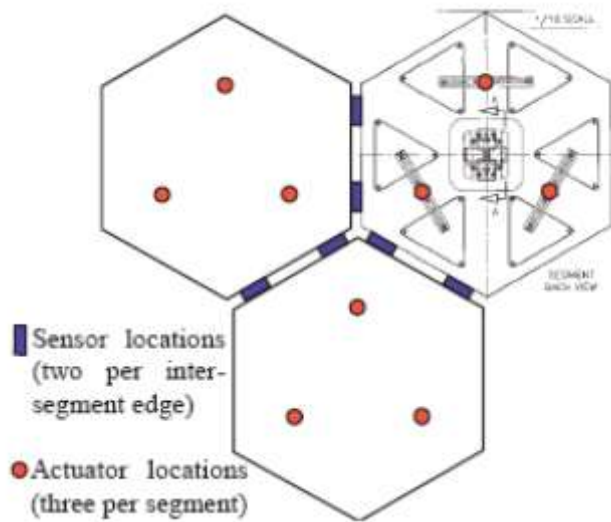
Shaking!





# 1 Case study I – Extremely Large Telescope

Sensors **break all the time** (actually, every other night)



$$\begin{aligned} \text{pinv}(\text{newIM}) &= (\text{newIM}^T \text{newIM})^+ \text{newIM}^T \\ &= ((\text{IM} - e_i a_i^T)^T (\text{IM} - e_i a_i^T))^+ (\text{IM} - e_i a_i^T)^T \\ &= (\text{IM}^T \text{IM} - a_i a_i^T)^+ (\text{IM}^T - a_i e_i^T) \end{aligned}$$

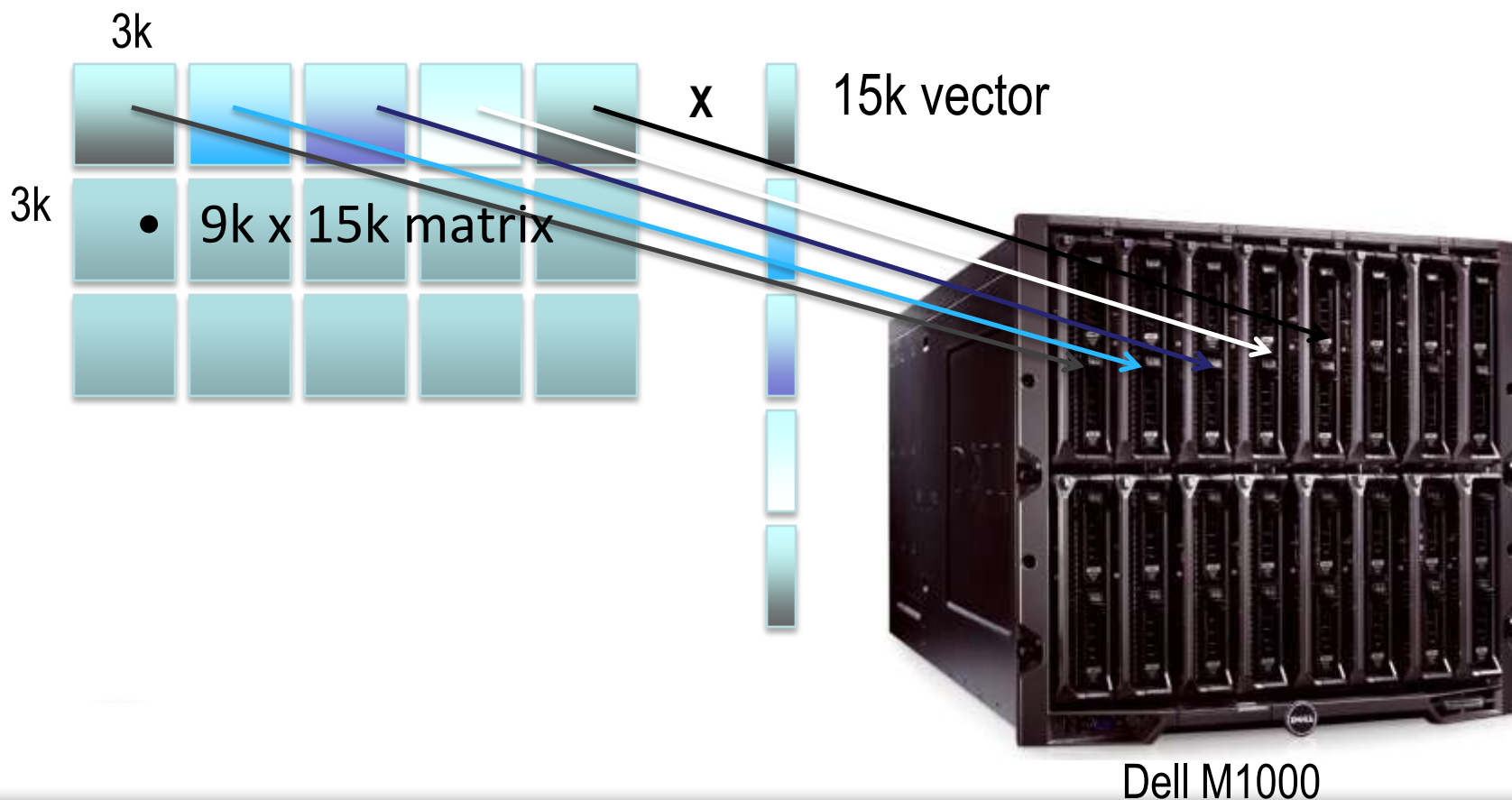
$$\begin{aligned} (\text{IM}^T \text{IM} - a_i a_i^T)^+ &= (\text{IM}^T \text{IM})^{-1} + \frac{(\text{IM}^T \text{IM})^{-1} a_i a_i^T (\text{IM}^T \text{IM})^{-1}}{1 - a_i^T (\text{IM}^T \text{IM})^{-1} a_i} \\ &= (\text{IM}^T \text{IM})^{-1} + \frac{b_i b_i^T}{1 - a_i^T b_i} \end{aligned}$$

$$\begin{aligned} \text{pinv}(\text{newIM})ES &= ((\text{IM}^T \text{IM})^{-1} + \frac{1}{1 - a_i^T b_i} b_i b_i^T) (\text{IM}^T - a_i e_i^T) ES \\ &= (\text{IM}^T \text{IM})^{-1} (\text{IM}^T \cdot ES) - (\text{IM}^T \text{IM})^{-1} a_i \cdot es_i + \\ &\quad \frac{b_i^T (\text{IM}^T \cdot ES) - (a_i^T b_i) \cdot es_i}{1 - a_i^T b_i} b_i \end{aligned}$$

Requires to recalculate pinv of 3K-by-3K matrix in 100 ms  
 → Sherman Morrison

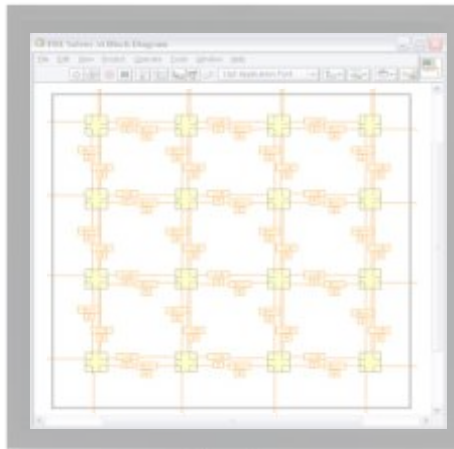
# 1 Adaptive Optics

## Distributing LabVIEW computations



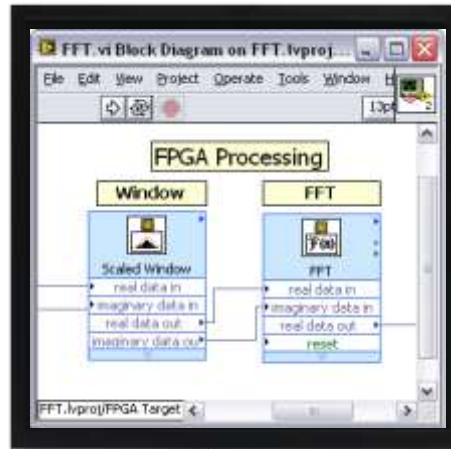
# Access through Graphical Programming

Multicore



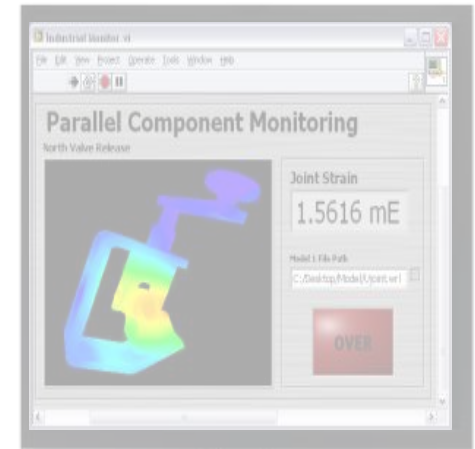
Desktop  
Supercomputing

FPGA



Rapid  
Embedded  
Development

Modular I/O



High  
Performance  
Interaction

# Advances in FPGA Technology

## Size

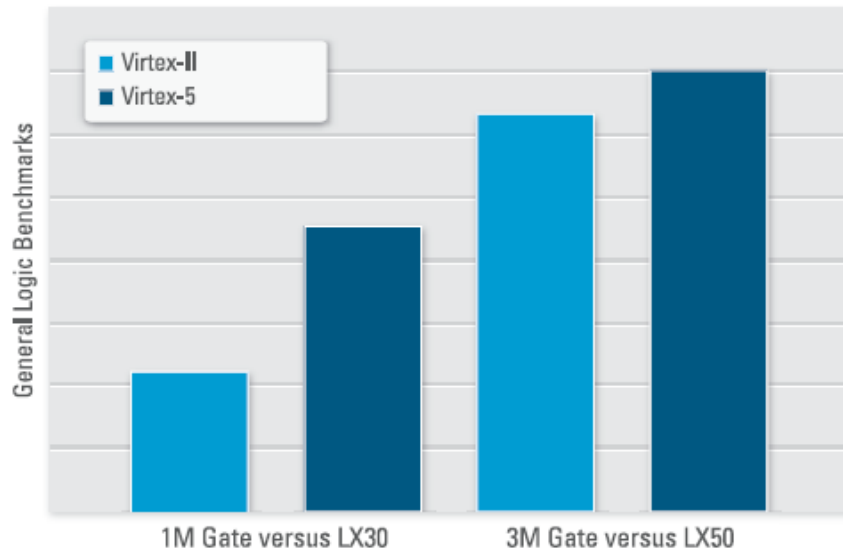


Figure 1. General logic benchmarks show that Virtex-5 FPGAs offer larger sizes when compared to Virtex-II FPGAs.

## Speed

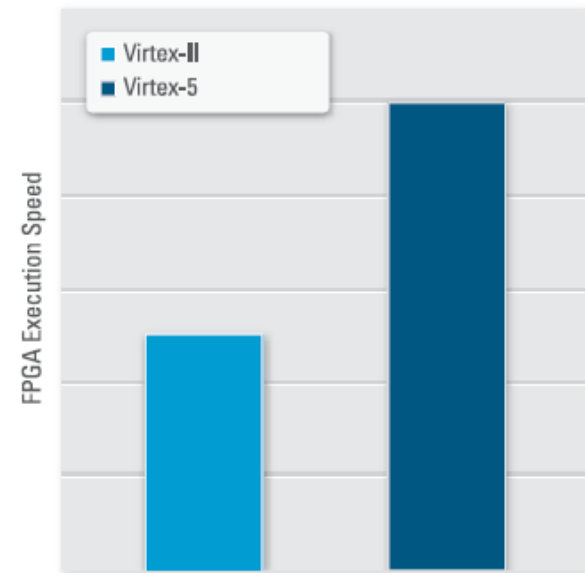


Figure 2. Execution speed benchmarks show that Virtex-5 FPGAs feature faster processing capabilities when compared to Virtex-II FPGAs.

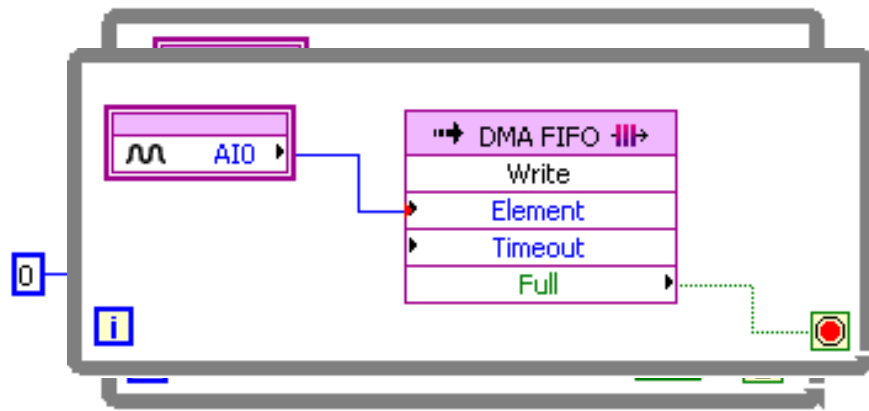
# Realizing the Potential

## Simplifying Access to FPGAs

# Counter

# Analog I/O

# I/O with DMA



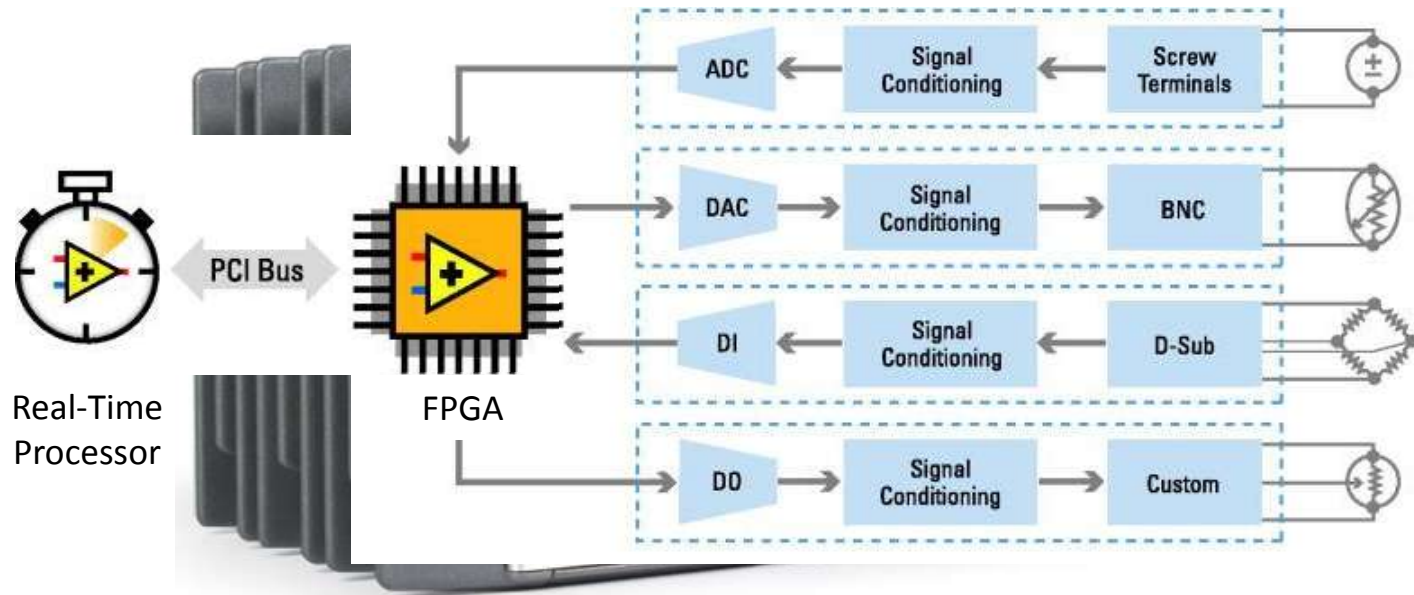
# LabVIEW FPGA

[illegible]

## VHDL ~4000 lines

# Blending Technologies for New Architectures

## CompactRIO



- **Reconfigurable FPGA** for high-speed and custom I/O timing, triggering, and control
- **I/O modules** with built-in signal conditioning for connection to sensors/actuators
- **Real-time processor** for reliable measurement, analysis, connectivity, and control

# Blending Technologies for New Architectures

## FlexRIO



### NI FlexRIO Adapter Module

- Interchangeable I/O
- Customizable by users
- Adapter Module Development Kit

### NI FlexRIO FPGA Module

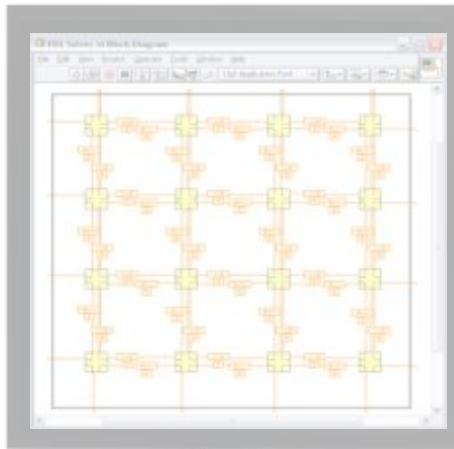
- Virtex-5 FPGA
- Up to 132 channels
- Up to 128 MB of DDR2 DRAM



# Introducing NI FlexRIO

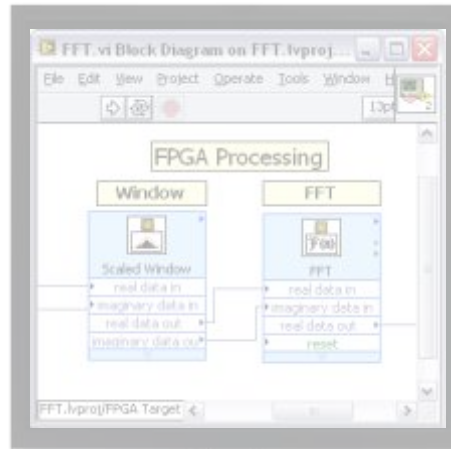
# Access through Graphical Programming

Multicore



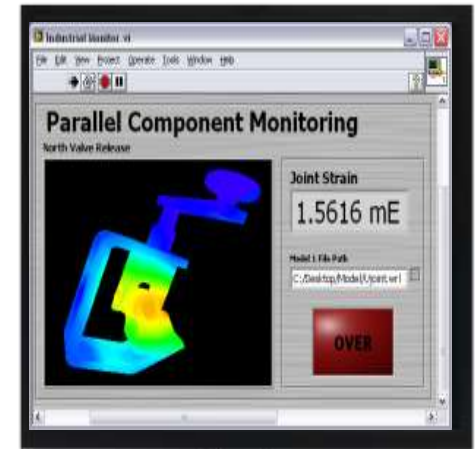
Desktop  
Supercomputing

FPGA



Rapid  
Embedded  
Development

Modular I/O

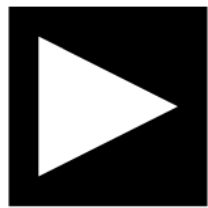


High  
Performance  
Interaction

# Modular I/O:

## Combinable Measurements & Rapid Data Access

- Combinable Measurements
  - Mix and match I/O to meet exact requirements
  - Access to leading edge measurement technology
- Rapid Data Access



**ANALOG  
DEVICES**

the latest bus technologies  
synchronization



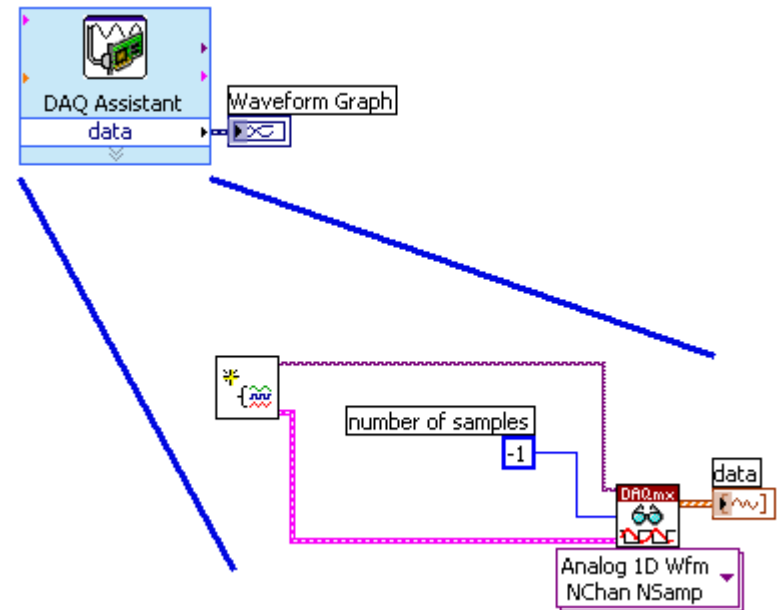
- integrated through a single, unified software language



# Realizing the Potential

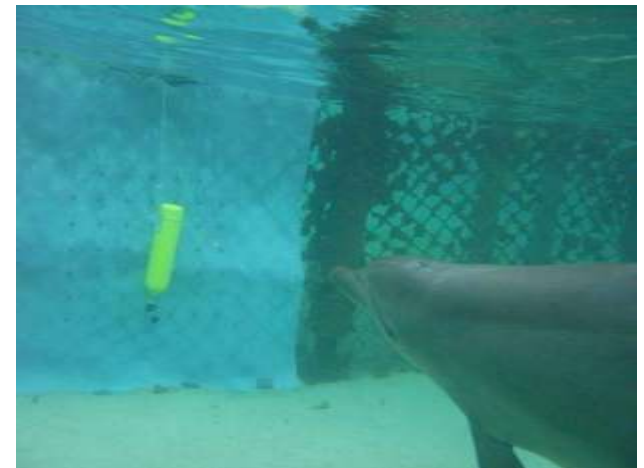
## Uniform Access to All Functionality

- Common APIs
- Measurement and Automation Explorer
- Simplifying Wizards
- Low Level Access



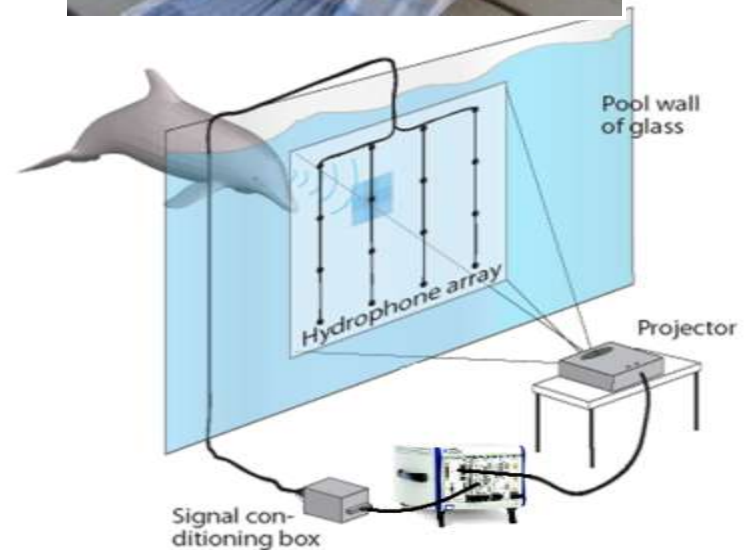
# Case Study – The Dolphin sonar project

- ELVIS II
  - Echo Location Visualization Interface System
- Lund University in collaboration with Kolmarden wild animal park
- PhD Student Josefin Starkhammar as developer
- LabVIEW and 47 channel PXI system for digitizing and visualizing dolphin sonar



# Project Objectives and Principle

- Learn more about dolphin behavior, cognition, sonar skills and intelligence
- Better understand the dolphin echolocation skills to be able to develop equipment for ultrasonic diagnostics and non-destructive testing of materials
- 47 simultaneously sampling hydrophones
- Triggers on arbitrary hydrophone in array
- Fast data streaming to disc
- Real time visualization of measurements
  - Allows to develop an acoustically operating touch screen



# C Series Modular I/O Platform



More than 60 Measurement modules



# C Series Modular I/O Platform



More than 60 Measurement modules

# Introducing Wi-Fi Data Acquisition

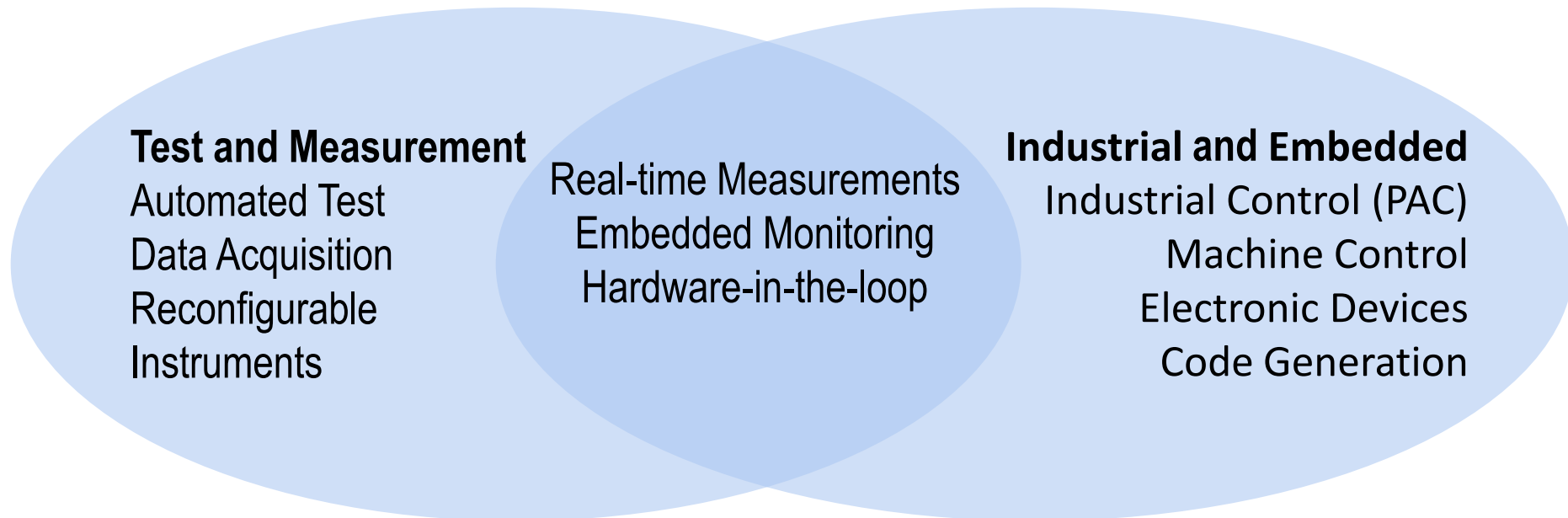
- IEEE 802.11b/g radio
- 10/100 Base-T/X Ethernet
- NI-DAQmx driver
- DC powered (9-30 VDC)
- C Series module support
  - NI 9211 (4-ch thermocouple)
  - NI 9215 (4-ch SSH  $\pm 10\text{V}$  inputs )
  - NI 9234 (4-ch IEPE accelerometers)
  - NI 9237 (4-ch strain gauges)
  - NI 9219 (4-ch universal inputs)



# The Engineering Design Transformation

# National Instruments Vision

## Graphical System Design

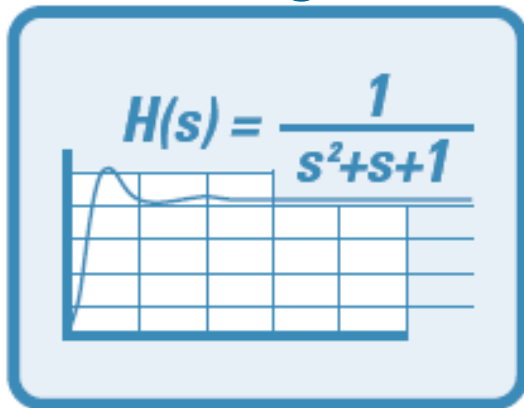


“To do for test and measurement  
what the spreadsheet did  
for financial analysis.”

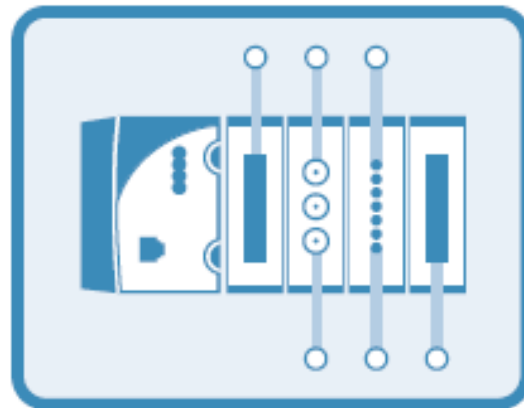
“To do for embedded what the  
PC  
did for the desktop.”

# Graphical System Design

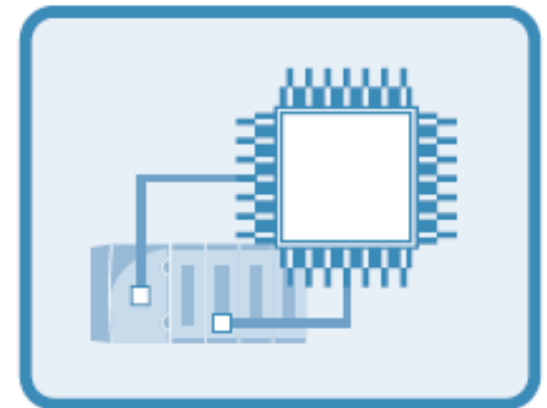
Design



Prototype



Deploy



## Algorithm Engineering

# Models of Computation

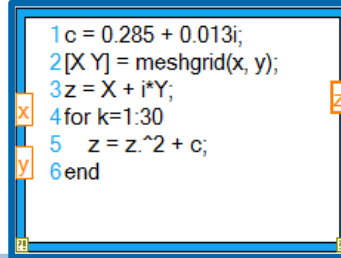
Dataflow



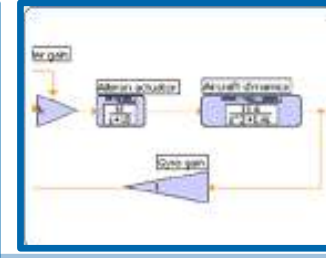
C / HDL Code



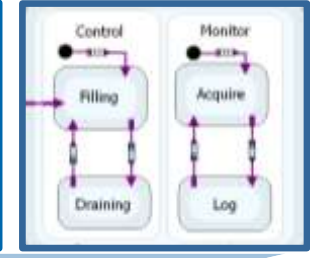
Textual Math



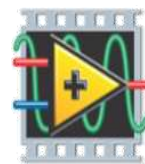
Simulation



Statechart



LabVIEW



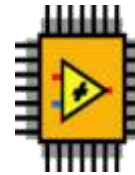
Desktop

LabVIEW



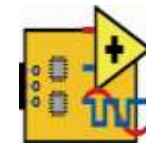
Real-Time

LabVIEW



FPGA

LabVIEW



MPU/MCU



Personal Computers



PXI Systems



CompactRIO



Single-Board RIO



Custom Design

# Training and Certification



Together, the National Instruments training and certification programs deliver the fastest, most certain route to increased proficiency and productivity using NI software and hardware.

## **NI Training: Build Your Knowledge**

NI training helps you build the skills to more efficiently develop robust, maintainable applications. We provide several training options including classroom, self-paced, online, or on-site training at your facility.

## **NI Certification: Validate Your Expertise**

NI certification confirms your technical growth and skill. This professional certification is ideal for differentiating yourself from the competition and making your own informed hiring and outsourcing decisions.

Visit [ni.com/training](https://ni.com/training) to learn more



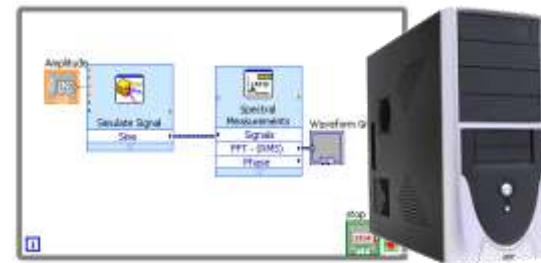
# Graphical System Design: From Kindergarten to Rocket Science



LEGO® Education WeDo Loop



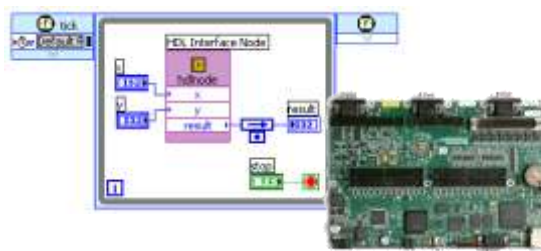
LEGO MINDSTORMS® NXT Loop



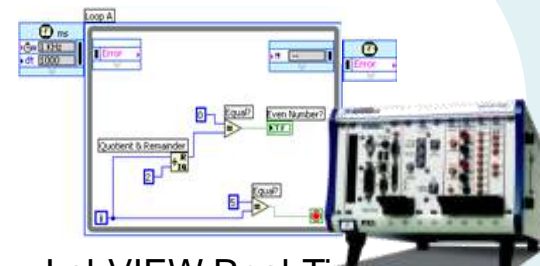
LabVIEW While Loop



LabVIEW Simulation Loop



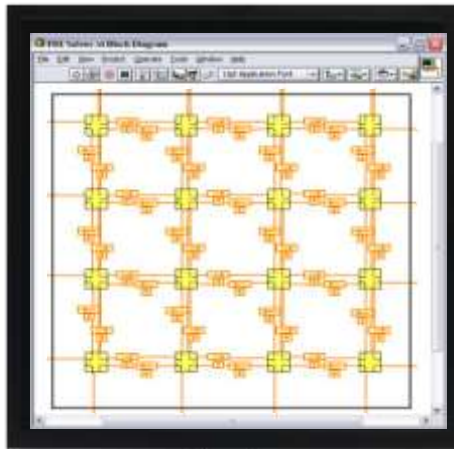
LabVIEW FPGA  
Single-Cycle Timed Loop



LabVIEW Real-Time  
Timed Loop

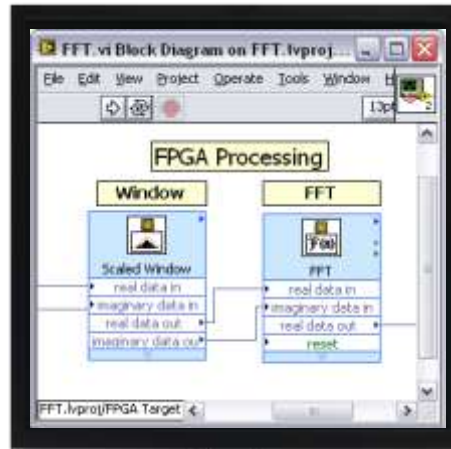
# Graphical System Design in Practice

Multicore



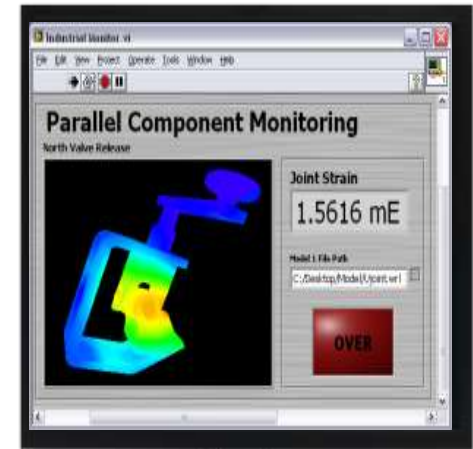
Desktop  
Supercomputing

FPGA



Rapid  
Embedded  
Development

Modular I/O



High  
Performance  
Interaction

# RF and GPS Production Testing

- **Application**
  - Automate production testing of 3.5GHz satellite transceivers and GPS tracking modules
- **Requirements**
  - Maximize production throughput while minimizing footprint and cost



# RF and GPS Production Testing

- **Technology**

- PXI
- Panel PC

- **Software Access**

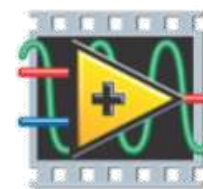
- LabVIEW
- TestStand
- NI Switch Executive
- PXI

- **Graphical System Design in Practice**

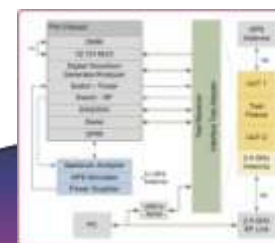
- Simulates GPS satellite signals over-air
- Performs mixed signal and RF measurement
- 32 ch 50MHz digital pattern generation
- 16 bit 250KS/s analog measurement
- Parallel testing allows 2 module tested at once



Multicore



LabVIEW



Desktop  
Supercomputing

# Wind turbine HIL Testing

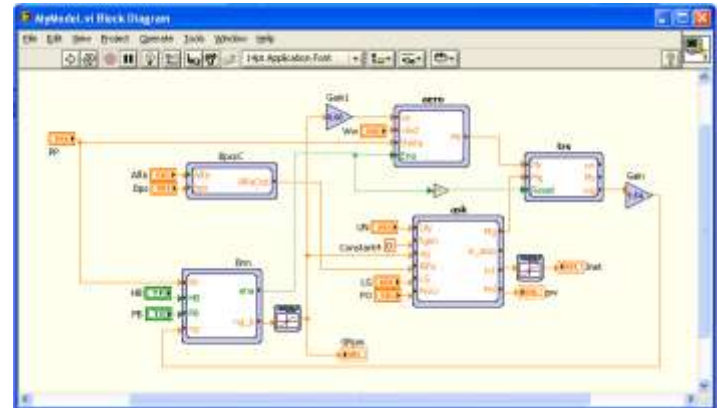
Designed a HIL test system that simulates the effects of wind, pitch and blade position to test turbine controller

## Software - *LabVIEW*

- Control Design and Simulation
- Real Time
- FPGA

## Hardware - *PXI*

- Real Time OS
- Multicore
- FPGA
- Analog I/O



# Tumor Treatment Medical Device

- **Application**

- Design of medical device for treatment of breast tumors

- **Requirements**

- Real-time ultrasound-guided control system
- No room for firmware errors
- Develop prototype in four months
- Strict regulatory guidelines (Class II)
- FDA approval
- EMC certification





# Tumor Treatment Medical Device

- **Technology**

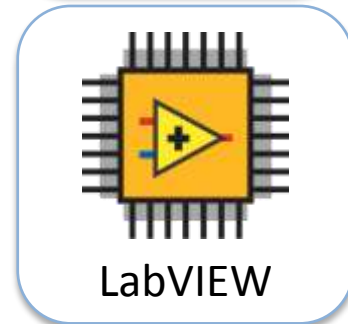
- CompactRIO
- Panel PC

- **Software Access**

- LabVIEW
- LabVIEW FPGA Module
- LabVIEW Real-Time Module

- **Graphical System Design in Practice**

- Nearly painless tumor elimination device
- Outpatient treatment that takes 10-20 minutes, no stitches
- Working prototype in just weeks



Rapid  
Embedded  
Hardware



# Engineering Grand Challenges



Make solar energy economical



Provide energy from fusion



Develop carbon sequestration methods



Manage the nitrogen cycle



Provide access to clean water



Restore and improve urban infrastructure



Advance health informatics



Engineer better medicines



Reverse-engineer the brain



Prevent nuclear terror



Secure cyberspace



Enhance virtual reality



Advance personalized learning



Engineer the tools of scientific discovery

Source: [www.engineeringchallenges.org](http://www.engineeringchallenges.org)

# Partner Introductions

NIDays 2009  
Drammen, Norway

Devotek



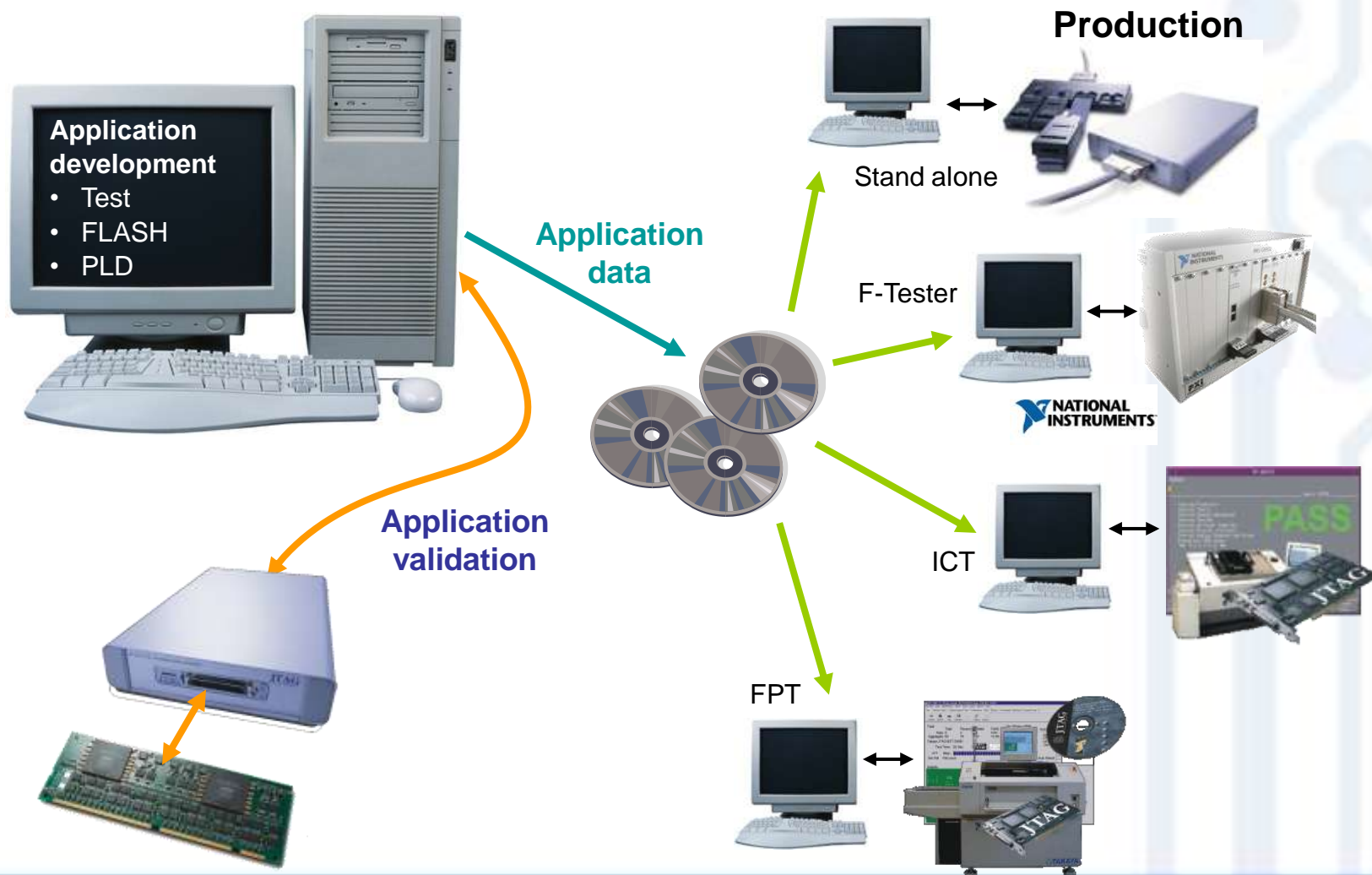
- Utviklingsressurser: 85 siv. ing og 2 x dr. ing.
- 110 ansatte
- 130 MNOK 2009 budsjettert oms. Selskap i sterk vekst.
- Uavhengig utviklingspartner
- Kontorer i Kongsberg, Asker, Mandal, Ålesund

- Utvikling av testsystemer med LabView / NI moduler
- Embedded utvikling (ARM, Atmel, DSP, FPGA)
- Softwareutvikling (C, C++, .NET, MDD, UML)
- Elektronikkutvikling (analog, digital, sensorer, drivere)
- Mekanisk design (3D, SolidWorks, NX etc)
- Numeriske analyser (CFD, termisk, stress, utmatning)
- 1000 m3 verksted (CNC, rapid prototyping, plast, sveis)
- Miljøtest-lab (temperatursykling, stresstesting ++)

- Referanser: KDA, Dresser Rand, Toyota, BMW, Opel, General Motors, Philips, Thales, Rolls Royce, Odim ++++

JTAG

# One development environment for all test methods



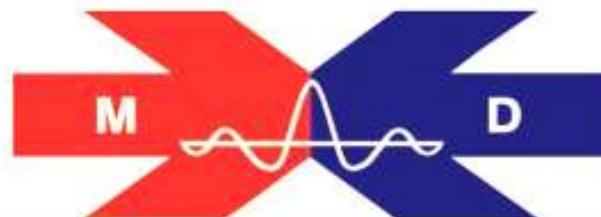
Marin -  
Innovasjon



# Marin-Innovasjon AS

- Kontrollsystemer
- Sanntidssystemer
- Datalogging
- Elektronikkdesign

# Maskindynamikk



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# MASKINDYNAMIKK AS

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TEL : +47 70 14 45 00 - FAX +47 70 14 78 78

[www.maskindynamikk.no](http://www.maskindynamikk.no)

- Machinery KnowHow
- Condition Monitoring
- Performance Monitoring
- LabView Online System
- Noise Control
- Torsional Analyses
- Troubleshooting
- Dynamic Machinery Analyses

Norautron  
Solutions AS

# Norautron Solutions AS

National Instruments  
Technical Symposium 2009

# Numeric Labs

# NIDays 2009

- Litt om firmaet

Startet sommeren 2000

Applikasjoner innen olje & gass, medisinsk, fiske industri og andre industrier.

Elektronikk, fpga og embedded sw

- Kl.1330 så skal jeg prate mer om

cRIO moduler

FlexRIO moduler

Vårt eget hovedkort 'Thor'





Prevas

# Key expertise

## xMove

Complex test solutions for electronic control units, used in automotive and other industry.

Application areas:

- Functional test
- Hardware In the Loop (HIL) test
- Repair test

## HSDH-RT

**High Speed Data Handling**  
- in **Real Time**  
Complex solutions for telecom, defence and data applications.

Application areas:

- Simulators in general
- High speed data
- RF simulations and analyses

## Large RT-Systems

Real Time systems used in control, measurement and test applications for a number of industries.

Main characteristics:

- Real Time
- Gbps data rate
- >20 interconnected computers
- Handling >2000 signals
- Scalable
- Distributed

The Göteborg design centre

- Engineering expertise in: LabVIEW, LabVIEW-RT, Multicore etc.
- Engineering expertise in: HW-design, FPGA, RF, interface design etc.

Virinco



the best loop for product improvement

proudly developed by



# Announcements

Time			Duration	Track A	Track B	Track C
7:30	-	8:30	1:00	Registration, Exhibition, CLAD exam *		
8:30	-	10:00	1:30	Keynote - Charles Schroeder		
10:00	-	10:30	0:30	Break and Exhibition		
10:45	-	11:45	1:00	How to get a jump start using CompactRIO - <b>Espen Ringnes</b>	Trends in Wireless Test: Benefits of Software Defined Instrumentation for MIMO-OFDM tests - <b>Stein-Arild Nordrum</b>	Raw Data to Results: Proper Data Management Techniques - <b>Frode Skulbru</b>
11:45	-	12:45	1:00	Lunch & Exhibition		
12:45	-	13:40	0:55	From rapid prototyping to low-cost deployment with LabVIEW embedded tools - <b>Jimmie Adolph</b>	Recording RF Signals Off of the Air: Advanced Techniques and Applications - <b>Leif Johansson</b>	VIRINCO
						maskindynamikk
13:40	-	13:45	0:05			
13:45	-	14:40	0:55	Introduction to Software Engineering for LabVIEW Applications - <b>Øyvind Østensen</b>	Building Audio and Video Test Systems with PXI - <b>Birger Schneider</b>	Noratron Solutions AS
						numeric labs
14:40	-	15:00	0:20	Break and Exhibition		
15:00	-	15:55	0:55	How to test embedded control systems with dynamic test methods - <b>Aku Wilenius</b> [Presentation by NI and Prevas]	Seeding the future of test with reconfigurable instruments - <b>Charles Schroeder</b>	
15:55	-	16:15	0:20	Wrap-Up / Prize draw		

# Announcements

- Return your Feedback forms during the day and claim your collector items
- Coffee breaks in the expo area
- In expo area at the end of day:  
Wrap-up / Lottery