HW pro Rapid Control prototyping, HIL a finální nasazení

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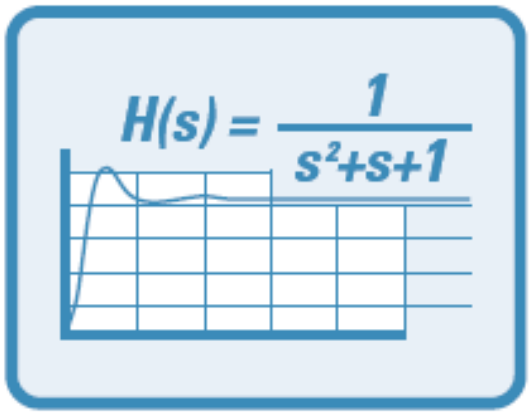
Tato prezentace je spolufinancována Evropským sociálním fondem a státním rozpočtem České republiky.

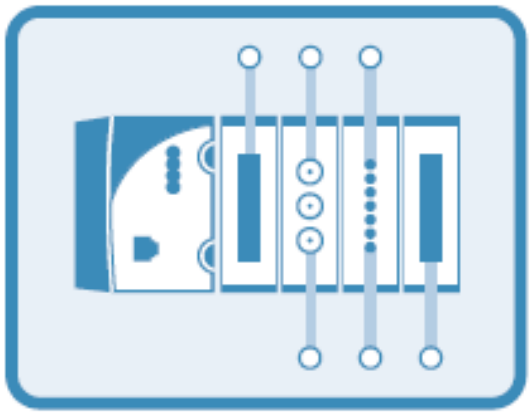
Agenda

- PXI / PXIe (PC – PCI / PCIexpress)
- FPGA boards - Reconfigurable IO
- FlexRIO
- Compact RIO
- Single Board RIO

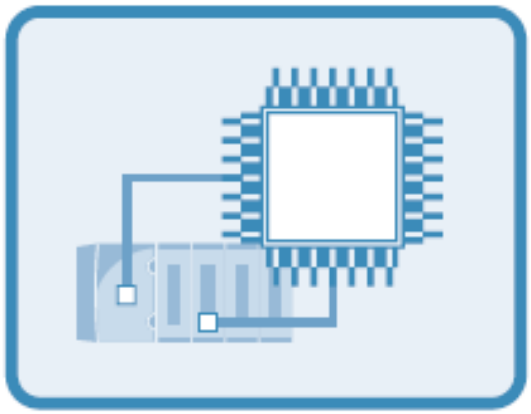
Graphical System Design



Design



Prototype



Deploy

Interactive Algorithm Design

- Control design
- Dynamic system simulation
- Digital filter design
- Advanced mathematics

Tight I/O Integration

- I/O modules and drivers
- COTS FPGA hardware
- VHDL and C code integration
- Design validation tools

Deployable Targets

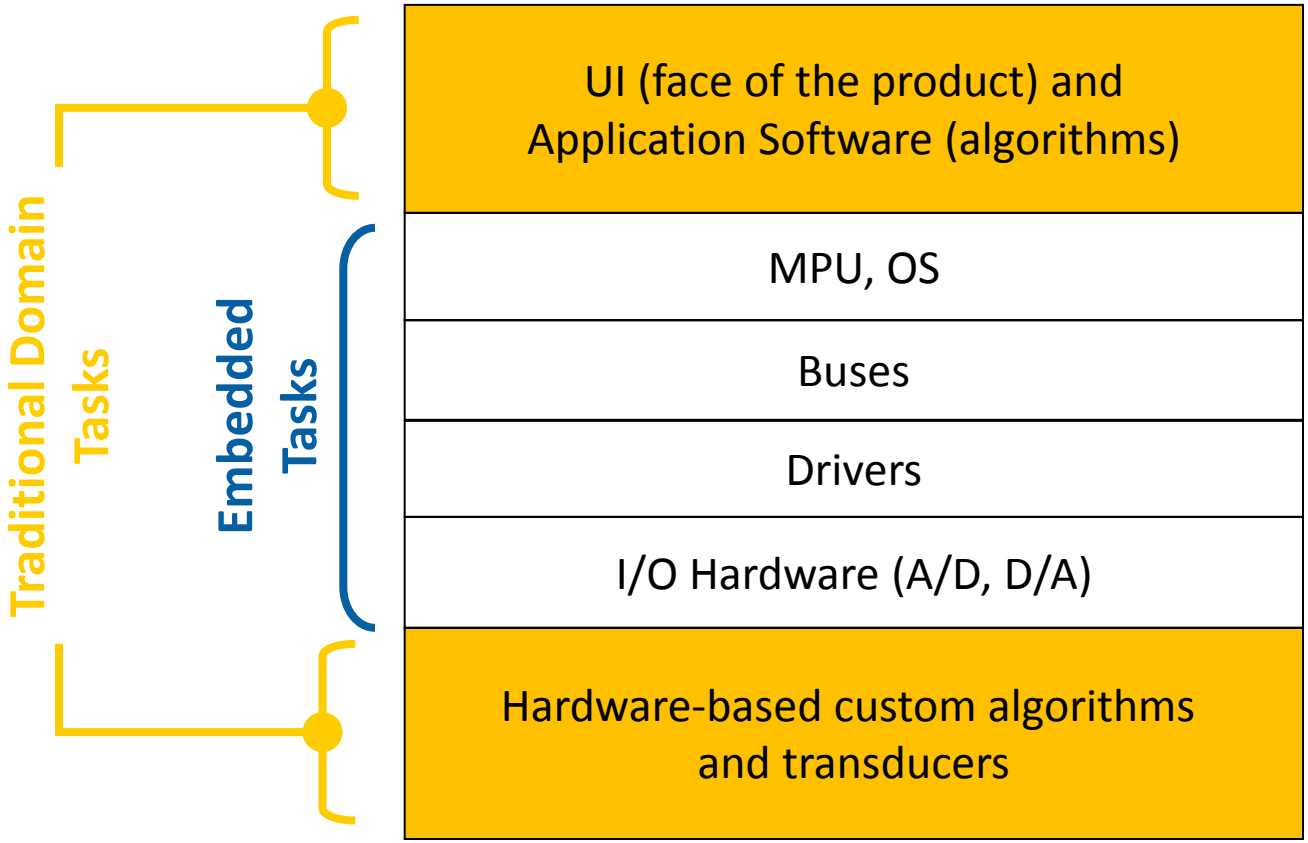
- Rugged deployment platforms
- Distributed networking
- Human-machine interfaces
- Custom designs

Who Benefits from Graphical System Design

- **The "Domain Expert"**
  - Non-embedded programming guru
  - System-level engineer or scientist
- **The "Embedded Expert"**
  - Anyone needing easier, faster development process
  - Anyone needing Commercial Off-The-Shelf (COTS) hardware to streamline development

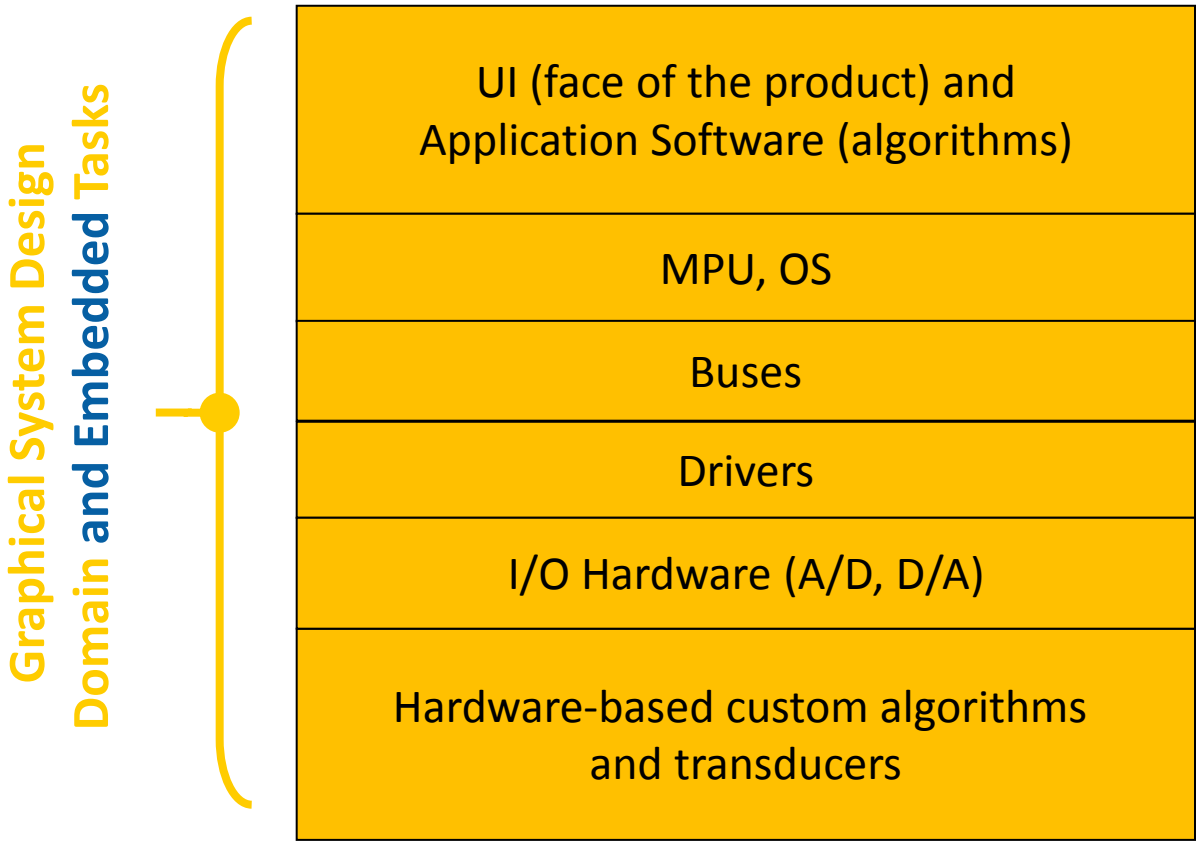
Traditional Embedded System Design

Embedded Engineer Carries The Load

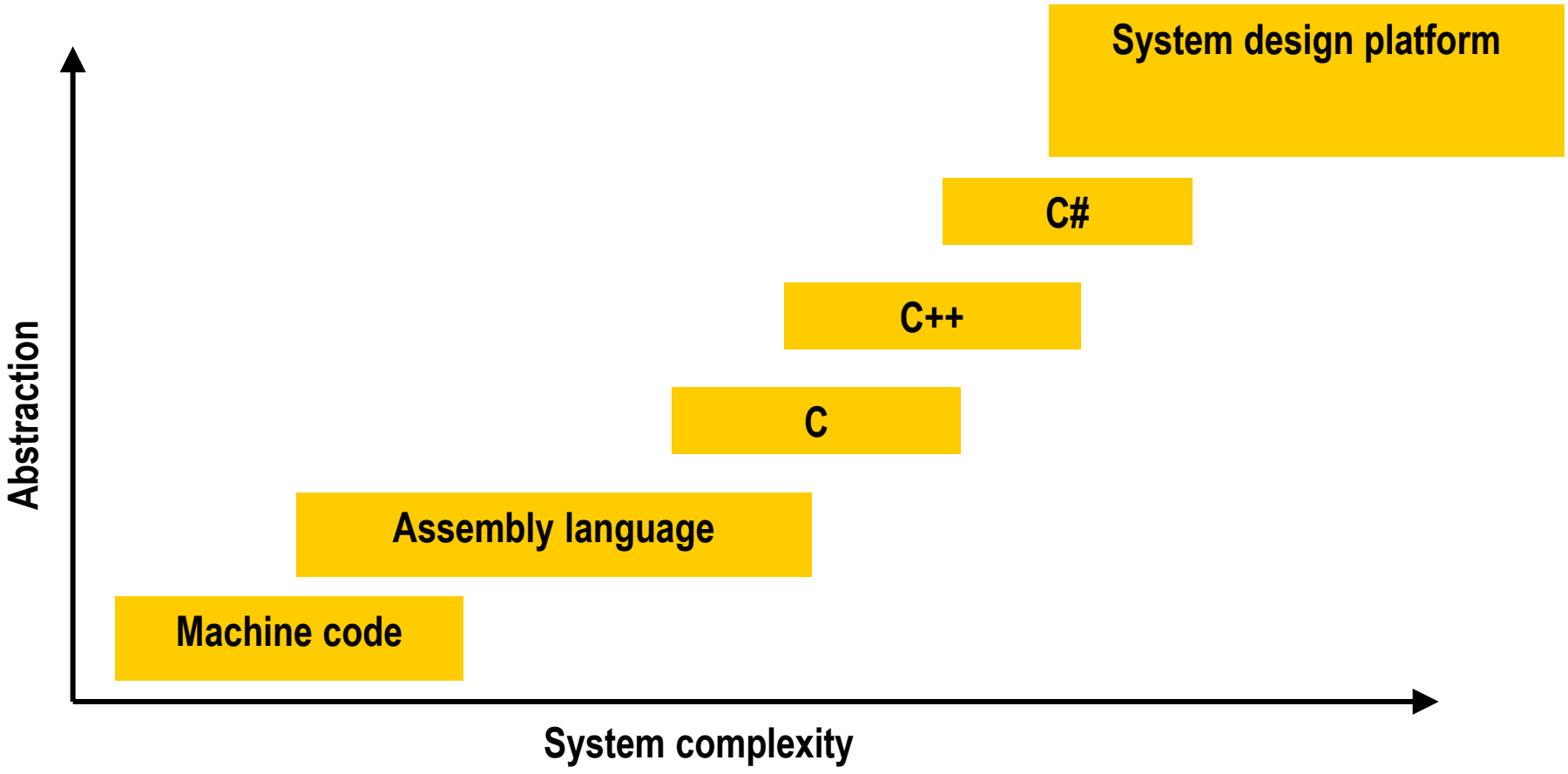


Graphical System Design

Bringing Embedded Design to the Masses



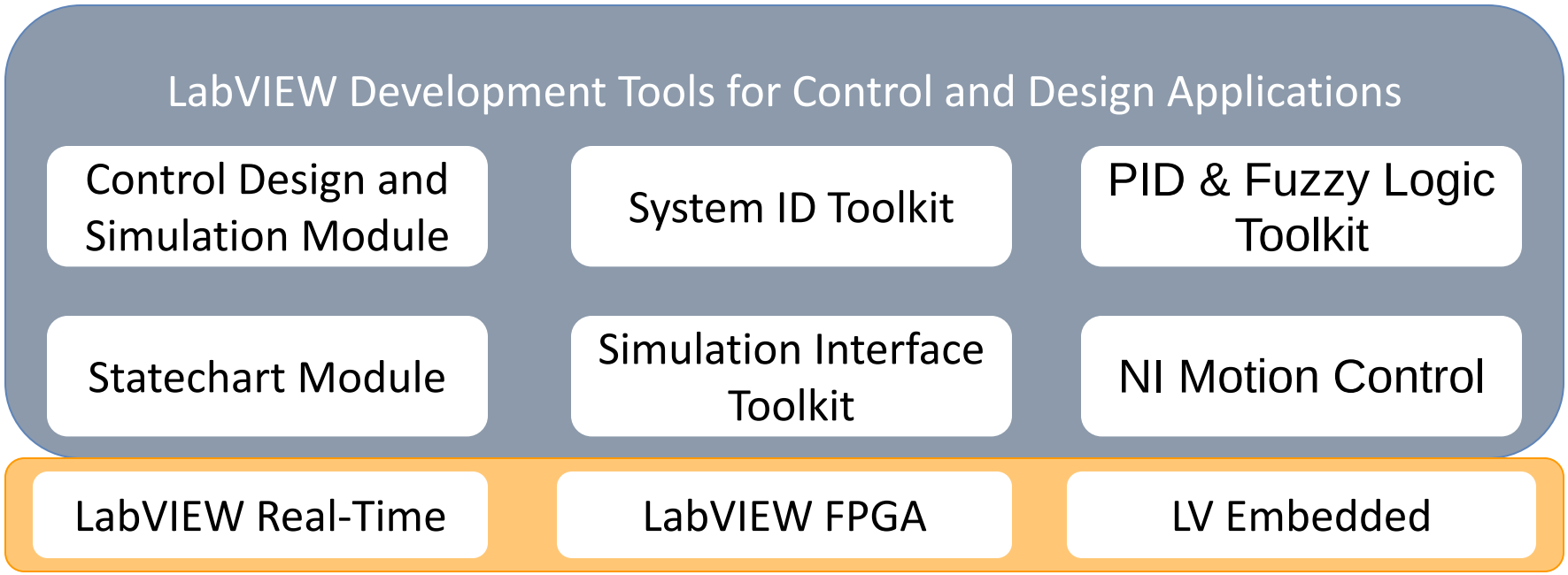
Evolution of Software Abstraction



High-level of Abstraction in LabVIEW

- Target different hardware (MPU, MCU, DSP, FPGA, GPU, hybrids….) from a High-level of Abstraction
- Graphical programming hides complexity of C, VHDL, Assembly code…..

NI Platform for Control



LabVIEW Real-Time Hardware Targets

LabVIEW Real-Time

PXI

Desktop or Industrial PC

Industrial Controllers

CompactRIO

Single-Board RIO

LabVIEW Real-Time System Development

LabVIEW RT Hypervisor

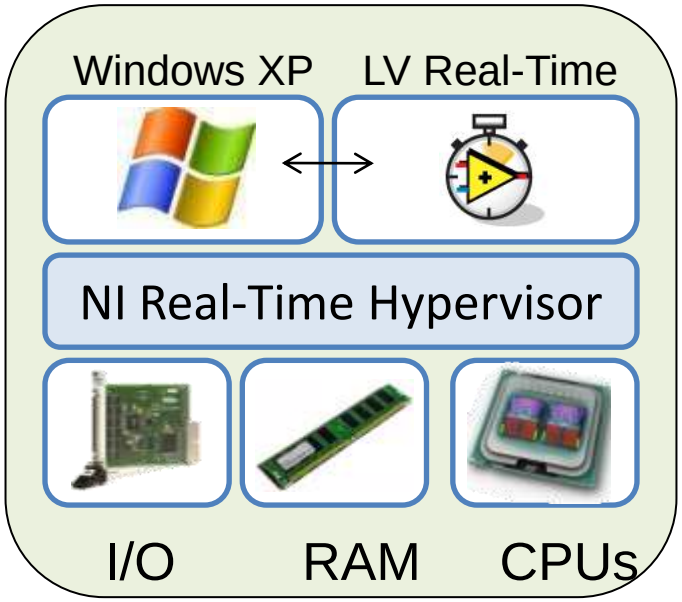
Develop on Host Computer → Execute on RT Target

Windows XP

LV Real-Time

NI Real-Time Hypervisor

- Run LabVIEW Real-Time and Windows XP simultaneously
- Available on multicore PXI / PXIe and industrial controllers
- Uses virtualization technology and Intel-VT



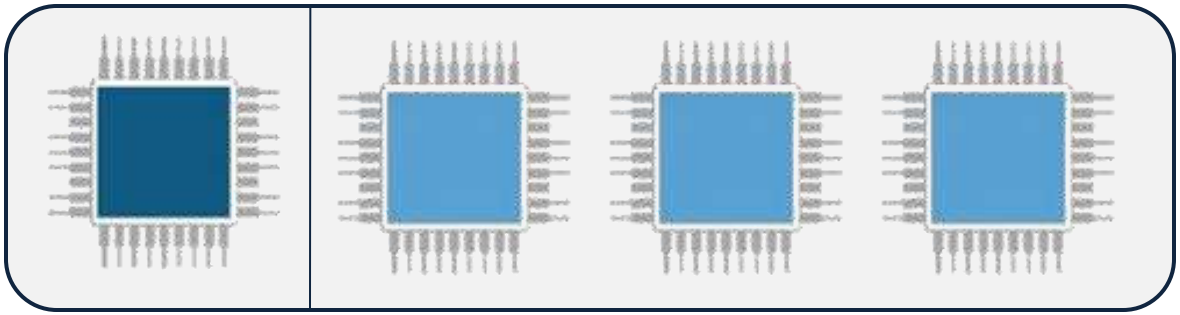
Supported hardware:

- PXI / PXIe 2-4 core controllers
- NI-3110 Industrial Controller

Benefits of the Real-Time Hypervisor

- **Efficiency:** take advantage of multicore processors effectively
- Custom distribution of computing power between RT and WIN
  - 1 : 3 or 2 : 2 or 3 : 1

Quad-Core Controller with Virtualization



Windows XP LabVIEW Real-Time

Benefits of the Real-Time Hypervisor

- **Consolidation:** reduce hardware costs, wiring, and physical footprint
- **Capability:** make use of real-time processing and Windows XP services

Applications

Graphics

Services

Determinism

Real-Time I/O

Timing

PXI (PCI eXtensions for Instrumentation)

PXI Controller
- Embedded PC or remote PC interface
- Runs all standard software

Chassis

PXI Backplane
- PCI bus
- Synchronization

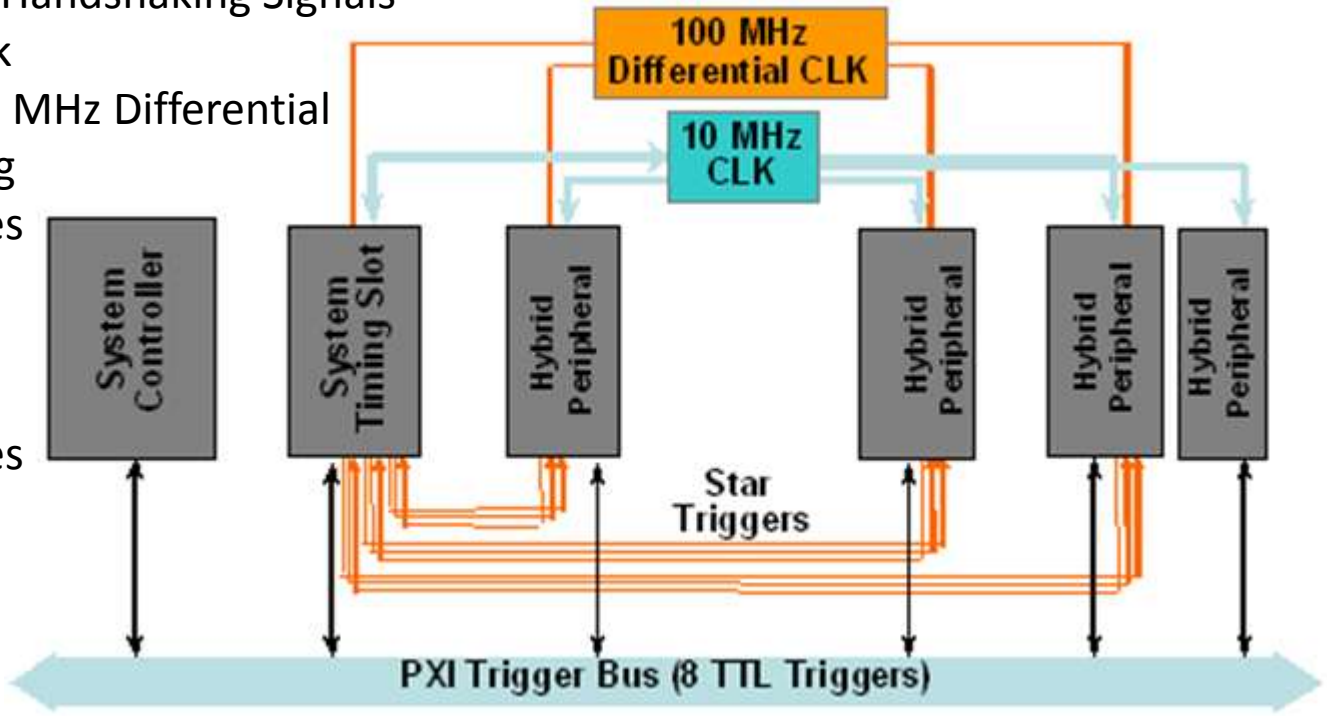
Peripheral Slots

PXI Chassis

- 3U, 6U, and 3U/6U combo
- 4 through 26 slots
- Portable, benchtop, rack mount
- AC and DC power options
- Application specific
  - Ultra rugged, integrated signal conditioning, integrated LCD, etc.

Timing and Synchronization Features of PXI

- PXI Trigger Bus
  - 8 TTL
  - Trigger, Clock, and Handshaking Signals
- System Reference Clock
  - 10 MHz TTL or 100 MHz Differential
  - Phase Lock Looping
  - Equal-Length Traces (< 200 ps skew)
- Star Trigger
  - Differential
  - Equal-Length Traces (< 150 ps Skew)



Embedded PXI System Controllers

General Purpose OSs

- Windows, Linux, etc.
- High performance
- Integrated peripherals
  - Gigabit Ethernet, USB 2.0, ExpressCard, etc.
- Ethernet / LAN control of PXI

Real-Time OSs

- LabVIEW Real-Time, VxWorks, etc.
- Determinism and reliability
- Headless operation

PXI Multiprocessing

Remote PXI System Controllers

PC Control of PXI

- Use latest high-performance PCs
- Build multichassis PXI systems

Laptop Control of PXI

- Control portable applications
- Use with DC-powered chassis for mobile systems

PXI Products. . .

Data Acquisition and Control

Multifunction I/O
Analog Input/Output
Digital I/O
Counter/Timer
FPGA/Reconfigurable I/O
Machine Vision
Motion Control
Signal Conditioning
Temperature
Strain/Pressure/Force/Load
Synchro/Resolver
LVDT/RVDT
Many More. . .

Modular Instrumentation

Digital Waveform Generator
Digital Waveform Analyzer
Digital Multimeter
LCR Meter
Oscilloscope/Digitizer
Source/Signal Generator
Switching
RF Signal Generator
RF Signal Analyzer
RF Power Meter
Frequency Counter
Programmable Power Supply
Many More. . .

Bus Interfaces

Ethernet, USB, FireWire
SATA, ATA/IDE, SCSI
GPIB
CAN, DeviceNet
Serial RS-232, RS-485
VXI/VME
Boundary Scan/JTAG
MIL-STD-1553, ARINC
PCMCIA/CardBus
PMC
Profibus
LIN
Many More. . .

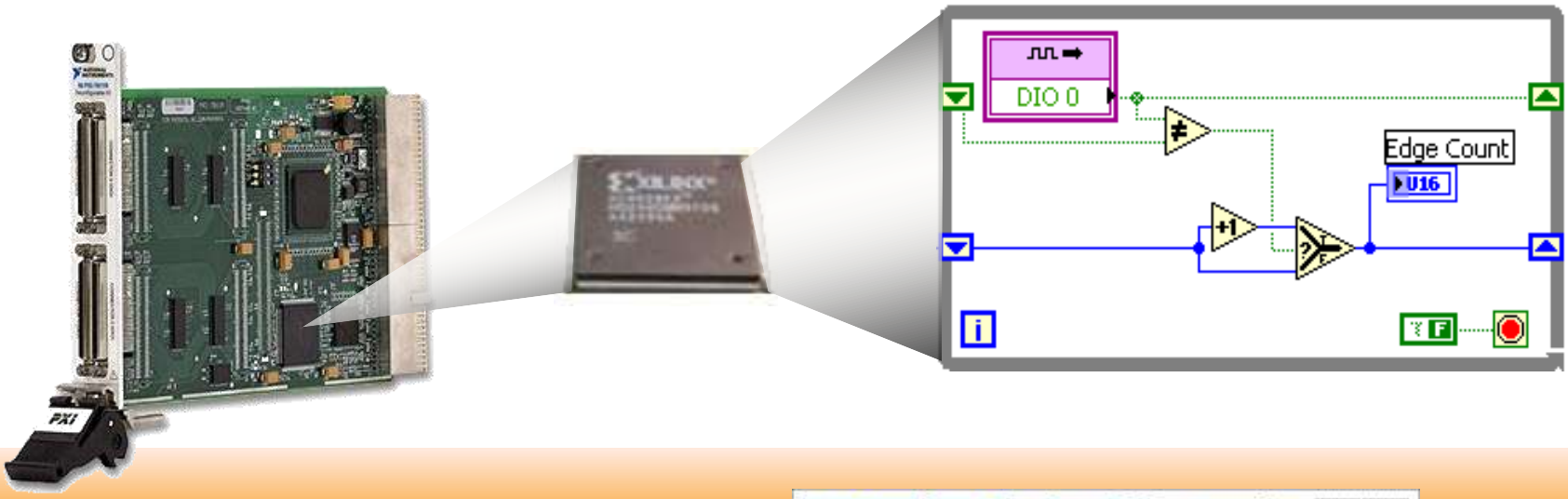
Others

IRIG-B, GPS
Direct-to-Disk
Reflective Memory
DSP
Optical
Resistance Simulator
Fault Insertion
Prototyping/Breadboard
Graphics
Audio
Many More. . .

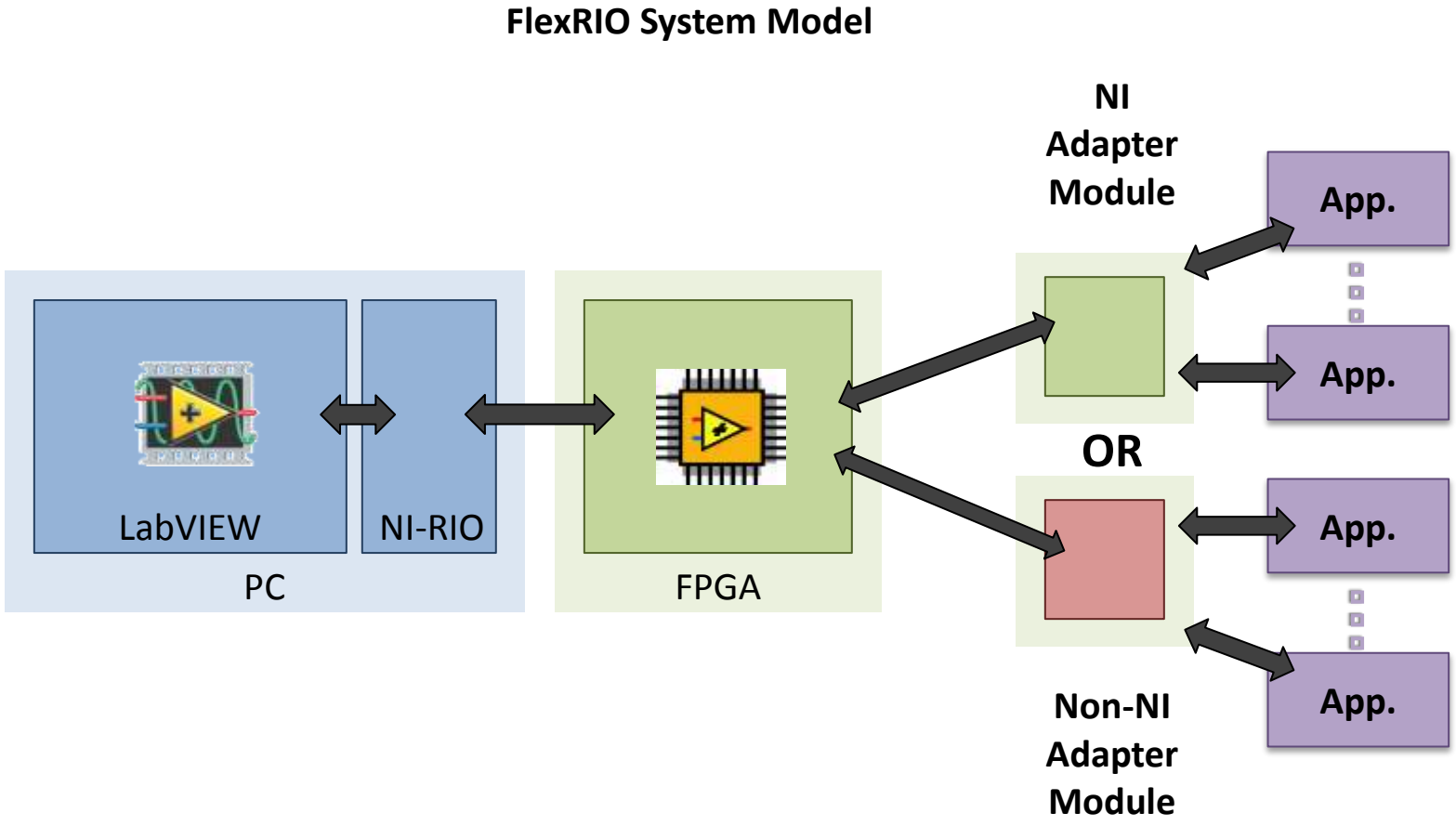
Over 1500 different modules from more than 70 manufacturers

Reconfigurable IO FPGA

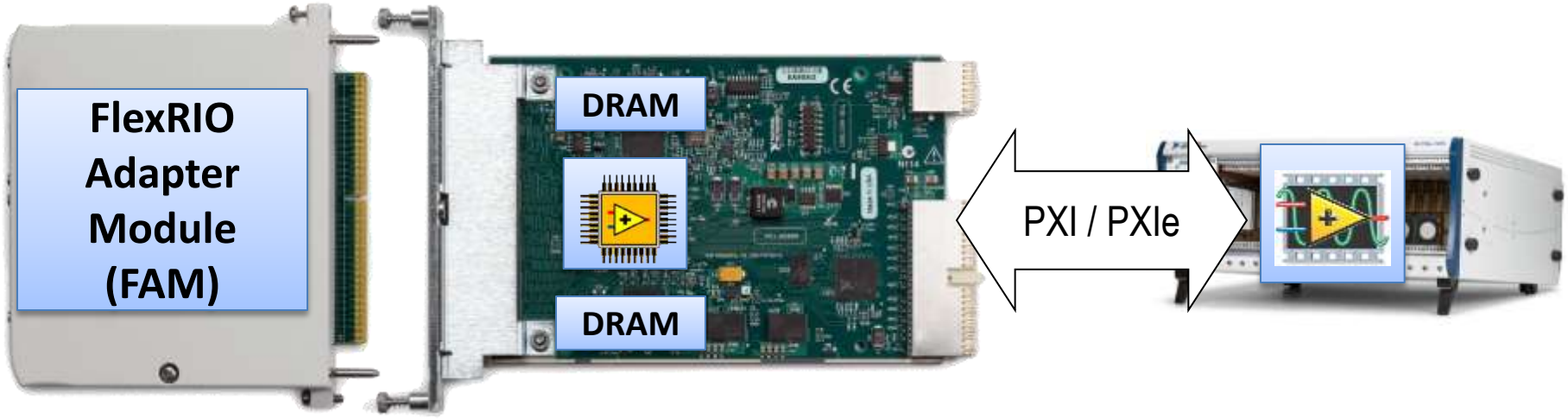
- Intuitive programming for both embedded engineers and domain experts
- High-speed timing and synchronization
- Custom digital protocols **User-defined COTS**
- In-line signal processing
- Hardware speed, reliability, and determinism



What is FlexRIO?



What's in the Box?



NI FlexRIO Adapter Module

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

NI FlexRIO FPGA Module

- Virtex-5 FPGA
- 132 digital I/O lines
- 128 MB of DDR2 DRAM
- Adapter module power supplies and interface

PXI Platform

- Synchronization
- Clocking/triggers
- Power/cooling
- Data streaming

NI FlexRIO Adapter Modules

- Digital

100 MHz SE DIO

200 MHz LVDS DIO

200 MHz SE/LVDS DIO

Camera Link

RS-485/422

- Analog

2 ch. 100 MS/s AI/AO

32 ch. 50 MS/s AI

4 ch. 250 MS/s AI

16 ch. 50 MS/s AI

NI FlexRIO Partner Modules

T2 Integrated Solutions

100 MHz PPMU

ADSYS CONTROLS INC.

Camera Link and GigE

IRS

MultiGigabit optical

Prevas

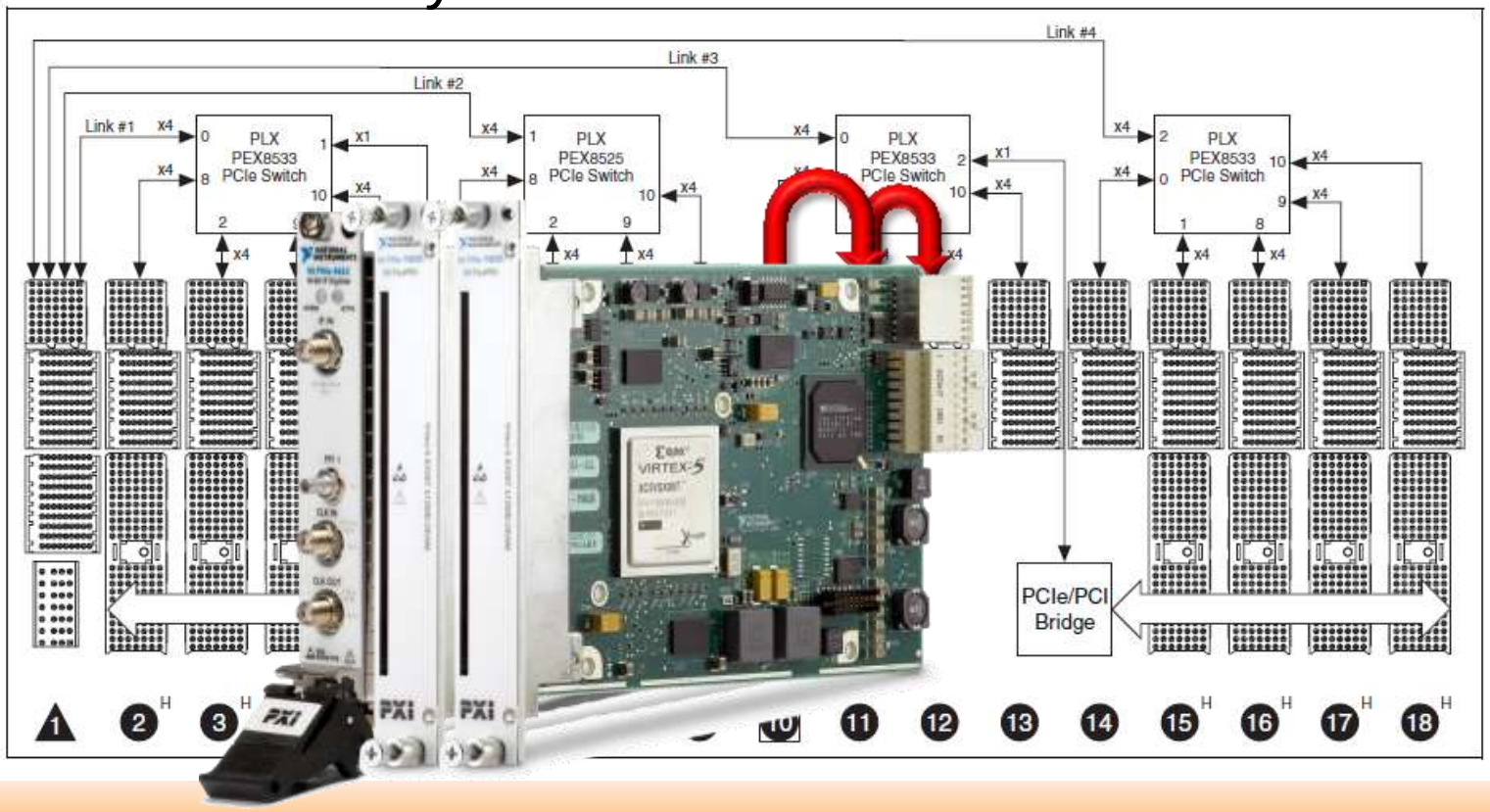
Dual Gigabit Ethernet

alfamation

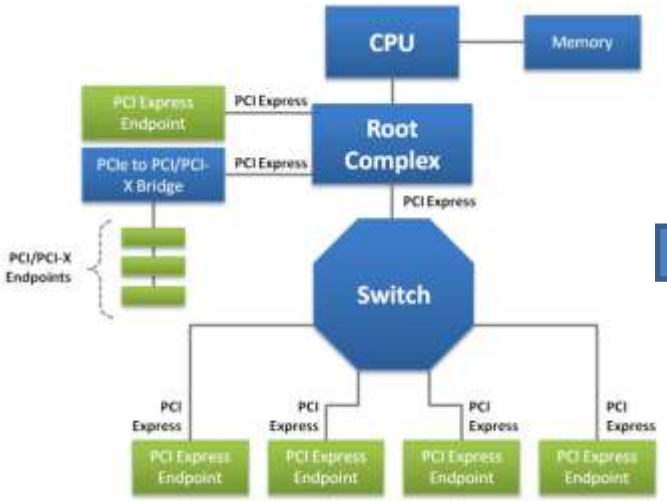
Video and Automotive

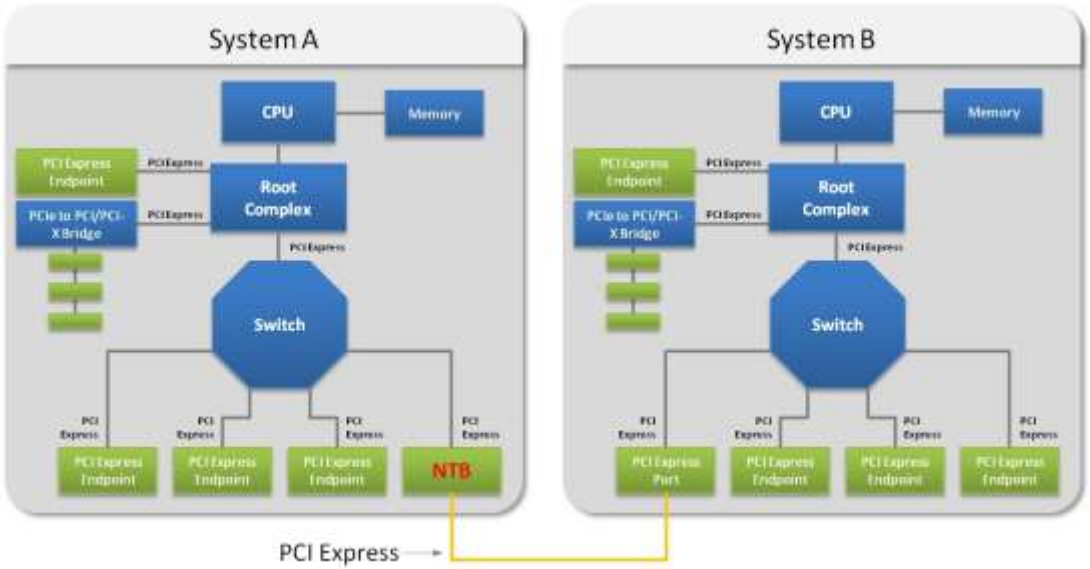
NI FlexRIO Peer-to-Peer Architecture

- >800 MB/s one-way
- >700 MB/s both ways
- ~10 us latency
- Up to 16 streams per FPGA

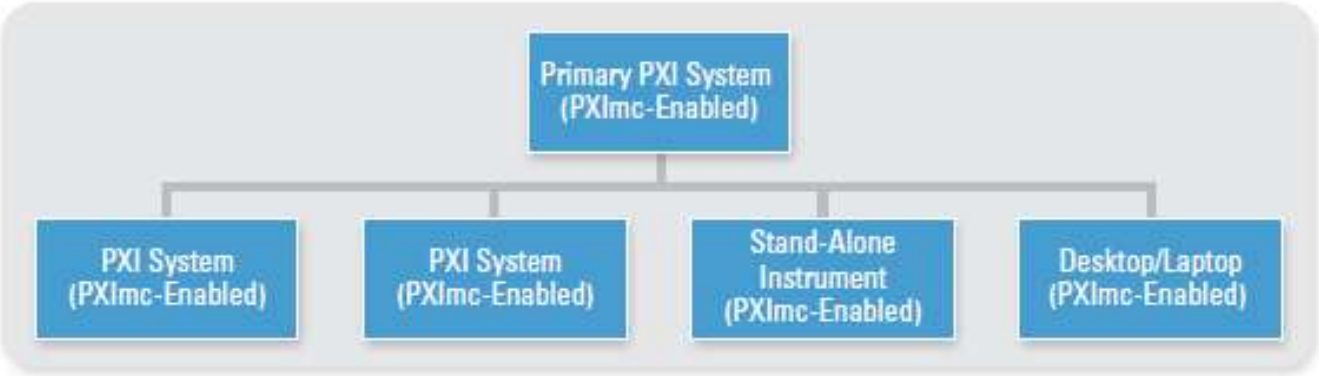


PXImc - High Performance Computing in PXIe





Where extreme computing power is required

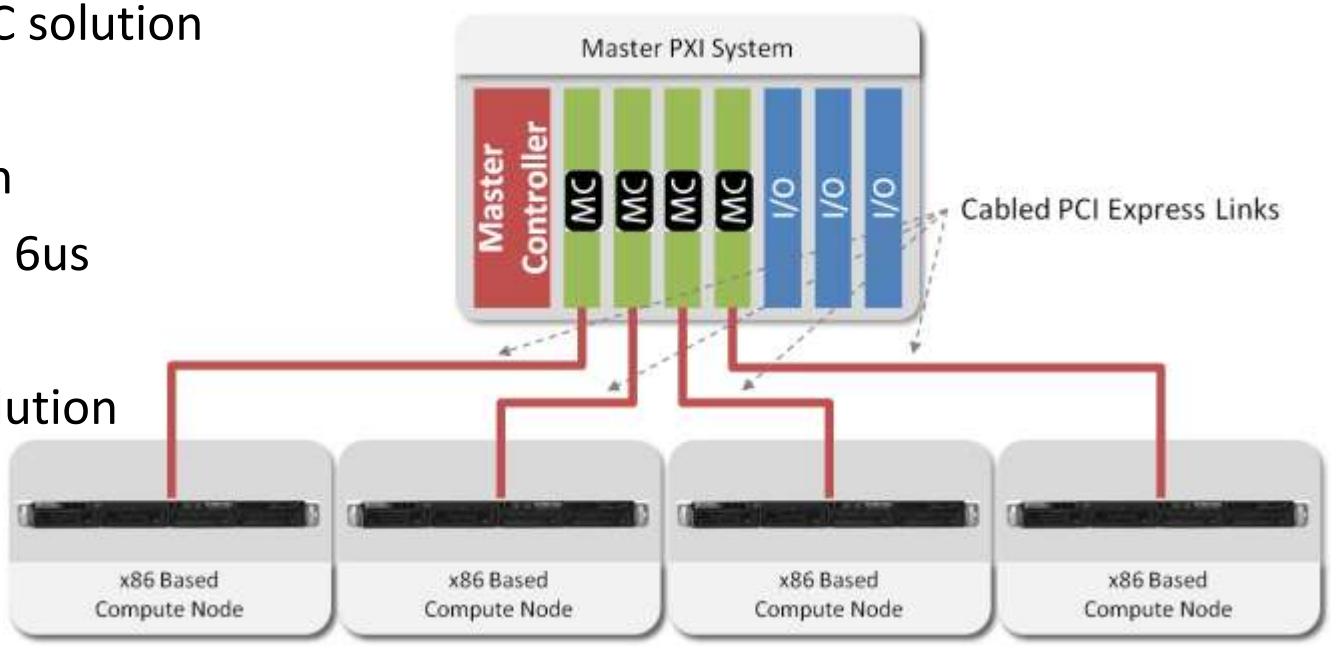


PXImc - High Performance Computing in PXIe

Example

PXIe 1078 chassis HPC solution

- PCI x4 gen 1
- 1GB/s / direction
- Latency down to 6us



Gbit Ethernet HPC solution

- 100MB/s
- 600us latency

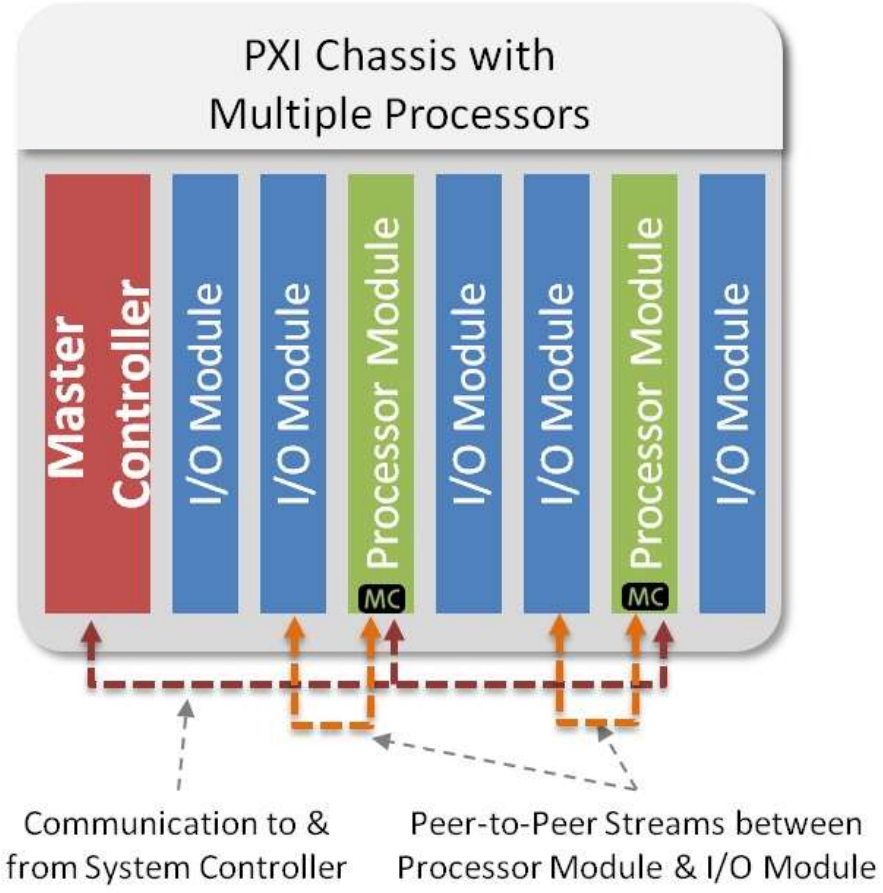
- 10x better data bandwidth
- 100x better data latency

PXImc + Peer 2 peer technology

PXIe Peer2Peer

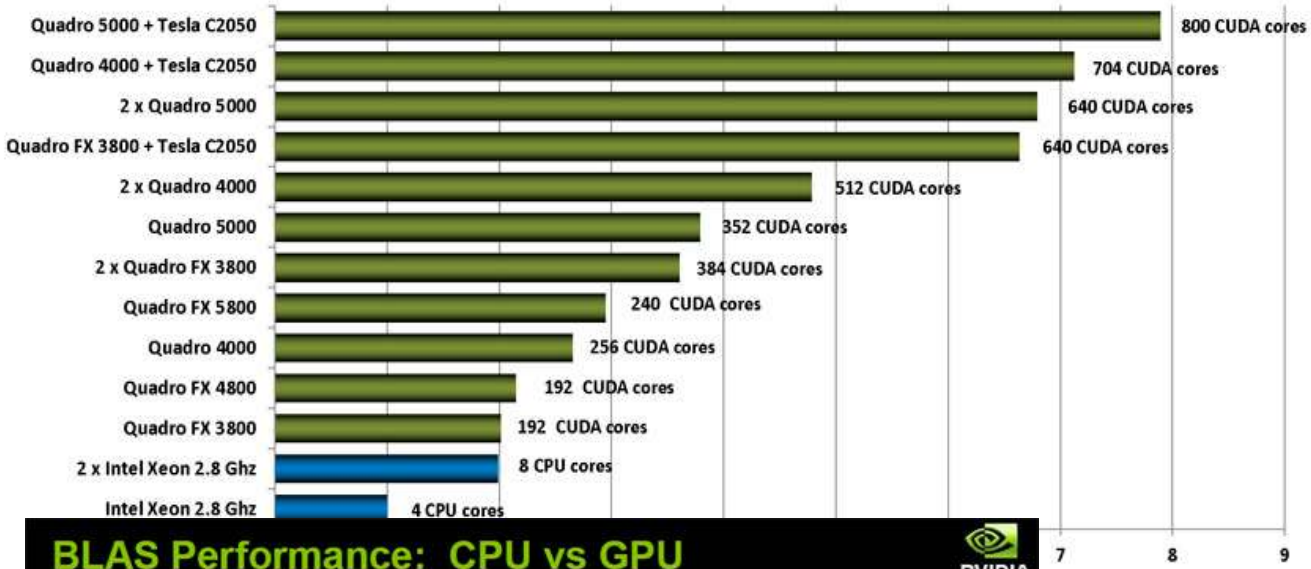
- Allows stream data between slots without passing data through controller

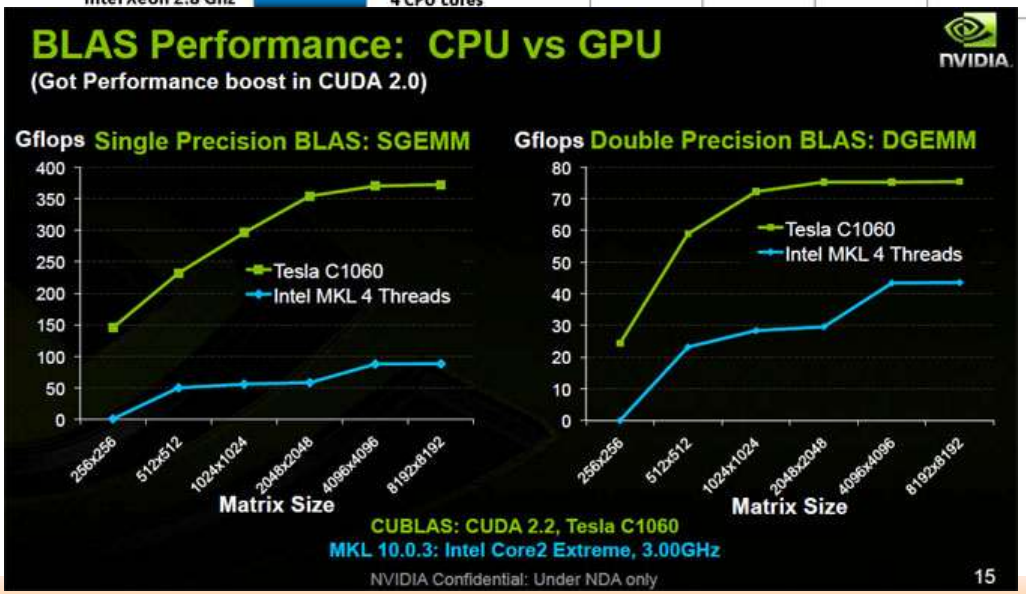
- PXImc + P2P allows high performance computing power for each I/O module



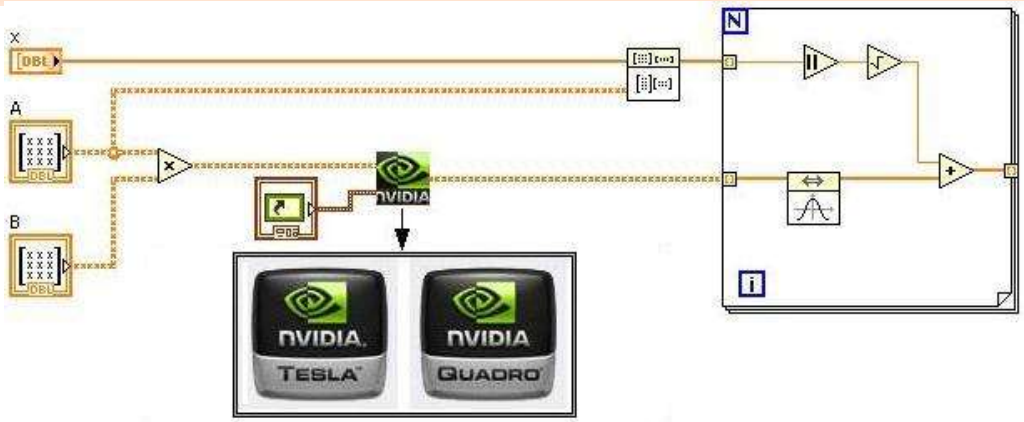
GPU computing – Why?

GPUs are for matrix math intensive application much faster





GPU computing – How?



Runs on nVidia Quadro and Tesla GPUs

Search for “LabVIEW GPU Computing” on ni.com

CompactRIO

Real-Time OS
Up to 800 MHz PowerPC
Reliable embedded control, analysis, and logging

Networked
Ethernet 10/100 BaseT. embedded Web and file servers; connectivity to modems

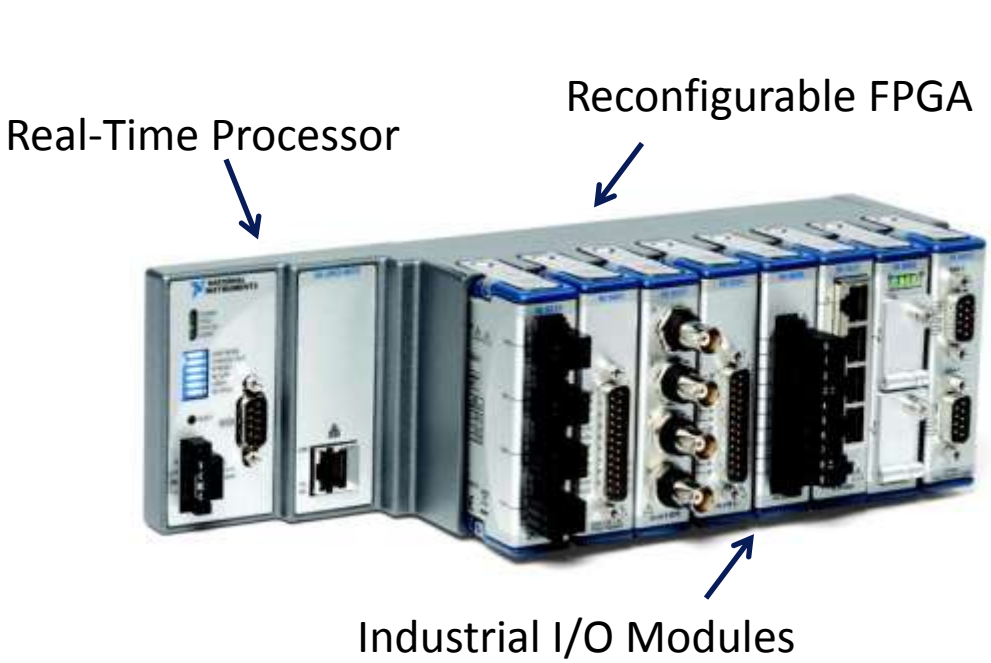
Extreme Durability
-40 to 70 °C temperature range
50 G shock, Industrial certifications

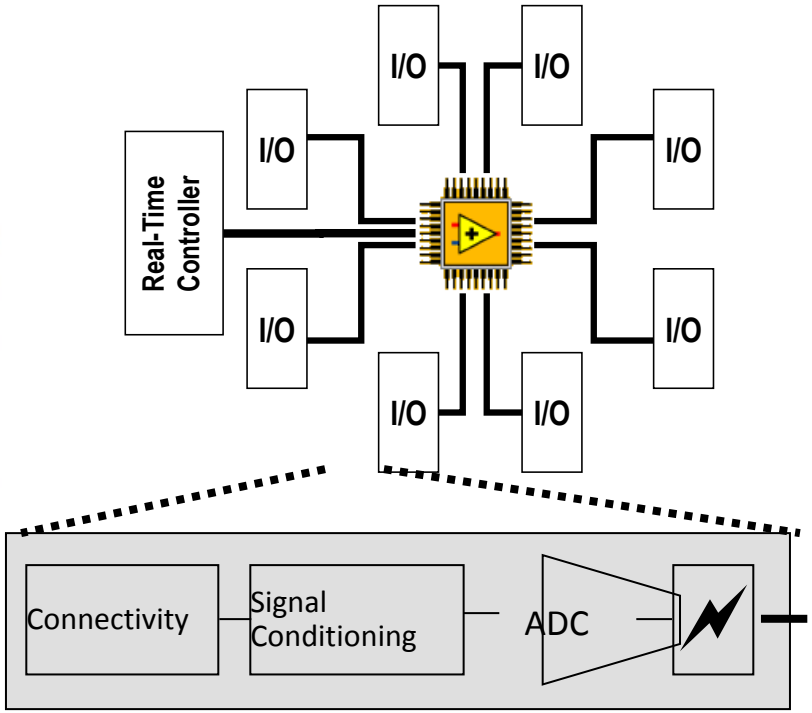
Small Size, Low Power Consumption
179.6 x 88.1 mm (7.07 x 3.47 in)
11 to 30 VDC power, 17 W max (7-10 W typ.)

Reconfigurable FPGA Circuitry
Custom hardware reliability; flexible timing, triggering, synchronization

Measurement I/O Modules
Isolated, industrial and high-precision options

NI CompactRIO Embedded System Architecture

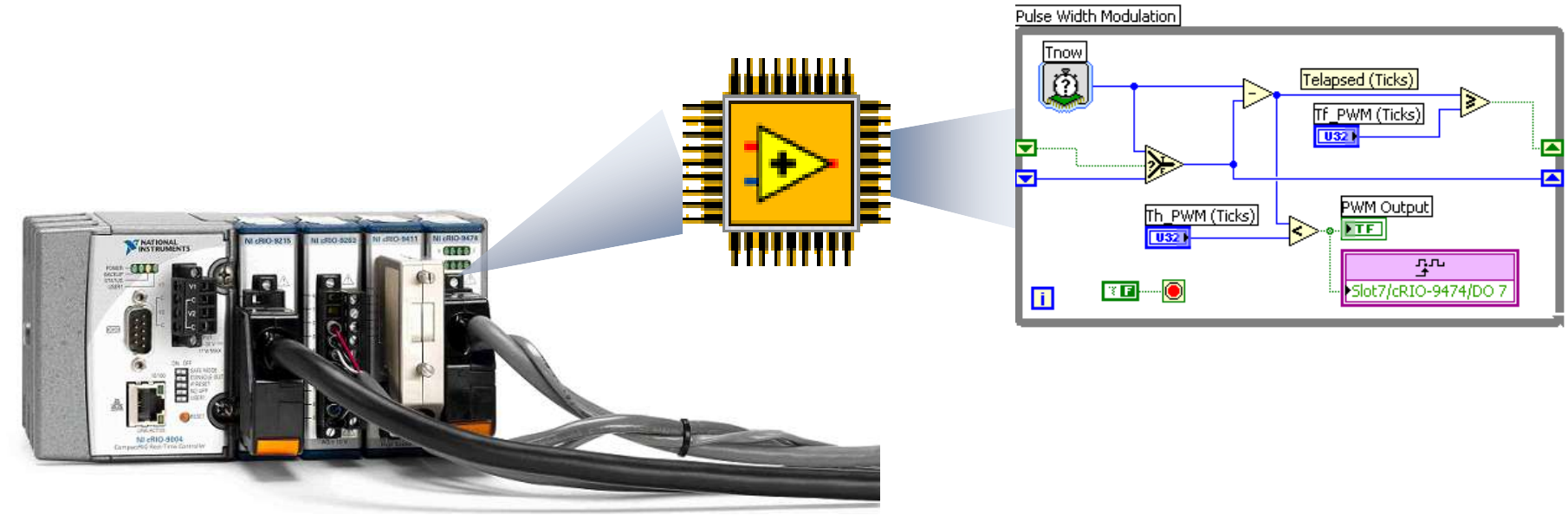




- Industrial I/O Modules with built-in signal conditioning for direct connection to industrial sensors/actuators
- Reconfigurable FPGA for high-speed and custom I/O timing, triggering, processing, control
- Real-Time Processor for deterministic, stand-alone operation and advanced analysis

Reconfigurable I/O (RIO)

Using LabVIEW to design hardware



Replace custom circuitry with software-programmable FPGA logic

- High speed control (1 MHz digital / counter-timer, 200 kHz motion control / analog PID)
- Dedicated logic in silicon for highest reliability
- Signal processing in the data path (decoding industrial sensor signals)

High precision
Industrial grade I/O for Control Design

- ✓Analog I/O
  - ✓Up to 24 bit
  - ✓Up to 1MSa/s
  - ✓Built in excitation
- ✓Digital I/O
  - ✓LVTTL to 250V
  - ✓Up to 30MHz

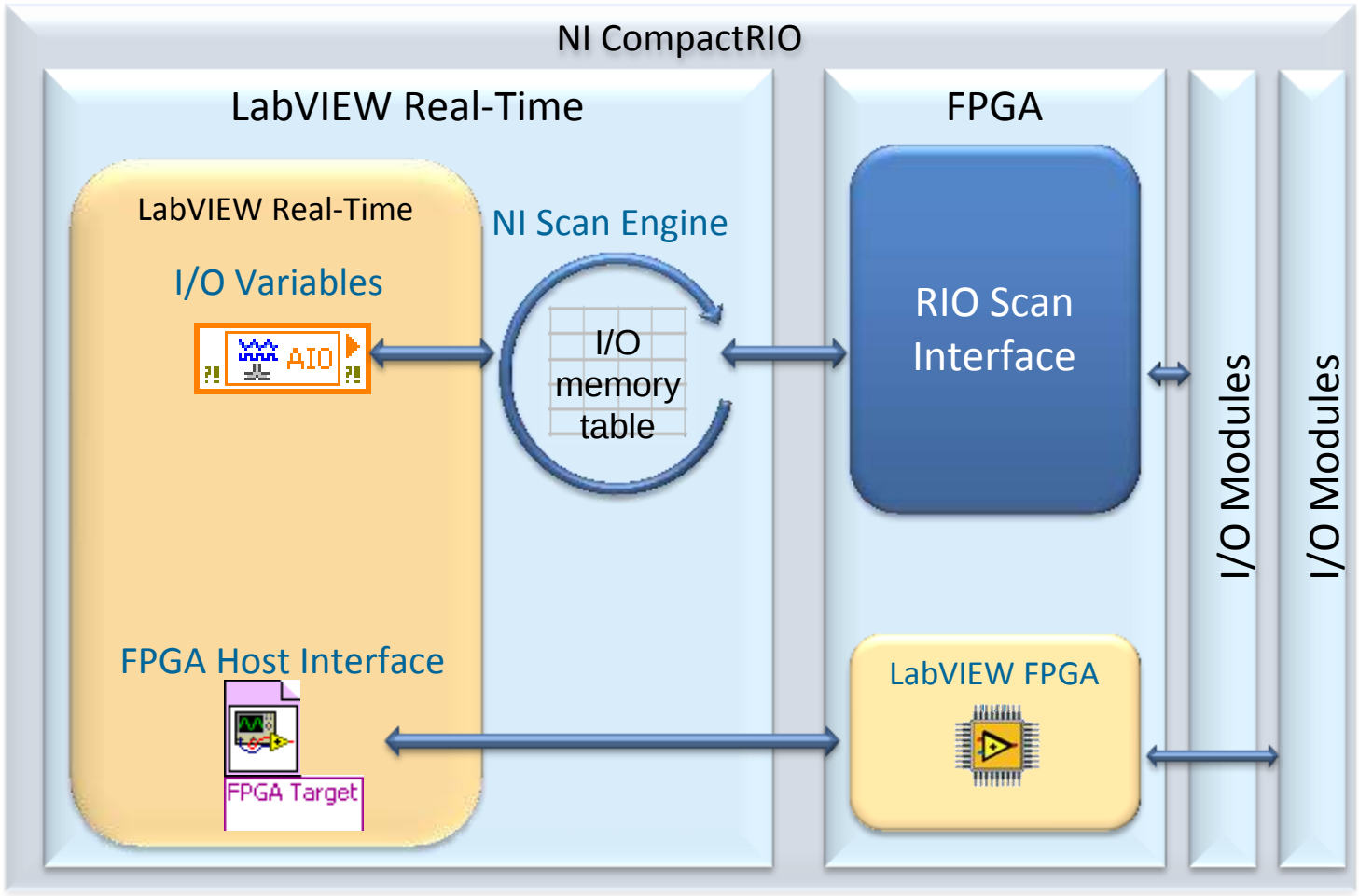
- ✓ Accelerometer
- ✓ Strain Gauge
- ✓ Load Cells
- ✓ Digital I/O
- ✓ Thermocouples
- ✓ 4 to 20mA
- ✓ RTD

- ✓ High Voltage (+/-400V or 300Vrms)
- ✓High Current (10Amps)
- ✓ Servo and sepper drive motion
- ✓ CAN, Serial, custom communication
- ✓ Relay
- ✓ Pulse genaration
- ✓ TEDS
- ✓Quadrature encoders and counters

Benefits of CompactRIO

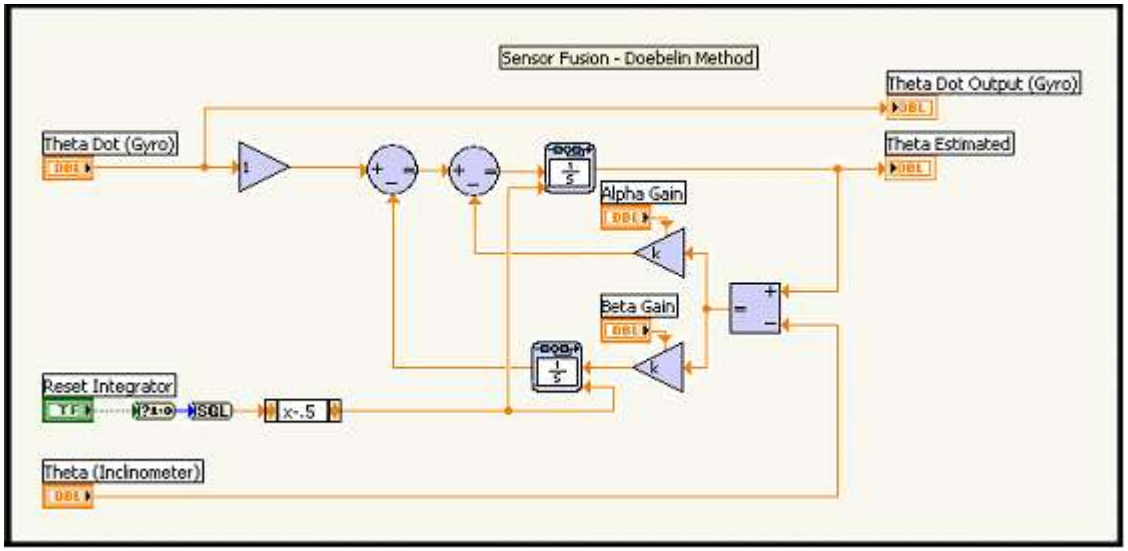
- Reconfigurable FPGA – great versatility
- Widely used in different industries
- Open Embedded System
- High performance
- Extreme Ruggedness
- Connectivity
- High academic discounts

Programming CompactRIO ScanEngine and LabVIEW FPGA



RPI Human Object Transporter

- Professor Kevin Craig, Rensselaer Polytechnic Institute (RPI)
- LabVIEW Simulation Module, CompactRIO, LabVIEW Real-Time, LabVIEW PDA
- Team of undergrads completed project in 4 months!



MXI CompactRIO

High Channel Count C-Series I/O

- 14 slots per chassis
- Up to 6 chassis per daisy chain
- Up to 8 daisy chains per controller

Best-in-Class FPGA

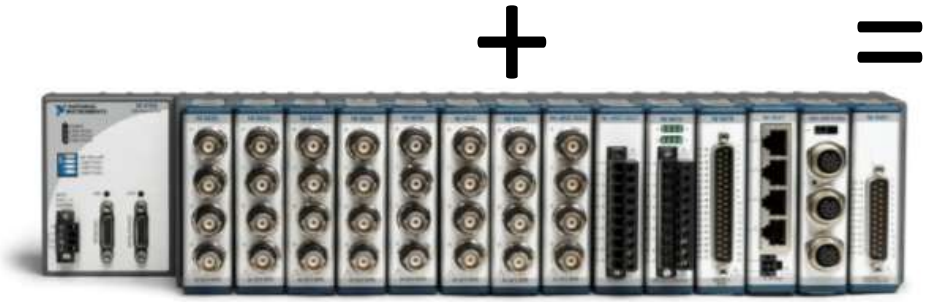
- NI 9157: Virtex5 LX85
- NI 9159: Virtex5 LX110

High-Throughput Cabled PCI-express x1 Connection

- 250MB/s theoretical throughput (20x EtherCAT or Ethernet)
- Connect to high performance PXI, PC, rack-mount, or industrial controllers
- Up to 7m cable length between chassis

NI 31x0 Industrial Controller

- The NI 3110 features an Intel SL9JT L2400 1.66 GHz Core Duo Processor
- The NI 3100 features an Intel 1.06 GHz Celeron M 423 processor
- Both controllers are configured with the Windows XP or RT operating system
- NI 3110 supports RT Hypervisor
- Controllers can be used as an interface to control remote I/O with hardware such as NI CompactDAQ, NI PXI, and NI plug-and-play PCI and PCI Express devices

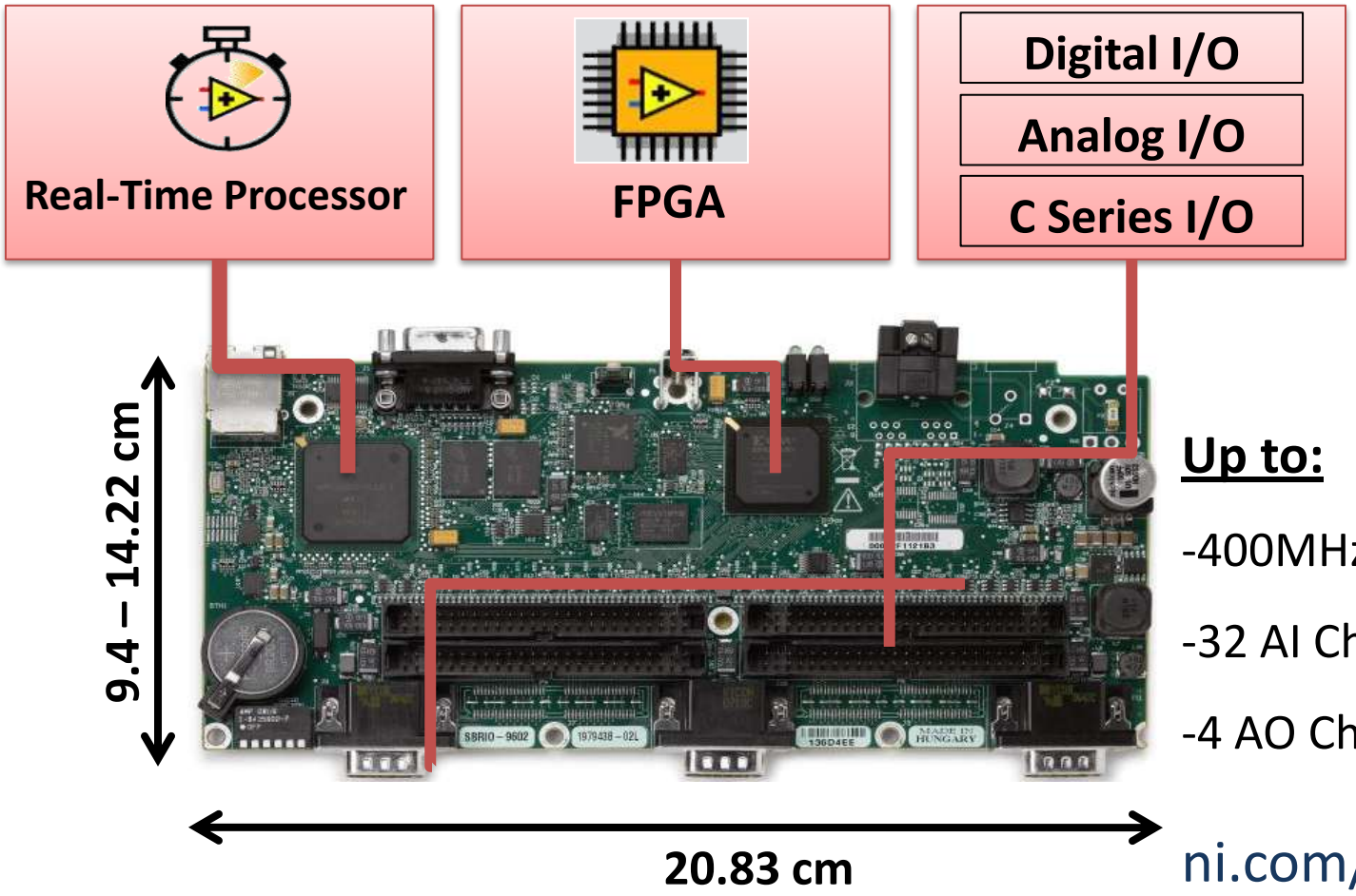


NI Single-Board RIO Embedded Device

- Single-Board Computer based on CompactRIO
  - Real-Time OS, Reconfigurable FPGA, uses C Series I/O Modules
- Several I/O modules included onboard (DIO, AI, AO, 24V DI & DO)
- Ideal for high-volume and OEM applications

NI Single-Board RIO Platform

"The power of CompactRIO on a single board."



Up to:

-400MHz Processor Spee

-32 AI Channels

-4 AO Channels

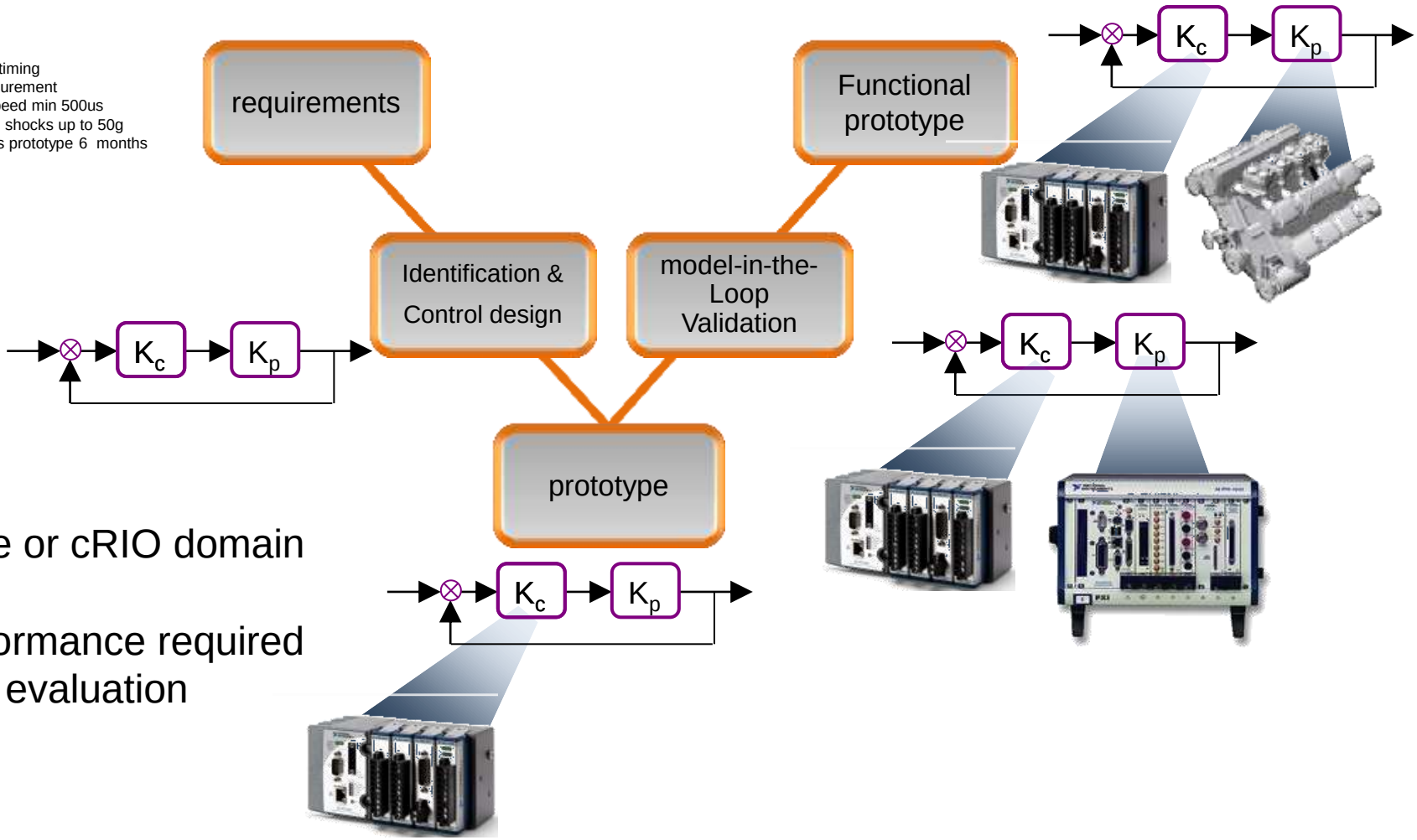
ni.com/singleboard

Single-Board RIO Variants

Model	Processor Speed (MHz)	FPGA Size (Gates)	3.3V DIO Lines	AI Channels	AO Channels	24V DIO Lines	C Series Expansion (Slots)	Size (Inches)
sbRIO-9601	266	1M	110	0	0	0	3	8.2x3.7
sbRIO-9602	400	2M	110	0	0	0	3	8.2x3.7
sbRIO-9611	266	1M	110	32	0	0	3	8.2x5.6
sbRIO-9612	400	2M	110	32	0	0	3	8.2x5.6
sbRIO-9631	266	1M	110	32	4	0	3	8.2x5.6
sbRIO-9632	400	2M	110	32	4	0	3	8.2x5.6
sbRIO-9641	266	1M	110	32	4	32/32	3	8.2x5.6
sbRIO-9642	400	2M	110	32	4	32/32	3	8.2x5.6

Prototyping V diagram

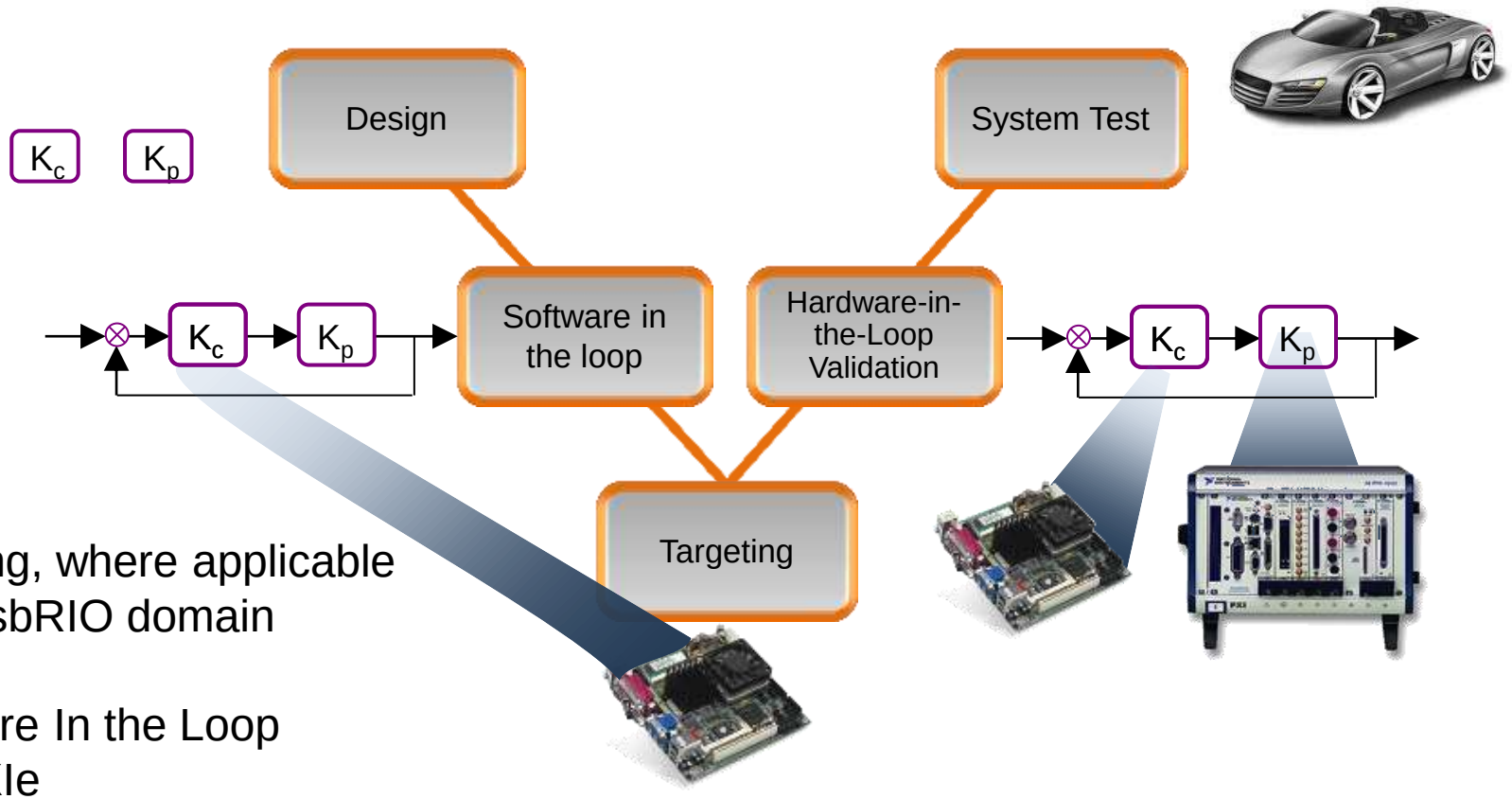
Gas Engine
Variable valve timing
Vibration measurement
Control loop speed min 500us
Must withstand shocks up to 50g
deadline to finis prototype 6 months



Prototype
PXI / PXIe or cRIO domain

High performance required for model evaluation

Target deployment V Diagram



Targeting, where applicable
cRIO / sbRIO domain

Hardware In the Loop
PXI/ PXIe

Manufacturing V diagram

Based on uP architecture
All tantal capacitor design
Control loop speed min 500us
Must withstand shocks up to 50g
deadline to finish production 6 months

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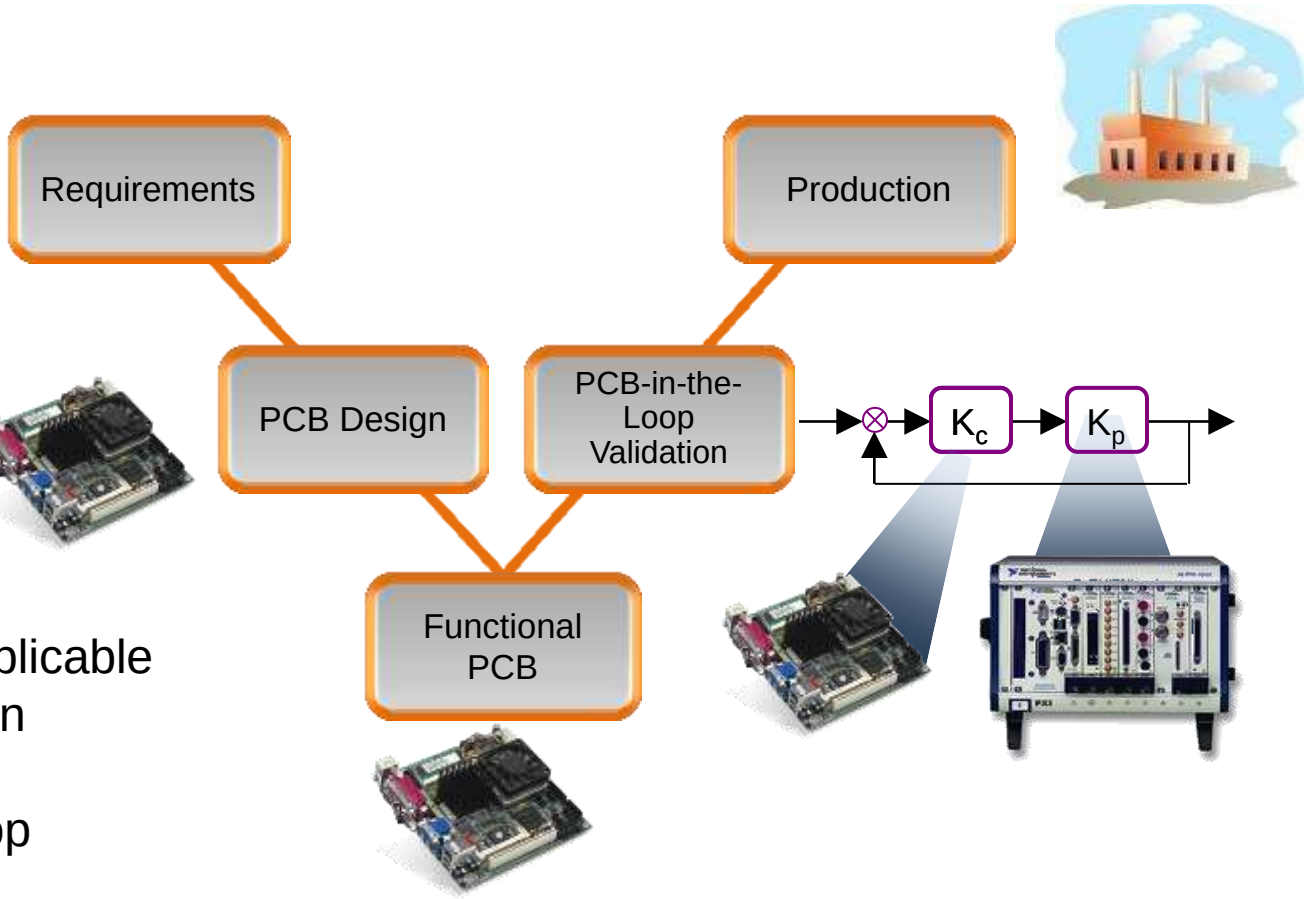

Targeting, where applicable cRIO / sbRIO domain

Hardware In the Loop PXI/ PXIe