DEVELOPING HIGH-PERFORMANCE EMBEDDED AND TEST APPLICATIONS USING NI FLEXRIO AND LABVIEW FPGA

PASI KARPPINEN

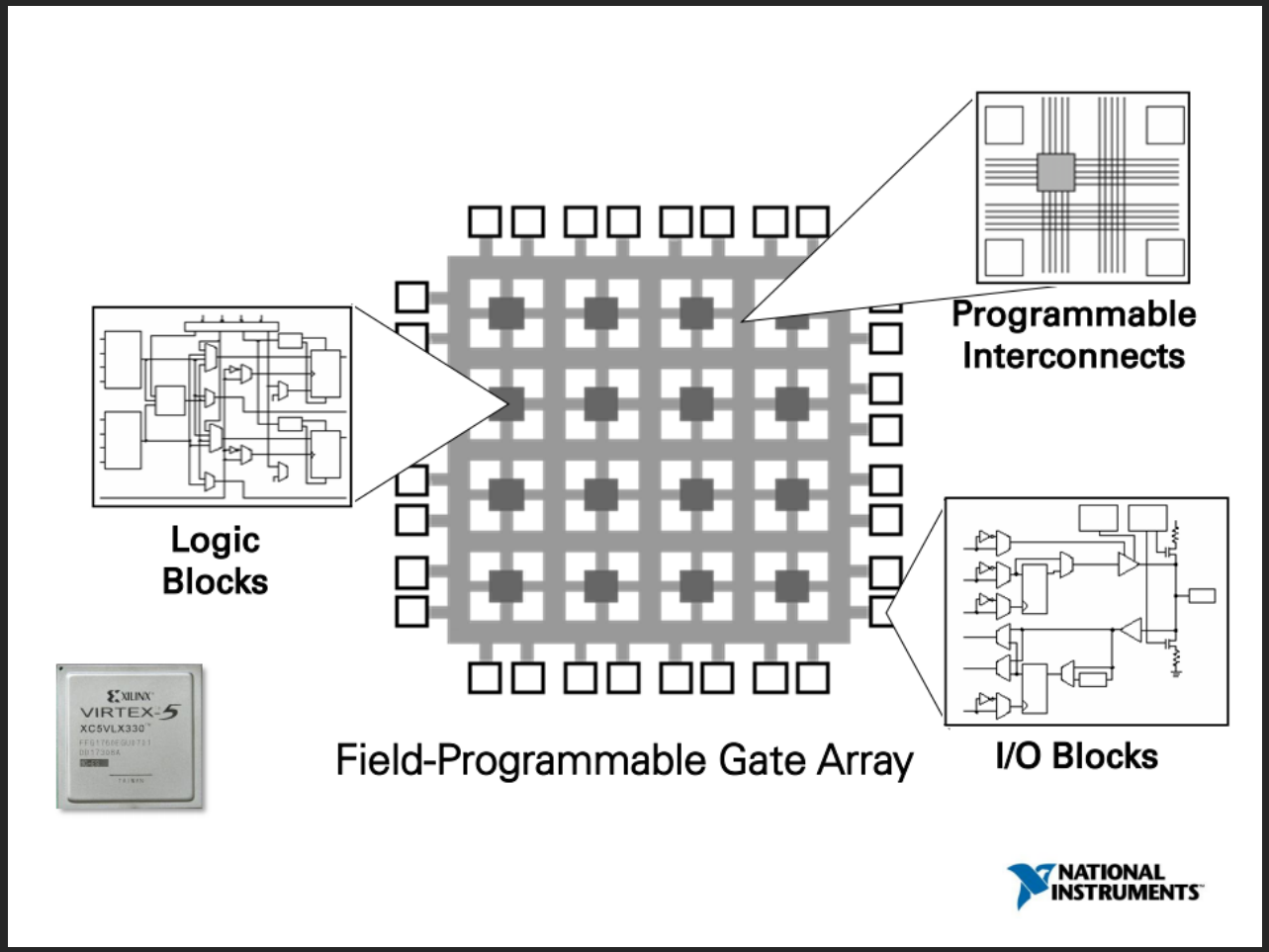
PROTORHINO COMPANY

- Offers custom measurement systems
  - Speciality in high-end FPGA systems
  - Strong instrumentation expertise with scientific measurement background
- Turn-key solutions or consultation

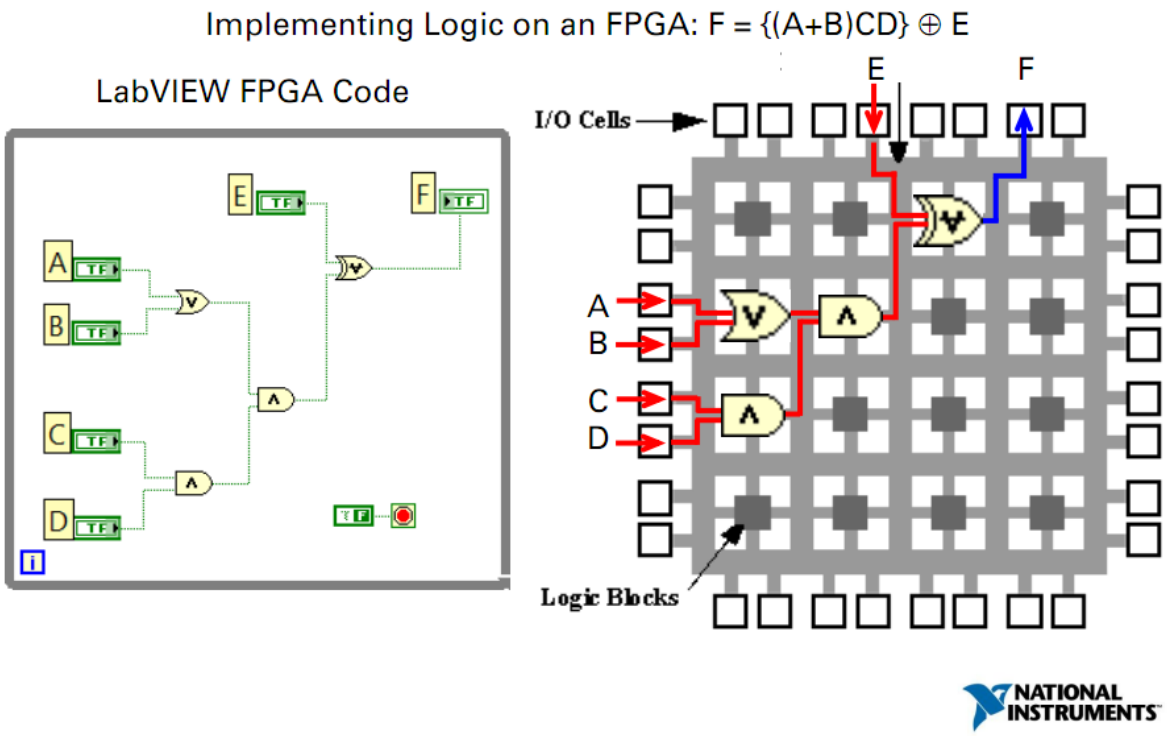
Kimmo Mustonen, CEO, M.Sc.

Pasi Karppinen, CTO, CLD

FPGA TECHNOLOGY



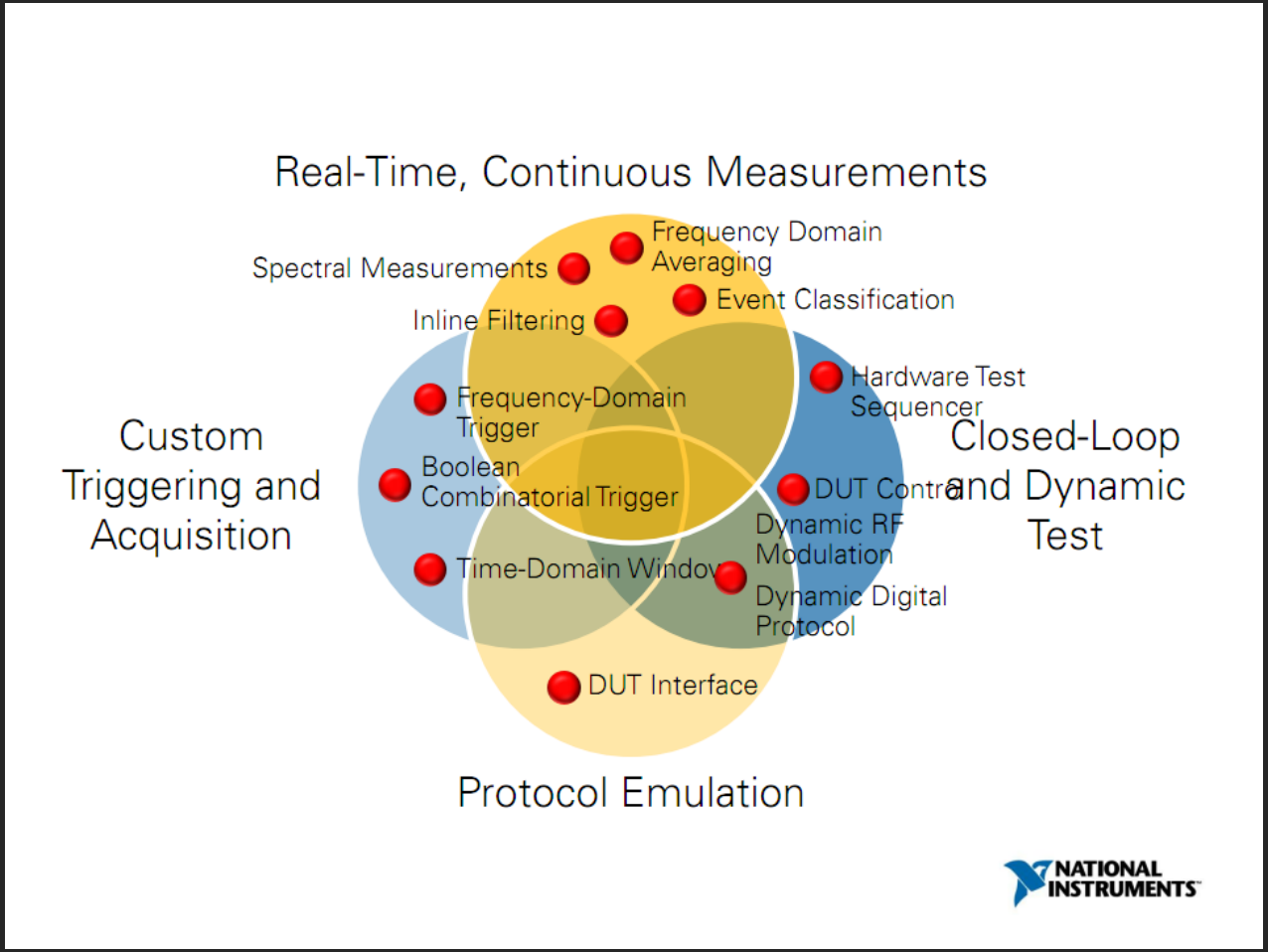
FPGA LOGIC IMPLEMENTATION



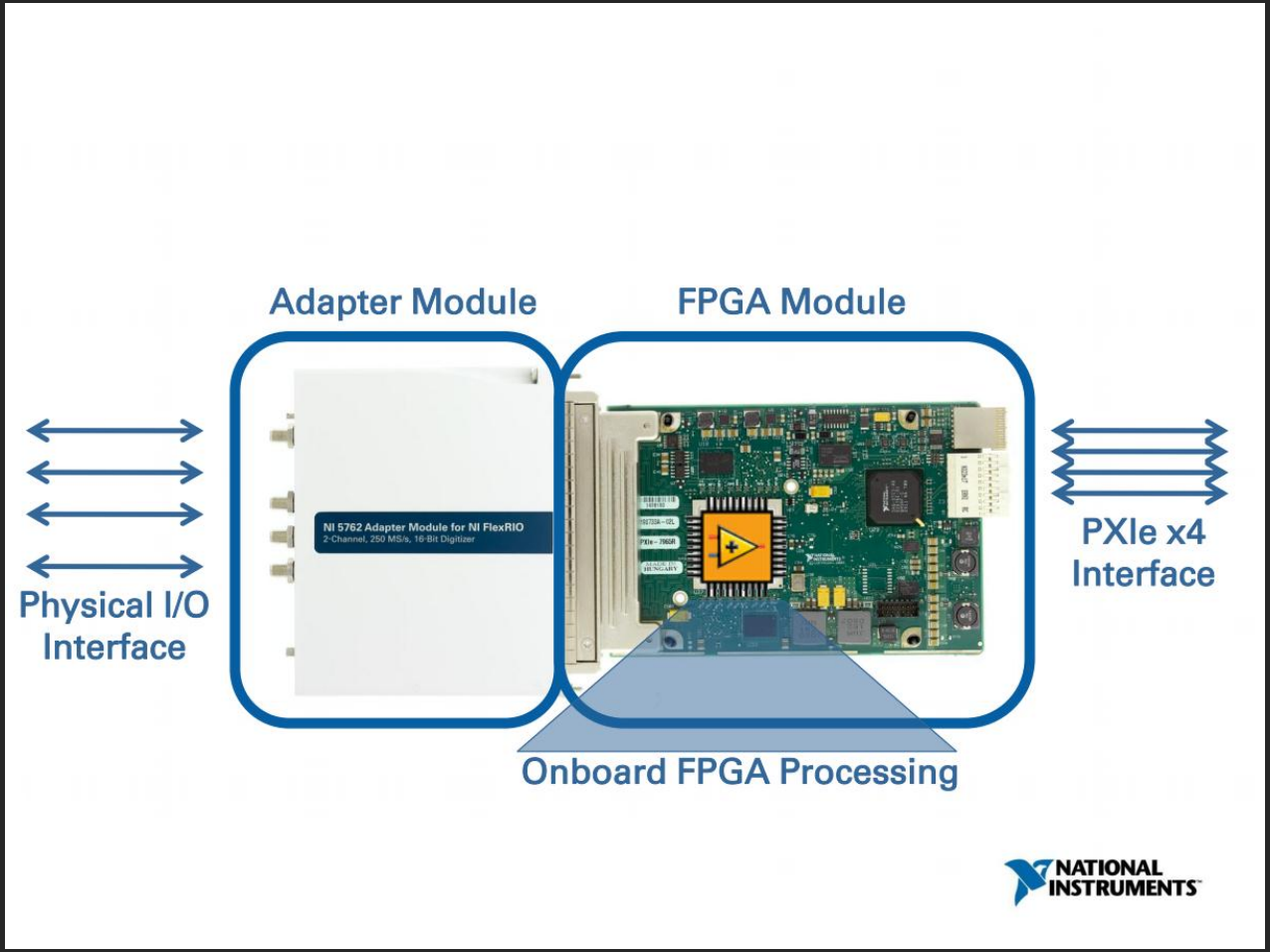
WHY ARE FPGAS USEFUL?

- High Reliability
- High Performance
- True Parallelism
- Low Latency
- Reconfigurable

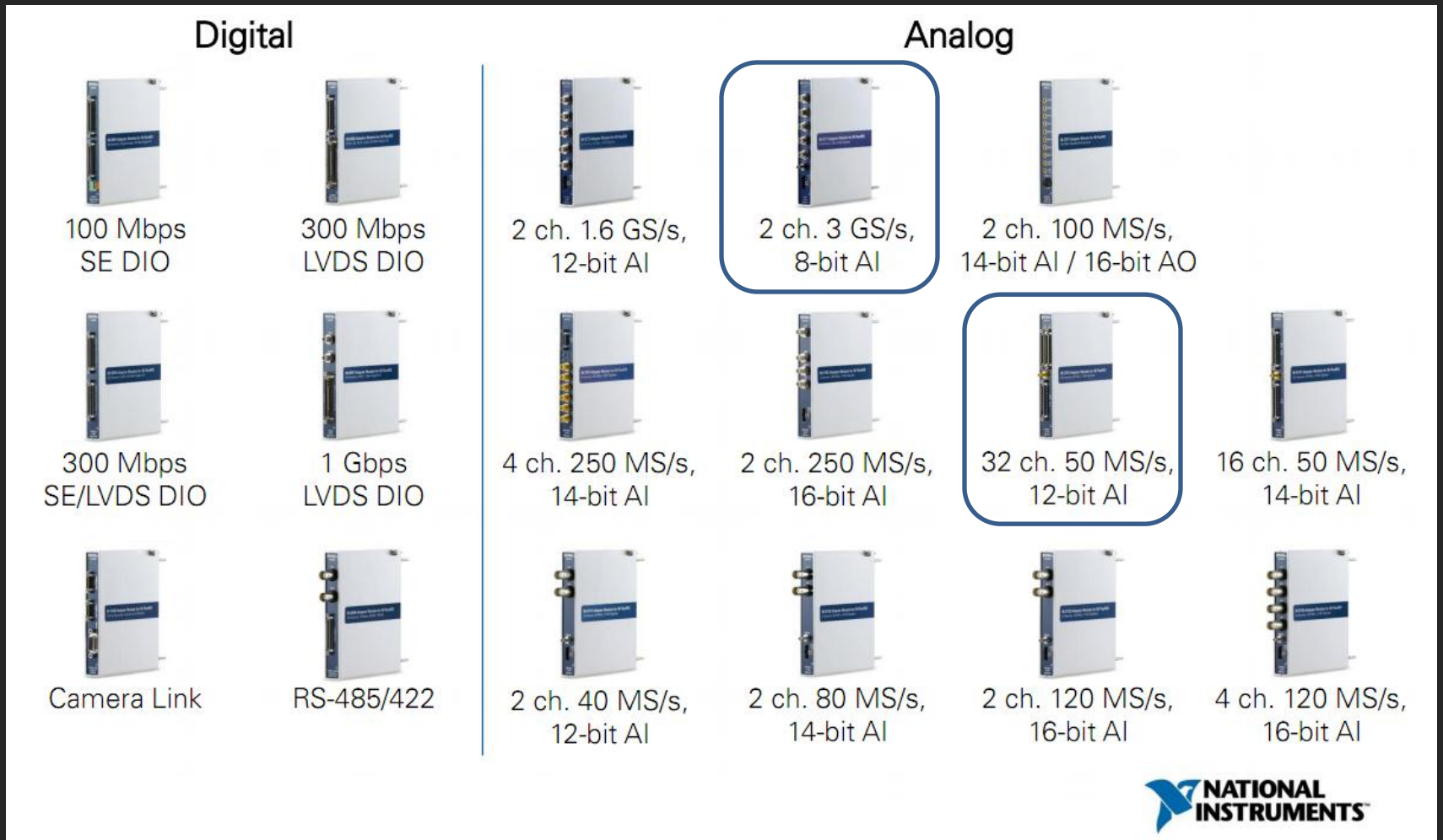
INSTRUMENT CUSTOMIZATION



NI FLEXRIO SYSTEM ARCHITECTURE

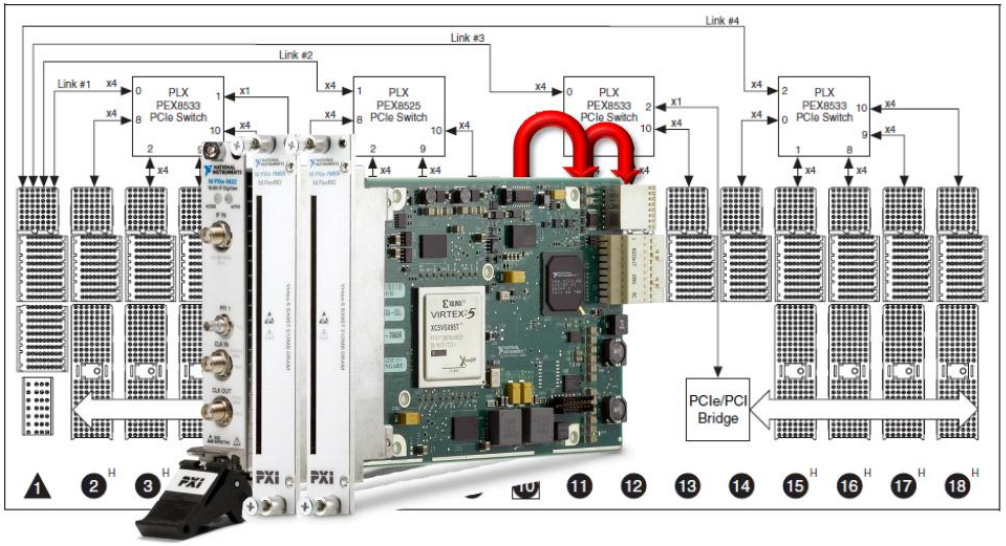


NI FLEXRIO ADAPTER MODULES



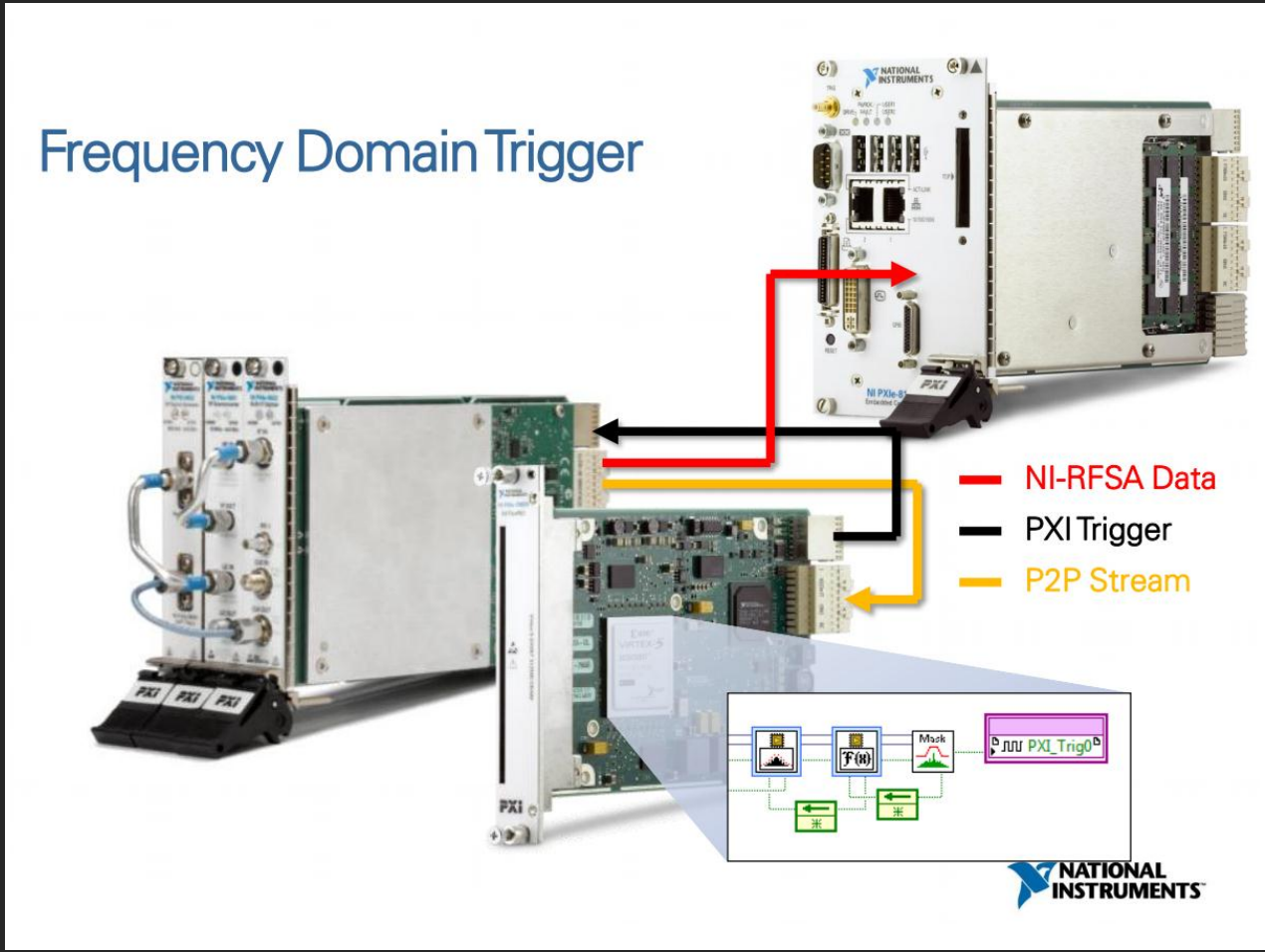
NI FLEXRIO PEER-TO-PEER ARCHITECTURE

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



NATIONAL INSTRUMENTS

EXAMPLE APPLICATION



LABVIEW FPGA PROGRAMMING

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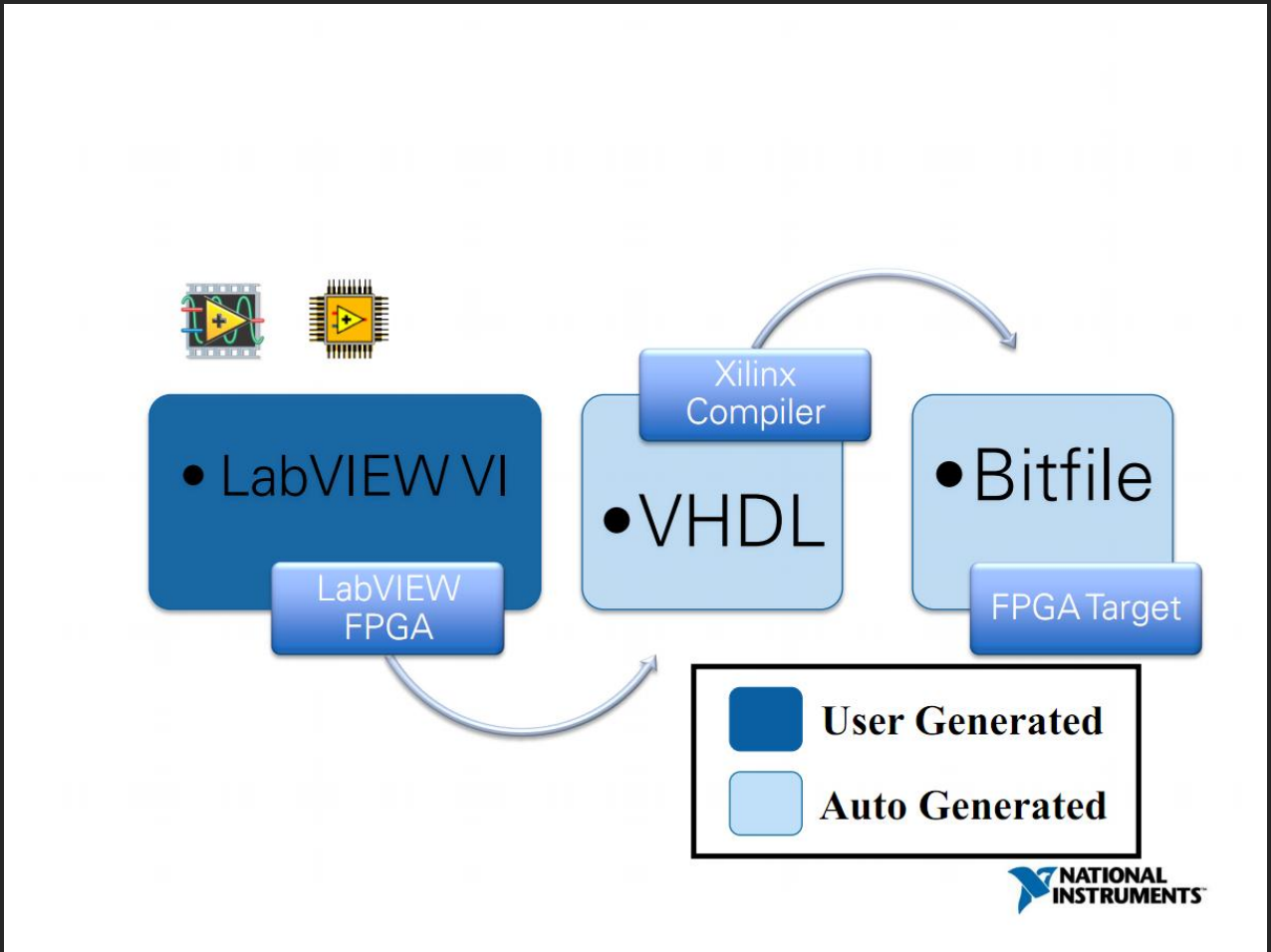
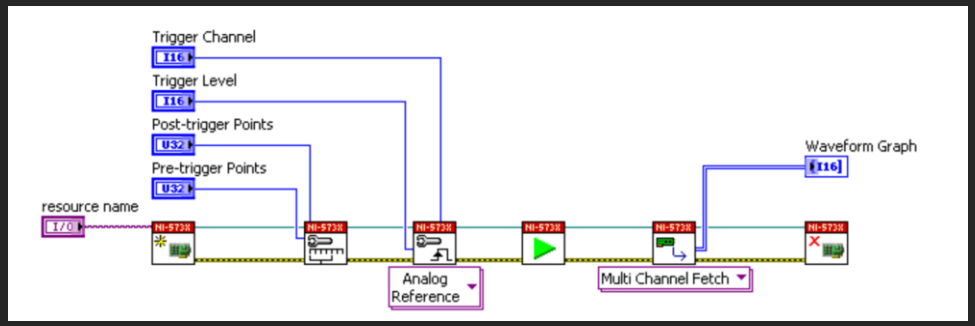
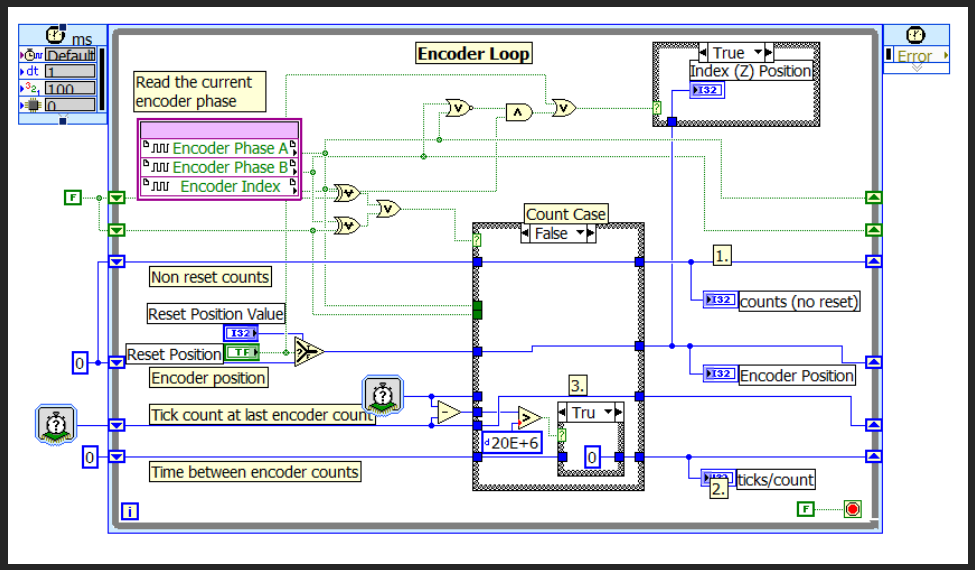


CODE EXAMPLES

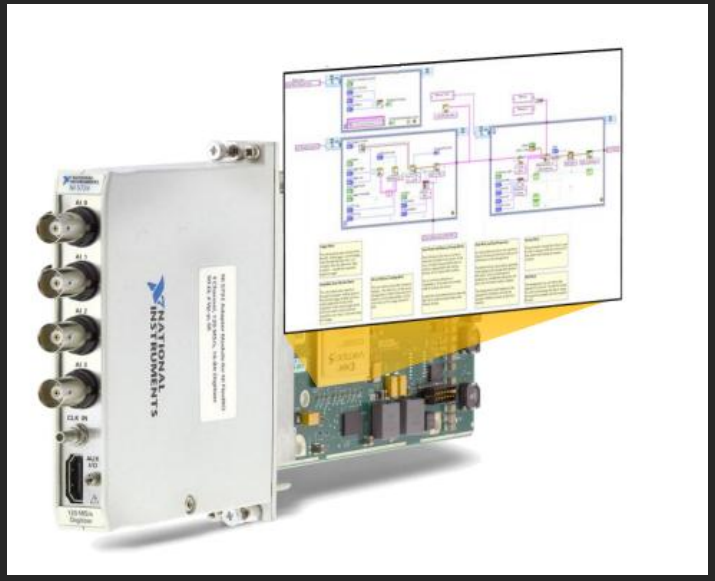
LabVIEW



LabVIEW FPGA

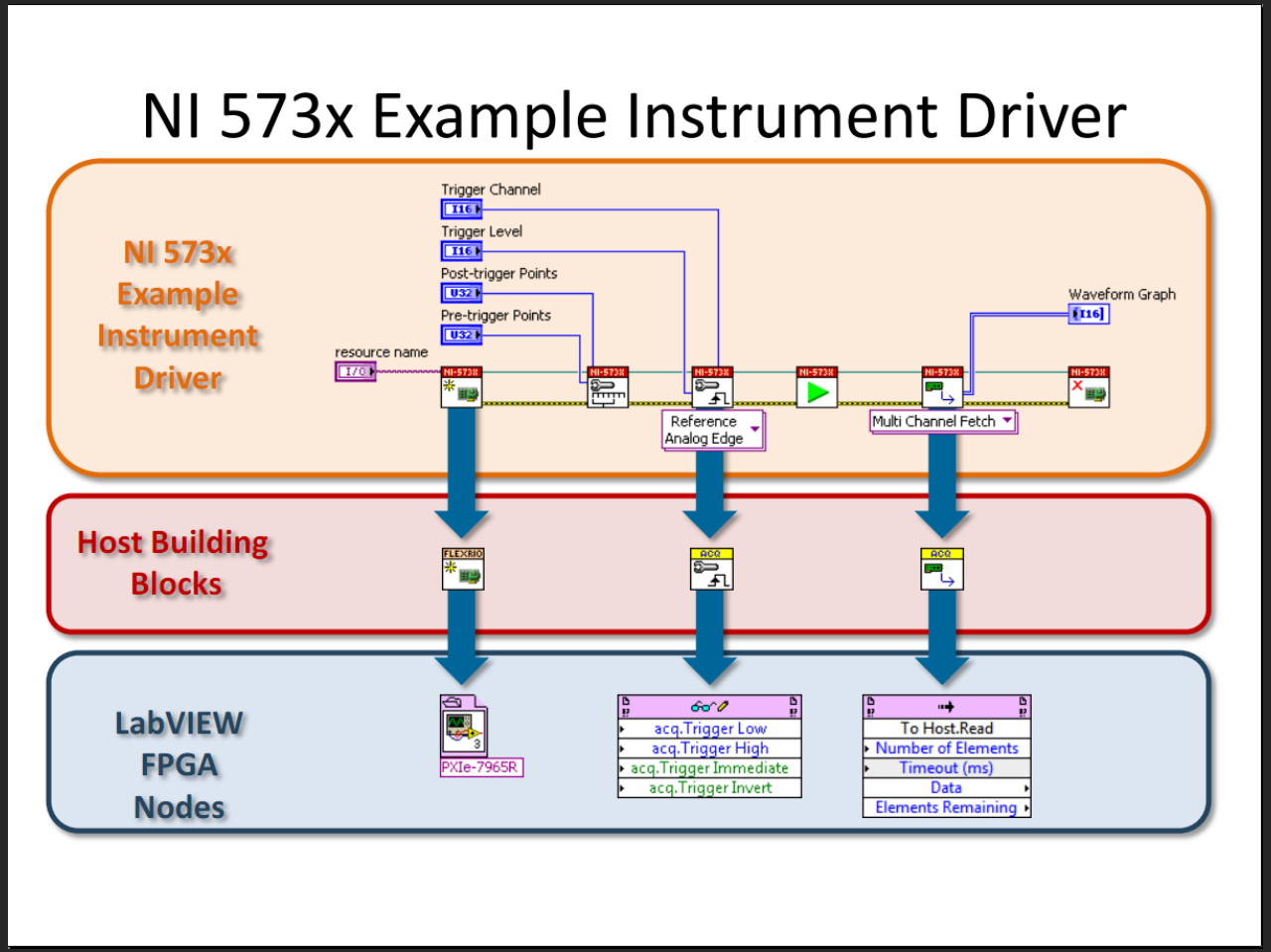


NI FLEXRIO INSTRUMENT DEVELOPMENT LIBRARY

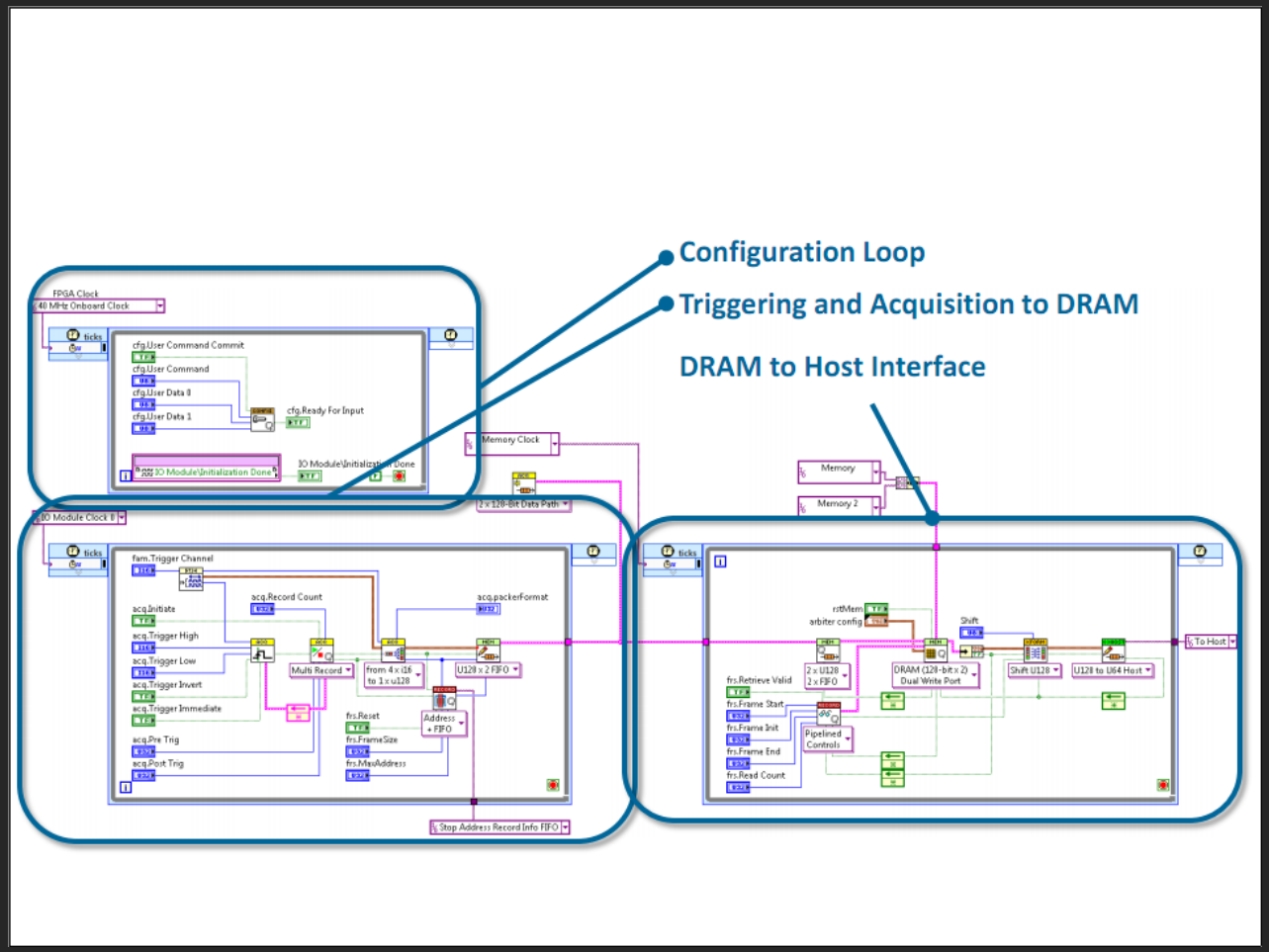


NI 573x Digitizer Adapter Modules

NI FLEXRIO INSTRUMENT DEVELOPMENT LIBRARY

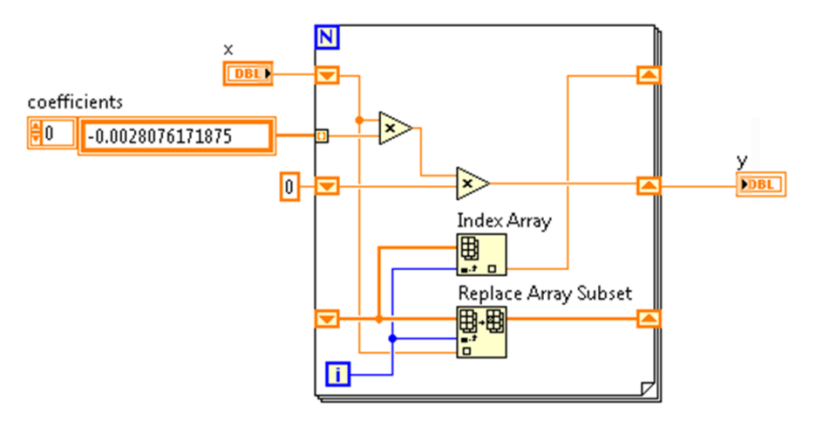


EXAMPLE FPGA ACQUISITION ENGINE

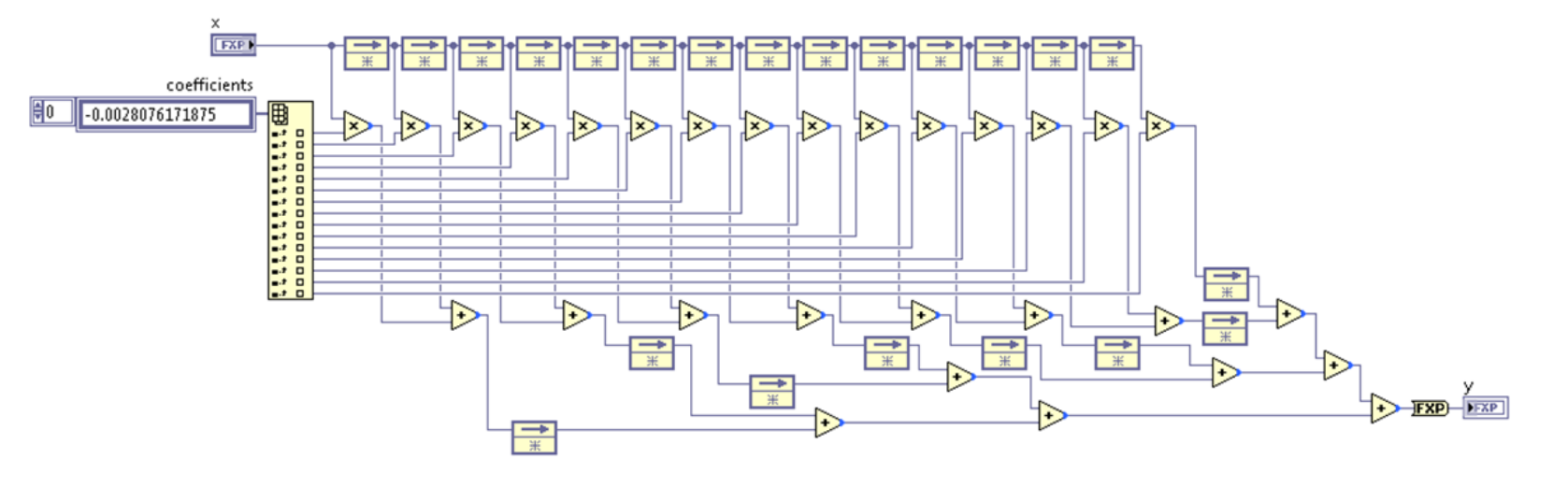


LABVIEW FPGA IP BUILDER

Original FIR filter



Manually Optimized FPGA version



LABVIEW FPGA IP BUILDER

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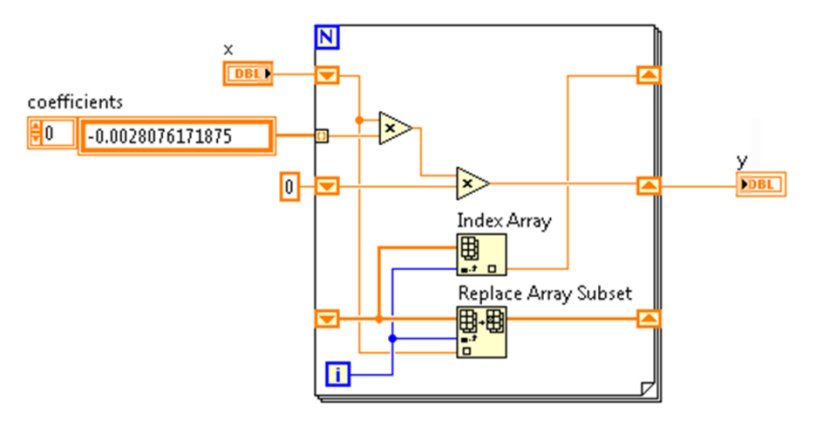
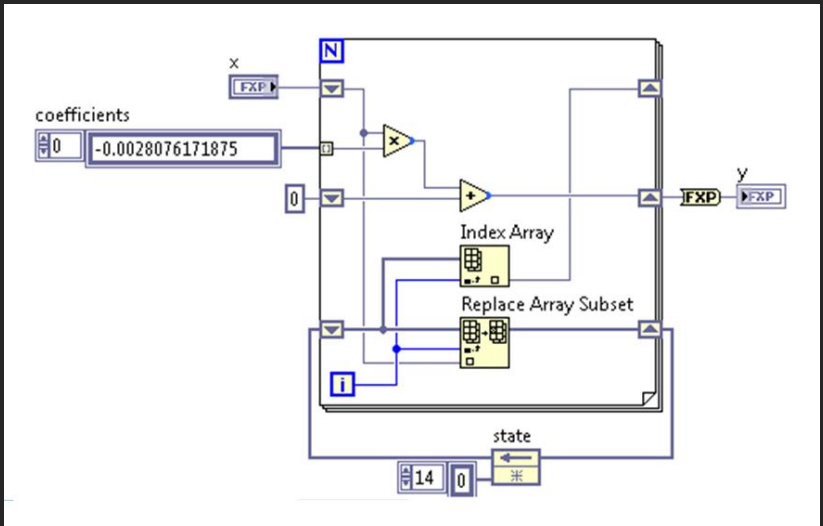
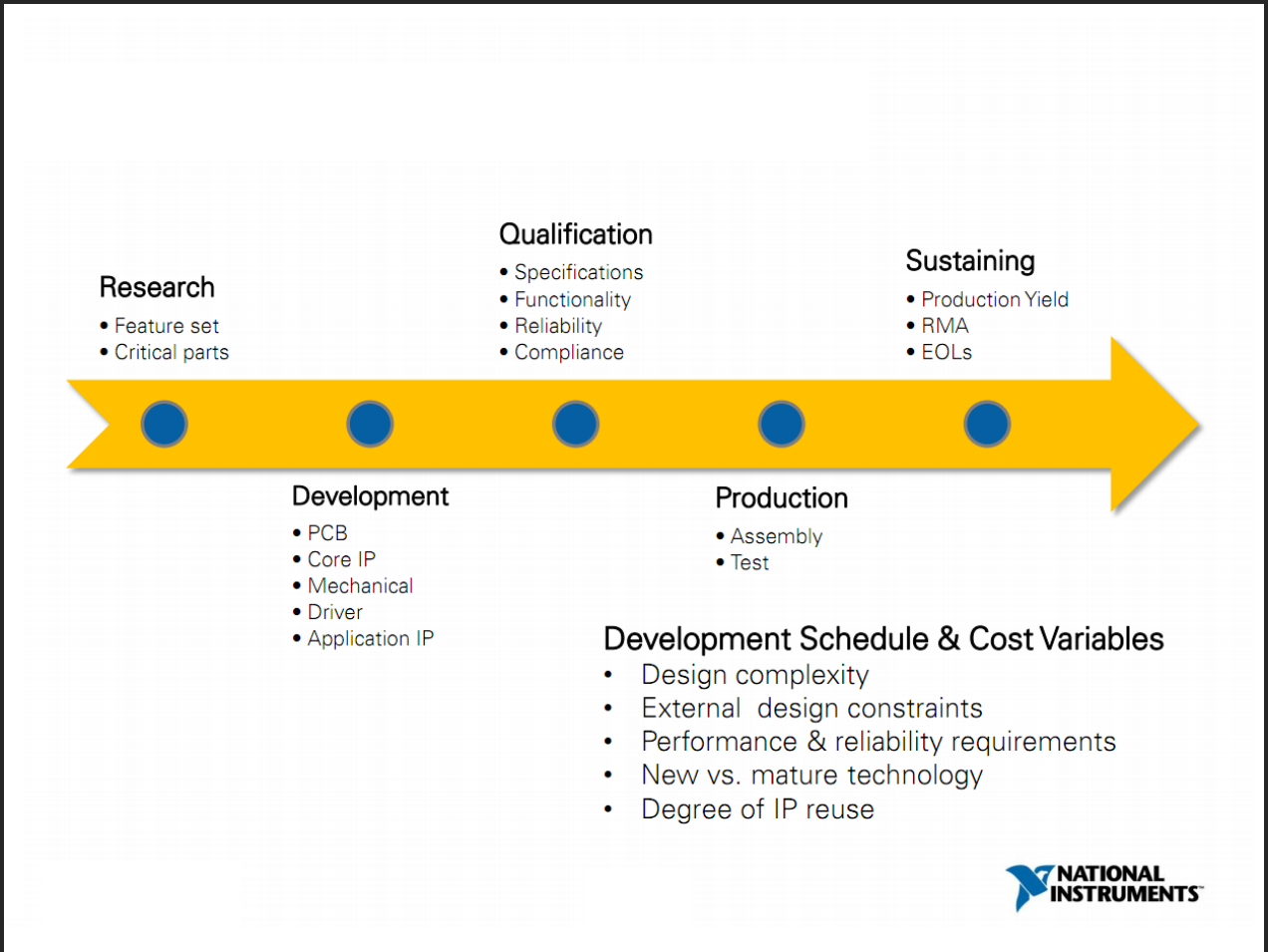


LabVIEW FPGA IP Builder input

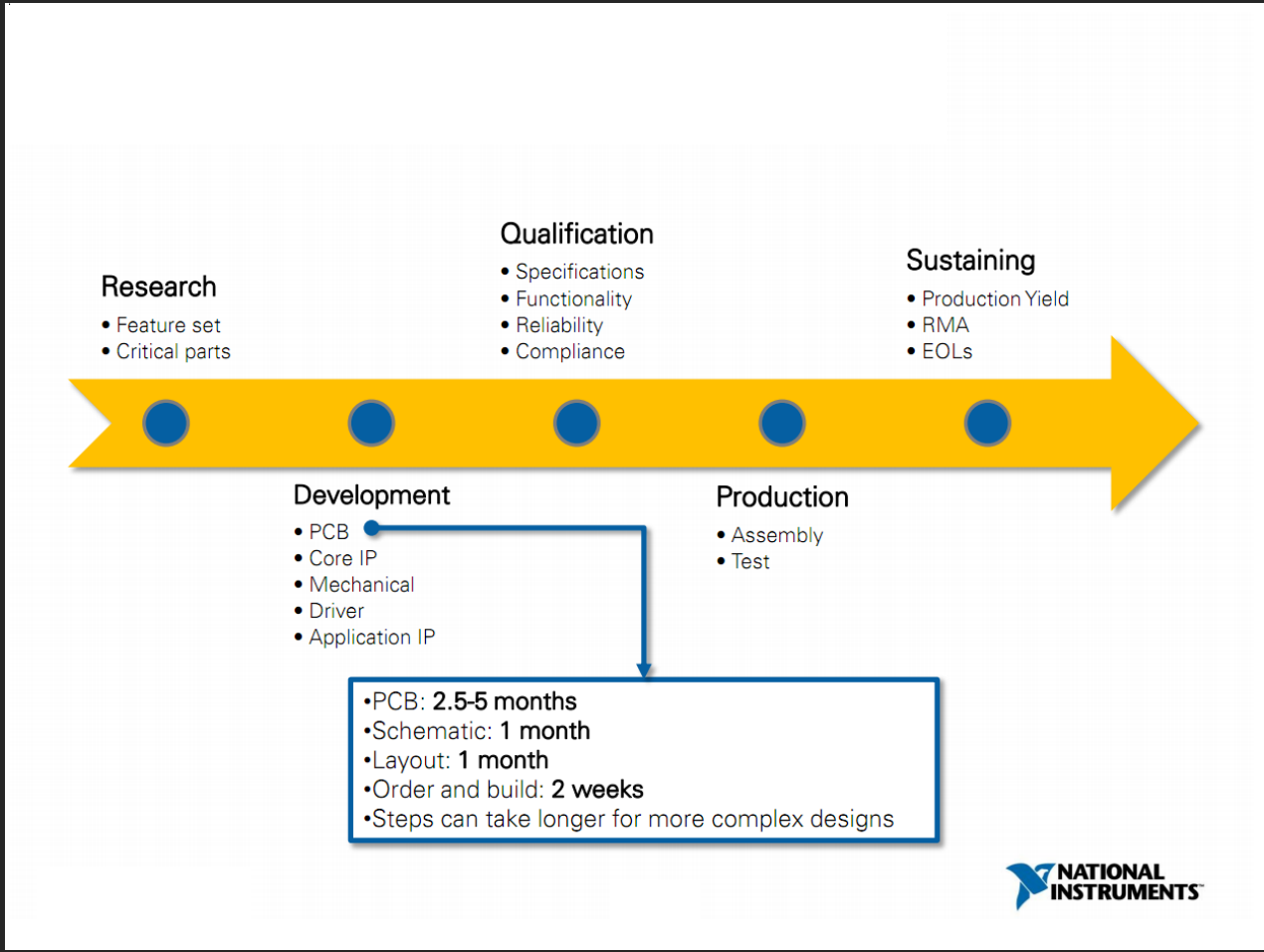


NI FLEXRIO FOR EMBEDDED APPLICATIONS

CUSTOM HARDWARE DEVELOPMENT



CUSTOM HARDWARE DEVELOPMENT



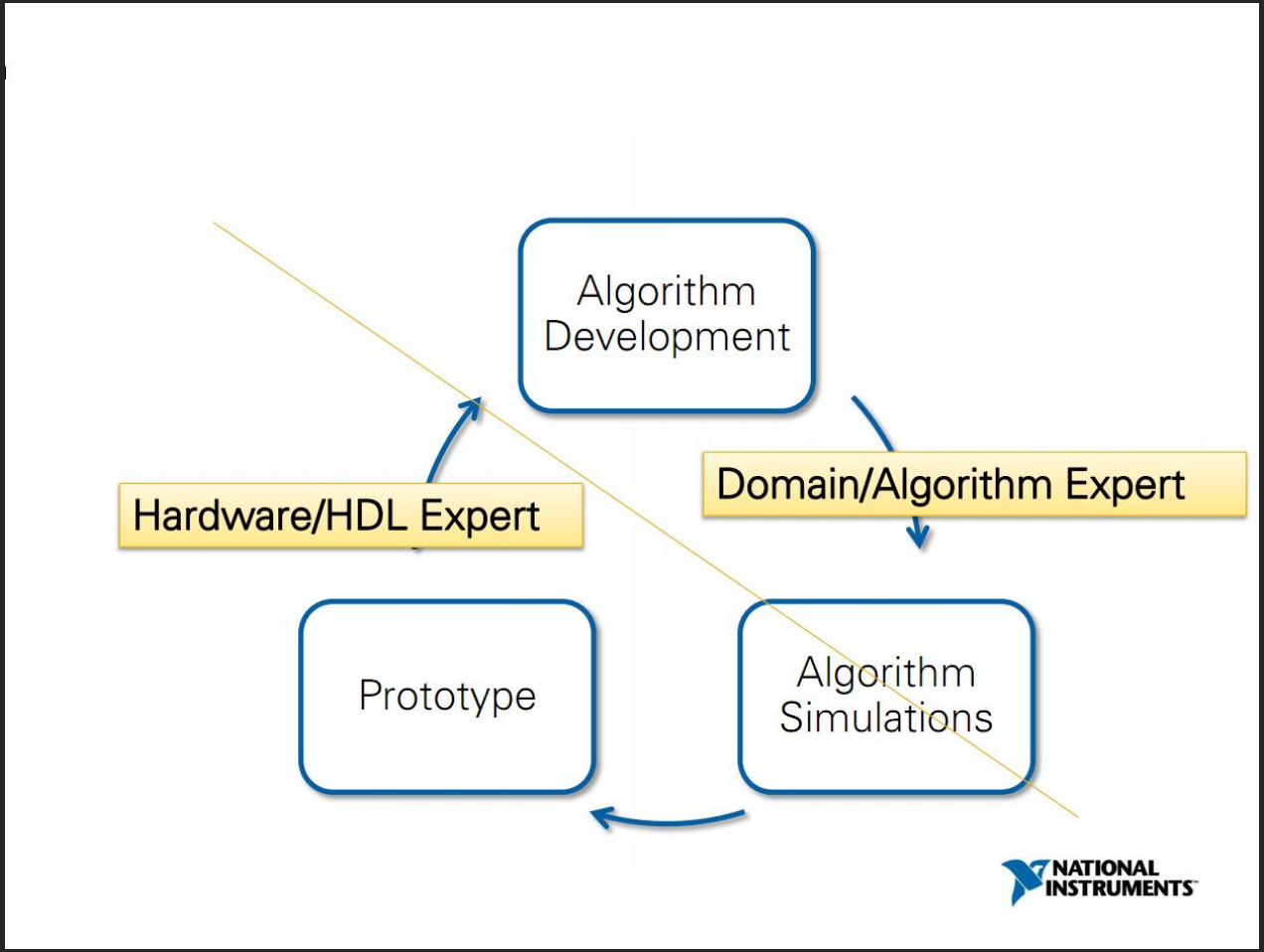
CORE IP AND INTERFACES

- **DRAM Example** – 200 MHz, DDR2, x32 data width
  - Layout (mentioned as part of PCB design): **1 month**
  - Pinout verification and closing timing in FPGA: **2-4 weeks**
  - Signal integrity: **2 weeks**
  - Bit error rate/margin testing: **2 weeks**
  - Total: **3 months**
  - If things don't go well, multiply by **2x or more**
  - If really bad, may need new PCB rev (go back to start)
- Similar steps for Bus Interface, Converters, and Control Interfaces

THE NI VALUE

- With modular FPGA hardware and the PXI platform, NI takes away the burden of many of the most difficult parts of a custom design...
- **You can cut short your development spans and efficiently develop flexible, scalable and customizable systems**

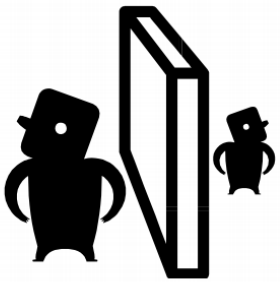
THE TRADITIONAL DEVELOPMENT APPROACH



THE TRADITIONAL DEVELOPMENT APPROACH

Domain/Algorithm Expert

- Floating Point
- Algorithm Development
- Algorithm Simulation
- Write Design Specification



Hardware/HDL Expert

- VHDL, Verilog, Fixed-Point
- Translate Design Spec to Hardware
  - Device Specific Implementation
  - Fixed-Point, Overflows, etc.
- Write HDL
- Write Testbench
- Run Simulation (Send Results to Domain Expert)
- Synthesis to FPGA or ASIC

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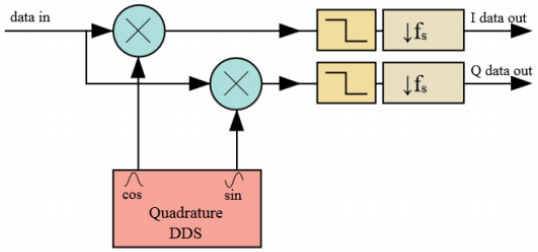
THE LABVIEW DEVELOPMENT APPROACH

Domain/Algorithm Expert

1. Algorithm Development
2. Algorithm Test (LabVIEW)
3. Map Algorithm to Hardware (LabVIEW FPGA palette)
4. Create Cycle Accurate Hardware Model (LabVIEW)
5. Simulate Using LabVIEW TestBench (LabVIEW FPGA)
6. Compile

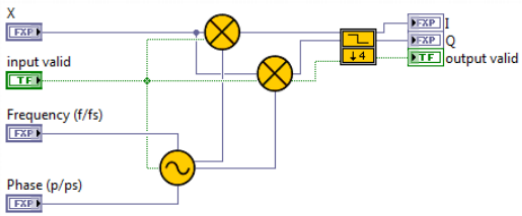
VALUE OF GRAPHICAL PROGRAMMING FOR FPGAS

How we think:



Source: Wikipedia

How we program:



Enable a domain expert to program FPGAs

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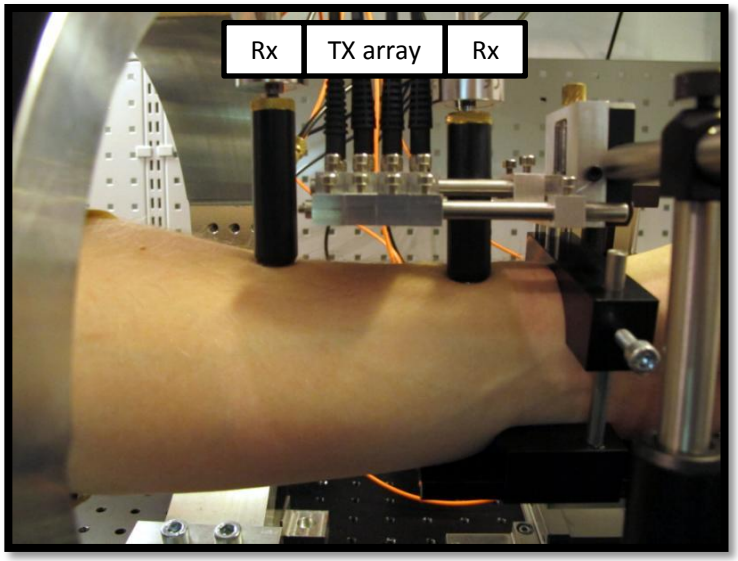
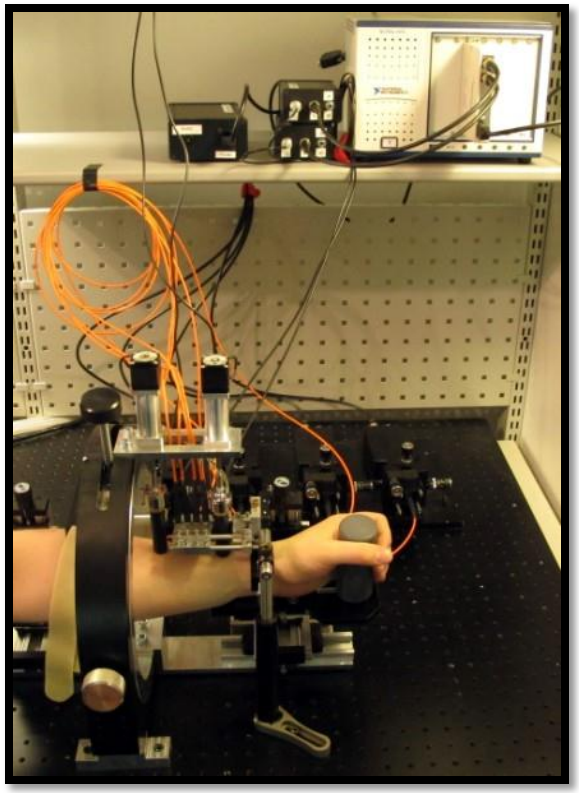
EXAMPLES OF PROJECTS WHERE NI FLEXRIO IS USED

- Challange - Developing a real-time system to tune photoacoustic measurements to clinically assess osteoporosis



"The development work was fast and easy because the NI products we chose gave us quick prototyping for cutting-edge medical research. With NI products, we bridged academic proof-of-concept studies and clinical trials."

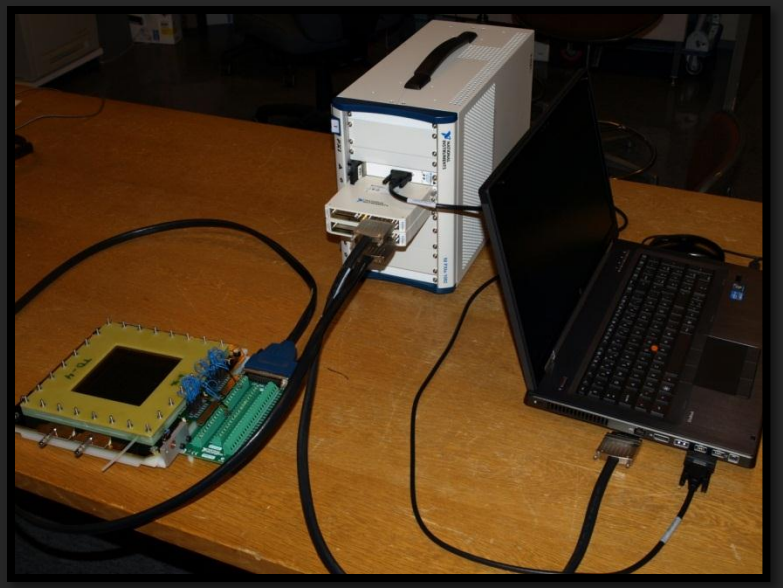


Pasi Karppinen *et al.* 2012

UNIVERSITY OF JYVÄSKYLÄ
UNIVERSITY OF HELSINKI
UNIVERSITY of OULU

USING NI FLEXRIO FOR PHOTOACOUSTIC QUANTITATIVE ULTRASOUND

- GEM detector readout prototype
  - 64 CH 50MS/s
  - Continuous acquisition (hours)
    - Not a single event missed



FLEXRHINO

- NI PXI platform + NI FlexRIO based unit
  - Customer tailored signal conditioning

Multichannel, high date rate measurement unit cabable of real-time data analysis

- **Turn-key solution**
- **Adaptable inputs**
- **Fast turnaround**
- **Modular extendibility**

THANK YOU!

FOR MORE INFORMATION:
PASI.KARPPINEN@PROTORHINO.COM