LabVIEW 2012 HO Session for Industrial measurements and advanced control
Agenda

• NI and Graphical System Design
• Introduction to Real-Time systems
• NI Real-Time Architecture
• Introduction to FPGA based systems
• NI RIO Architecture
• Programming NI PAC systems
• Control and analysis
• Programming with LabVIEW FPGA
• Resources for Development
National Instruments

Corporate headquarters: Austin, Texas

Year established: 1976

Revenue: $873 million in 2010

Global operations: offices in 40 countries

Investment in R&D: 16% of annual revenue

Customer base: 30,000 companies annually

Network: More than 600 Alliance Partners

Diversity: no industry makes up more than 15% of revenue
More than 30,000 companies

...including 90% of Fortune 500 manufacturing companies
The NI Approach for Today’s Challenges

Low-Cost, Modular Measurement and Control Hardware

Productive Software Development Tools

Highly Integrated, Expandable Platforms

Used by thousands of engineers and scientists for automated test, industrial control, and embedded design applications.

ni.com
Graphical System Design

Computational Models

- Data Flow
- C / HDL code
- Textual Math
- Simulation
- State Chart

LabVIEW
- Desktop
- Real-Time
- FPGA
- MPU/MCU

Personal Computers
PXI Systems
CompactRIO
Single-Board RIO
Hardware Custom

ni.com
Introduction to Real-Time
What is Real-Time?

• Real-time **does not** always mean real fast
• Real-time means **absolute reliability**
• Real-time systems have timing constraints that must be met to avoid failure
• Determinism is the ability to complete a task within a fixed amount of time
Spectrum of Real-Time Applications

Test and Validation

Industrial control

Embedded Design
## Operating System Characteristics

### General Purpose OS
- High-priority tasks can be preempted by lower-priority tasks
- Extraneous background programs
  - Screen savers, disk utilities, virus software, and so on
- Peripheral Interrupts
  - Mouse, keyboard, and so on

### Real-Time OS
- Scheduler ensures high-priority tasks execute first
- Direct control over all tasks
- Stand-alone (no mouse, keyboard, and so on)

<table>
<thead>
<tr>
<th>Loop Rate</th>
<th>Software Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–100 Hz</td>
<td>Unbounded</td>
</tr>
<tr>
<td>Up to 50kHz</td>
<td>Bounded</td>
</tr>
</tbody>
</table>
NI Real-Time Architecture
Real-Time Embedded Processor

Chassis or Scan-Engine

Analog I/O
Digital I/O
Custom I/O
# Real-Time Development Tools

<table>
<thead>
<tr>
<th>Development Software</th>
<th>LabVIEW Real-Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compiler</td>
<td>Execution Trace Toolkit</td>
</tr>
<tr>
<td>Linker</td>
<td></td>
</tr>
<tr>
<td>Debugger</td>
<td></td>
</tr>
<tr>
<td>System Analysis Tools</td>
<td>LabVIEW Real-Time Target</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real-Time Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTOS</td>
</tr>
<tr>
<td>Microprocessor</td>
</tr>
<tr>
<td>I/O Connectivity</td>
</tr>
</tbody>
</table>
LabVIEW Real-Time Module

Rapidly develop robust and reliable systems with graphical programming
Implement and visualize precise deterministic performance
Eliminate time spent integrating diverse I/O
LabVIEW Real-Time Targets

CompactRIO

PXI

Smart Camera

Stand-Alone CompactDAQ

Single-Board RIO
## LabVIEW Real-Time Targets

<table>
<thead>
<tr>
<th>Feature</th>
<th>cRIO</th>
<th>sbRIO</th>
<th>PXI</th>
<th>Standalone cDAQ</th>
<th>Smart Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O Variety</td>
<td>🟡</td>
<td>🟡</td>
<td>🟡?</td>
<td>🟡?</td>
<td>🟡?</td>
</tr>
<tr>
<td>Scalability</td>
<td>🟡?</td>
<td>🟡</td>
<td>🟡?</td>
<td>🟡?</td>
<td>🟡?</td>
</tr>
<tr>
<td>Performance</td>
<td>🟡?</td>
<td>🟡</td>
<td>🟡?</td>
<td>🟡?</td>
<td>🟡?</td>
</tr>
<tr>
<td>Ruggedness</td>
<td>🟡?</td>
<td>🟡</td>
<td>🟡?</td>
<td>🟡?</td>
<td>🟡?</td>
</tr>
</tbody>
</table>

- Good 🟡
- Better 🟡?
- Best 🟡
Introduction to FPGA
What is FPGA?

Field-programmable gate arrays (FPGAs) reprogrammable silicon chips

- Faster I/O response times and specialized functionality
- Exceeding the computing power of digital signal processors
- Rapid prototyping and verification without the fabrication process of custom ASIC design
- Implementing custom functionality with the reliability of dedicated deterministic hardware
- On FPGAs different processing operations do not have to compete for the same resources (Native Parallelism).
The application logic is implemented in hardware circuits rather than executing on top of an OS, drivers, and application software.
NI RIO Architecture
Processor

FPGA

Analog I/O

Digital I/O

Motion I/O

Custom I/O

LabVIEW™ 2012
FPGA Development Tools

- Development Software
  - Dev. Environment
    - FPGA Compile Server
    - FPGA Compile Worker
  - OffloadCompilation

- FPGA Hardware
  - Download BitFile
  - FPGA Technology
  - I/O Connectivity

LabVIEW FPGA
- FPGA Compile Farm Toolkit
- LabVIEW FPGA Target

ni.com
LabVIEW FPGA Targets

- CompactRIO
- PXI
- Smart Camera
- Stand-Alone CompactDAQ
- Single-Board RIO
NI CompactRIO

- Extreme Durability
- Reconfigurable FPGA Circuitry
- Isolated Industrial I/O
- Real-Time OS
- Small Size, Low Power Consumption
NI Single-Board RIO

**Real-Time Processor**
400 MHz processor for floating-point control, analysis, and logging

**Networking/Peripherals**
10/100 Ethernet port
RS232 Serial port

**Reconfigurable FPGA**
Customized timing and processing of I/O

**Small Size, Low Power**
21 x 9 cm.
19-30 VDC power,
-20 to 55 °C operating temp
-20 to 85 °C storage temp

**Expansion I/O**
Connect up to three C Series modules for additional I/O (strain, TC, comm., motion, etc.)

**Onboard Analog and Digital I/O**
110 DIO, Up to 32-ch AI, up to 4-ch AO,
Up to 32-ch of 24 V DIO

ni.com
C Series I/O Modules

- **Analog Input**
  - 32 channels/module MAX
  - 24-bit resolution
  - 1 MS/s MAX
  - Multiplexed or simultaneous sampling

- **Analog Output**
  - ±10 V output range
  - 16-bit resolution
  - 100 kS/s simultaneous
  - Current and voltage output

- **Digital I/O**
  - Up to 30 MHz timing
  - 8 and 32-channel options
  - 5V/TTL, 12/24/48 V logic levels
  - Available ch-to-ch isolation

- **Other**
  - 2-port CAN modules (high and low speed)
  - Brushed DC servo motor drive module
cRIO/sbRIO Applications

**Machine Control**
- Packaging/Processing
  - High-speed motion control, batch control, discrete control
- Heavy Machinery Control
  - Real-time signal processing and control of power electronics, hydraulic systems
- Semiconductor/Biomed
  - Custom motion and vision inspection, material handling

**Machine Monitoring**
- Machine Condition Monitoring
  - Bearing order analysis, lubrication monitoring, cooling, combustion...
- Mobile/portable DSA, NVH
  - Noise, vibration, harshness, dynamic signal analysis, acoustics
- Distributed Acquisition
  - Central controller with distributed I/O nodes over Ethernet/wireless

**In-Vehicle Data Acquisition**
- In-Vehicle Data Acquisition
  - Automobiles, motorcycles, recreational vehicles, research aircraft, trains
- Engine and ECU test cells
  - HIL testing of engines and engine controllers, sensor simulation using FPGA
- Rapid Control Prototyping
  - Automotive/aerospace control prototyping
Programming NI PAC systems
Programming cRIO and sbRIO
Exercise Station – CompactRIO Demo Box

• Controller:
  • cRIO 9024

• Modules:
  • NI 9211
  • NI 9474
  • NI 9423
  • NI 9227
  • NI 9234
  • NI 9215
  • NI 9263
  • NI 9225

The overall architecture is designed for control or a hybrid of control and waveform streaming or logging. MCM or stand-alone embedded loggers
Exercise 1

Temperature Threshold Measurement
The LabVIEW Timed Loop

- Each timed loop is a real-time task
- Variety of sources for loop timing
- Assign unique priorities to a maximum of 128 tasks
- Obtain timing feedback from loop
- Dynamically change loop timing
- Assign to particular CPU core on multicore systems
Exercise 2

Managing I/O Variables in Open-Loop
Control and Analysis
Closed-Loop Control System

Set Point -> Error (+) -> Compensator -> Actuator -> System

Sensor Feedback

Process Variable
Control System Diagram

Fan Speed Control System

- **Desired Speed**: 0-6000 RPM
- **Error**: Measured Speed - Desired Speed
- **PID Compensator**: PID Function Block
- **PWM Output**: 62%
- **Servo Motor**: NI 9472
- **Encoder Sensor**: NI 9411
- **Unbalanced Noise**

*NI LabVIEW Real-Time Hardware*

*LabVIEW Front Panel*
Exercise 3

Managing I/O Variables in Closed-Loop
Implementing Control in LabVIEW

Minimal change in code for different types of I/O

Built-in Tools for Control
PID, Fuzzy Logic, Advanced
Import C algorithms, Simulink Models
LabVIEW Real-Time Functions

Built-in Tools for Control
- PID, Fuzzy Logic, Advanced
- Import C algorithms, Simulink Models

Complete Analysis Libraries
- FFT, Linear Algebra, Filtering
- Point by Point Analysis and Signal Generation

Easily Integrate Diverse I/O
- Data Acquisition
- Modular Instruments
- Serial, GPIB, CAN, IEEE 1394, DeviceNet

IEC61131-3 Function Blocks
- 18 new functions common in industrial control
- Seamless LabVIEW Project integration
Programming with LabVIEW FPGA
FPGA Technology

- Logic Blocks
- Programmable Interconnects
- I/O Blocks
Importance of FPGA in Systems

- **High Reliability** – Designs become a custom circuit
- **High Determinism** – Runs algorithms at deterministic rates down to 25 ns (faster in many cases)
- **True Parallelism** – Enables parallel tasks and pipelining
- **Reconfigurable** – Create new and alter existing task-specific personalities
CPU Usage Benchmark

Use LV FPGA for these applications

28.4% CPU 80 PID Channels

1000 Hz

500 Hz

100 Hz

CPU % Usage

Number of Channels: AI + PID + AO

ni.com
How Does LabVIEW FPGA Work?

1. Same graphical programming
2. Generate VHDL
3. Compile VHDL through Xilinx
4. Generate downloadable bit file
When to Use LabVIEW FPGA?

- Waveform acquisition > 1kHz
- Custom triggering
- Hardware based analysis
- Highest performance
- Unsupported modules
- Unsupported targets
FPGA Co-Processing

- Hardware-in-the-loop
- Sensor simulation
  - Cam and crank
  - LVDTs
- Encoding/decoding sensors
  - Tachometers
  - Custom digital protocols
- Signal Processing and Analysis
  - Spectral analysis (FFT and windowing)
  - Filtering, Averaging, etc.
  - Integrate 3rd party IP
Programming CompactRIO with LabVIEW FPGA
Combining Scan Mode with FPGA Mode

- Add FPGA to project
- Drag modules to FPGA
- Requires compile
- Scan mode modules
- FPGA mode modules
Exercise 4

Square Wave Generation
Resources for Development
NI Embedded Evaluation Kit

Contents

- NI Single-Board RIO with DIO, AI, AO
- Signal accessory daughter card
- LabVIEW evaluation software
  - LabVIEW, LabVIEW Real-Time, and LabVIEW FPGA (expiring license)
- Getting started guide with exercises and tutorials
- Power supply
- Ethernet cable

• Price
  - 400 € for 90-day eval kit

ni.com/embeddedeval
CompactRIO Developer’s Guide

Sezione 1: Architetture LabVIEW per il controllo
Implementazione di una architettura in grado di scalare con l'applicazione, per la modularezza dei codici, il debug e la validazione.

Vai alla sezione 1

Sezione 2: Aggiunta di comunicazioni, I/O di espansione, motion e machine vision
Aggiunta di comunicazioni Ethernet, I/O di rete, I/O da altri dispositivi e funzionalità avanzate come motion control e machine vision.

Vai alla sezione 2

Sezione 3: Personalizzazione hardware con LabVIEW FPGA
Utilizzo di FPGA su scheda per loop ad alta velocità, inline filtering, I/O forme d'onda o mission-critical interlock.

Vai alla sezione 3

Sezione 4: Creazione di un'interfaccia utente di rete
Aggiunta di interfaccia utente di rete al sistema CompactRIO embedded da utilizzare su interfaccia operatore sulla macchina.

Vai alla sezione 4

Sezione 5: Deploymet e replicazione dei sistemi
Deploymet di sistemi finali, configurazione per start-up automatico e replicazione di sistemi già sviluppati.

Vai alla sezione 5

CompactRIO Developer’s Guide: Download completo
Scarica la guida completa incluse tutte le cinque sezioni.

Scarica la guida completa
Alliance and Certification Program

More than 500 independent companies
- Select – less than 20 companies
- Consultants
- System Integrators
- Add-on products

Certification Program
- LabVIEW Developer
- LabVIEW Architect
- TestStand Developer
- TestStand Architect
- Professional Instructor
LabVIEW 2012 What’s New

Le nuove funzioni

- Ottimizzazioni del compiler
  Esecuzione del codice più veloce del 20 per cento con le nuove tecnologie del compilatore back-end e i miglioramenti del codice custom

- Trasferimento dati sulla rete
  Trasferimento continuo dei dati tra le applicazioni di LabVIEW con il nuovo Network Streams API

- SubVI Inlining
  Nuova opzione di esecuzione per migliorare le prestazioni delle applicazioni con l’eliminazione della overhead associata con le chiamate subVI.

- Configurazione hardware basata sul web
  Configurazione e manutenzione hardware remota con una configurazione router-like

- Trova e installa instrument driver
  Operazioni di misura più veloci con oltre 10.000 instrument driver certificati

- Nuove funzioni realizzate grazie al feedback degli utenti
  Sviluppo facilitato con 14 nuove funzioni sviluppate in base ai feedback degli utenti

- Risparmia i VI senza il codice compilato
  Semplificazione della gestione del codice sorgente con la separazione degli oggetti compilati dal codice sorgente da scrivere in LabVIEW.

- Esportazione dei dati dei grafici su Excel
  Esportazione dei dati su Microsoft Excel con la semplice opzione tasto destro

- Importazione IP FPGA esterni
  Facile sviluppo di FPGA tramite l’importazione delle librerie di IP da Xilinx Core Generator in LabVIEW

- Librerie Packed Project
  Semplificazione della distribuzione del codice inserendo il codice sorgente in un singolo file con Packed Project libraries

ni.com/labview/whatsnew/i/
Additional Information

Visit

ni.com/labview/i
ni.com/pac/i
ni.com/realtime
ni.com/fpga
ni.com/compactrio or ni.com/sbrio

Product information
User applications
Training opportunities
In-depth tutorials

Technical Support

• www.ni.com/ask
• www.ni.com(zone)
NI Italy Services

Customer Education

Hardware Maintenance

Technical Support

Software Maintenance
LabVIEW World

La prima rivista italiana per la comunità LabVIEW
Per abbonarti, visita il sito www.labviewworld.it
Se sei un utente Developer Suite o Standard Service Program di National Instruments, un anno di abbonamento è incluso
Thank You

National Instruments Italy