Embedded Data Logging with CompactRIO and LabVIEW
Today’s Engineering Challenges

• Doing more with less
• Managing global operations
• Getting increasingly complex products to market faster
• Adapting to evolving application requirements
• Maximising operational efficiency
• Minimising power consumption
• Protecting system and resource investments
The NI Approach to Meeting Today’s Challenges

Low-Cost, Modular Measurement and Control Hardware

Productive Software Development Tools

Highly Integrated, Expandable Platforms
More than 30,000 companies
...including 90% of Fortune 500 manufacturing companies
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
Agenda

• Data Logging: A Hardware/Software solution
  ▪ Introduction to LabVIEW
  ▪ Introduction to CompactRIO
  ▪ Exercise 1 (optional) & Exercise 2

• Software Architectures for Data Logging
  ▪ Programming tools in LabVIEW
  ▪ The State Machine Architecture
  ▪ Exercise 3&4

• Extending a data logging solution to the cloud
What is a data Logger?

Data logging is the measuring and recording of physical or electrical parameters over a period of time.

<table>
<thead>
<tr>
<th>Tethered</th>
<th>Stand Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy Bus – eg.</td>
<td>• Distributed</td>
</tr>
<tr>
<td>USB, Ethernet</td>
<td>• Long term –</td>
</tr>
<tr>
<td>• Reconfigurable</td>
<td>reliability</td>
</tr>
<tr>
<td>• Price</td>
<td>• Portable</td>
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</table>
Highly Distributed Data Acquisition

Environmental Monitoring in the Costa Rican Rain Forest

The NIMS based on NI technology will help researchers take better measurements at the La Selva Biological Station.
Structural Health Monitoring
Portable, Stand-Alone Data Acquisition
The Solution involves Hardware and Software

Hardware + Software
The Software
Hardware and Software Integration

Dataflow

C Code

Textual Math

Simulation

Statechart

LabVIEW

Real-Time

FPGA

Microprocessor

Personal Computers

PXI Systems

CompactRIO

SB RIO

Custom Design

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Graphical System Design

Dataflow

C Code

Textual Math

Simulation

Statechart

Personal Computers

PXI Systems

CompactRIO

SB RIO

Custom Design

LabVIEW™
Programming Language
Hardware Support
Analysis and Technical Code Libraries
Reporting and Data Visualisation Tools
Technology Abstraction
Models of Computation
Instructor Demo: The LabVIEW Environment

“VI” = program or function

“Front Panel” = user interface

“Block Diagram” = code
The Hardware
What is RIO?

RIO = Reconfigurable I/O and it consists of 3 components:
The CompactRIO System
The CompactRIO System

1. **Real-Time Processor**: For reliable measurement, analysis, connectivity & control
2. **Reconfigurable FPGA**: For high-speed and custom I/O timing, triggering, and control
3. **I/O-Modules**: With built-in signal conditioning for connection to sensors/actuators

**Extreme Ruggedness**
- -40 to 70 °C temperature range
- 50g shock, 5g vibration

**Low Power Consumption**
- 9 to 35 VDC power, 7-10 W typical
LabVIEW Development with CompactRIO

1. Develop on Host

2. Download to Target

3. Deploy to run stand-alone or communicate over Ethernet with host

4. Optional – develop a web interface to access data
Scan Mode for CompactRIO

• **Automatic** module detection
• **Out-of-the-box** access to synchronised I/O
• **Distributed System Manager** for on-line debugging
• **Specialty Digital** support
• **I/O synchronised** to Timed Loop (500 nS jitter)
• **LabVIEW FPGA** expandable
Programming Models for cRIO

NI CompactRIO

LabVIEW Real-Time Controller

LabVIEW Real-Time
I/O Variables

FPGA Host Interface

NI Scan Engine

I/O memory table

Backplane

RIO Scan Interface

I/O Modules

I/O Modules

LabVIEW FPGA

FPGA Target

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Exercise 1&2:
The State Machine Design Pattern
Controlling Program Execution

- Looping (For and While)
- Case structure
- Sequence structure
- State machines
- Event structure
- State diagram editor
- Timered loop
Execution Control Structures

While Loop
- Run until stop condition met

For Loop
- Run N times

- Allow same piece of code to run multiple times
- Exit conditions different for each
LabVIEW Case Structure

Primary decision making block
Iterative Data Transfer

- When programming with loops, you often need to know the values of data from previous iterations of the loop
- Shift registers transfer values from one loop iteration to the next
Background – Static Sequence
Background

**Dynamic Sequence:** Distinct states can operate in a programmatically determined sequence
How It Works

Case structure has a case for every state

Transition code determines next state based on results of step execution

Step Execution

Transition Code

FIRST STATE

NEXT STATE

Shift registers used to carry state
Why use a state machine in data logging applications?

- Stable
- Maintainable
- Expandable
- Flexible
Exercise 3&4:
Web Services in LabVIEW

Integrated Web Server

Web Client (Browser)
Web Services in LabVIEW

- Web Service runs on Windows and Real-Time systems
- Enables custom Web clients applications
- No LabVIEW Run-Time Engine required on web client
Web Services in LabVIEW

VI deploys data via Web Service

Web Server

Web Client

HTTP Protocol

Adobe Flex
Adobe Flash
Silverlight
Java
LabVIEW Web UI Builder

Web Server

VI deploys data via Web Service

HTTP Protocol

Web Client

Use the Web UI Builder for a LabVIEW client application without LabVIEW Run Time
World Wide Communication & Maintenance


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## CompactRIO-Host Connectivity Chart

<table>
<thead>
<tr>
<th>TCP/IP</th>
<th>UDP</th>
<th>Network Streams</th>
<th>Shared Variables</th>
<th>Web Service / Web Client</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Windows" /></td>
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Demo: Web Services & Web UI Builder
Your Next Steps

• Visit ni.com/labview
  ▪ Try LabVIEW Online for FREE
  ▪ Read technical white papers
  ▪ View webcasts on-demand
  ▪ Find other seminars in your area

• Schedule a visit with your local field engineer to discuss your application

Acquire | Analyze | Present
---|---|---

with NI LabVIEW
Worldwide LabVIEW User Community

- Over 100,000 members on award-winning NI Discussion Forums
- NI & LabVIEW user-contributed blogs
- More than 100 LabVIEW User Groups
- Third-party community web sites in over 15 languages
- Hundreds of third-party add-on tools on the LabVIEW Tools Network
Software Maintenance and Support

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Learn More about NI LabVIEW and data logging Systems

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- View DAQ product specs and demos: [www.ni.com/daq](http://www.ni.com/daq)
- Schedule a visit with your local field engineer to discuss your application
Questions?

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