Introduction to
LabVIEW for Wireless Sensor Networks

NI-Days 2010

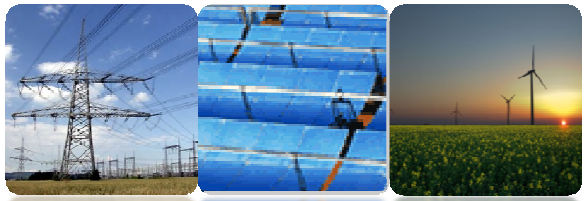
Wireless Application Areas

Environmental Monitoring

Resource Monitoring

Industrial Measurements

Air/ Climate | Water/ Soil | Indoor Monitoring



Power Monitoring | Solar Monitoring | Wind Farm Monitoring

Structural Health Monitoring | Machine Condition Monitoring | Process Monitoring

The Benefits of Wireless Measurements

Reduce Costs

- Reduce installation costs and time
- Reduce maintenance costs

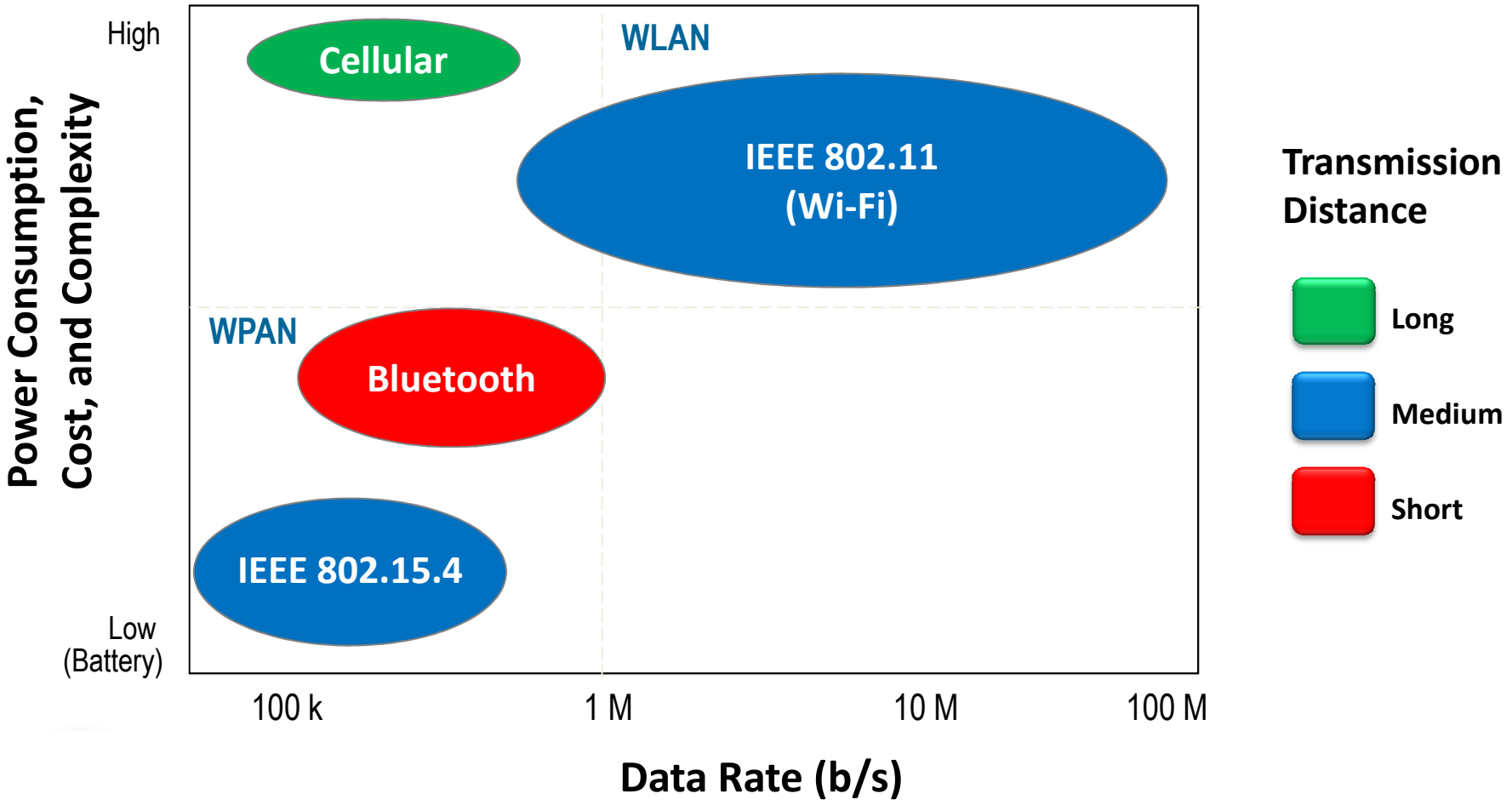
Increase Efficiency

- Optimize measurement processes
- Access data almost anywhere and anytime
- Decrease downtime

Monitor Anywhere

- Overcome power and infrastructure limitations
- Solve new and previously challenging applications

RF Communication: Wireless Standards



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The NI Wireless Platform

NATIONAL INSTRUMENTS LabVIEW™

Wireless Test

PXI RF

Wireless Measurements

Wireless DAQ

NI WSN

Third Party

Simple. Secure. NI Wi-Fi Data Acquisition.

Simple: NI C Series modules with direct sensor connectivity and NI-DAQmx driver software

Secure: Highest commercially available data encryption and authentication (WPA2)

Wi-Fi: Streaming waveform measurements over 802.11g or Ethernet network infrastructure

Wireless and Ethernet C Series Module Support

Measurement	Module	Signal	# Chan	Rate
Analog Input	NI WLS-9205	±10 V analog input, 16 bits	32	250 kS/s
	NI WLS-9206	600 VDC isolated, 16 bits	16	250 kS/s
	NI WLS-9215	Simultaneous sampling, 16 bits	4	100 kS/s/ch
Thermocouple	NI WLS-9211	Thermocouple, 24 bits	4	14 S/s
	NI WLS-9213	Thermocouple, 24 bits	16	75 S/s/ch
Universal	NI WLS-9219	Universal (11 modes)	4	100 S/s/ch
Sound/Vibration	NI WLS-9234	IEPE (accelerometer), 24 bits	4	51.2 kS/s/ch
Bridge	NI WLS-9237	Bridge completion, 24 bits	4	50 kS/s/ch
Digital I/O	NI WLS-9421	11 to 30 VDC sinking digital input	8	Software timed
	NI WLS-9472	6 to 30 VDC sourcing digital output	8	Software timed
	NI WLS-9481	60 VDC, 250 V_{rms} relay	4	Software timed

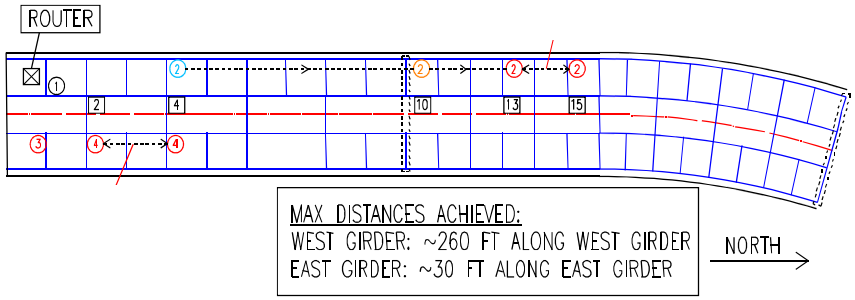
Inspection and Monitoring of Fracture-Critical Steel Bridges

Application: Researching economical methods for inspecting and monitoring the temperature, strain, and acceleration of steel-girder highway bridges at the Ferguson Structural Engineering Lab at The University of Texas

Challenge: Continuous, real-time monitoring of a loaded steel bridge several hundred feet long

Products: LabVIEW, Wi-Fi DAQ, and WSN

Key Benefit: Time and money saved by eliminating cables and wiring



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Process Monitoring and Control with LabVIEW and Wi-Fi DAQ

Application: Monitor and control the frequency of cement granules bursting in a furnace to characterize and optimize the cement manufacturing process

Challenge: Continuous, real-time monitoring under harsh conditions from a control room located 100+ m from the furnace

Products: LabVIEW and Wi-Fi DAQ

Key Benefit: Retrofit an existing control system using existing code to add remote measurements with no additional cabled infrastructure

"With the flexibility of LabVIEW, we were able to reuse our existing code to quickly expand the reach of our measurements using Wi-Fi data acquisition devices."

– Jean-Michel Chalons, President, Saphir

Choosing the Right Wireless Measurement Platform

	NI Wi-Fi DAQ (IEEE 802.11g)	NI WSN (IEEE 802.15.4)
Battery Lifetime	1 to 2 days	2 to 3 years
Max. Bit Rate	54 Mbit/s	250 kbit/s
Range	100 m	300 m
Security	IEEE 802.11i (WPA2 Enterprise)	Gateway Association

Low-Power. Reliable. Wireless Sensor Networks.

- **Low-Power**
  Up to 3-year lifetime with 4 AA batteries
- **Reliable**
  NI WSN protocol and mesh routing
- **Wireless Sensor Networks**
  Remote wireless measurements

What Is a Wireless Sensor Network (WSN)?

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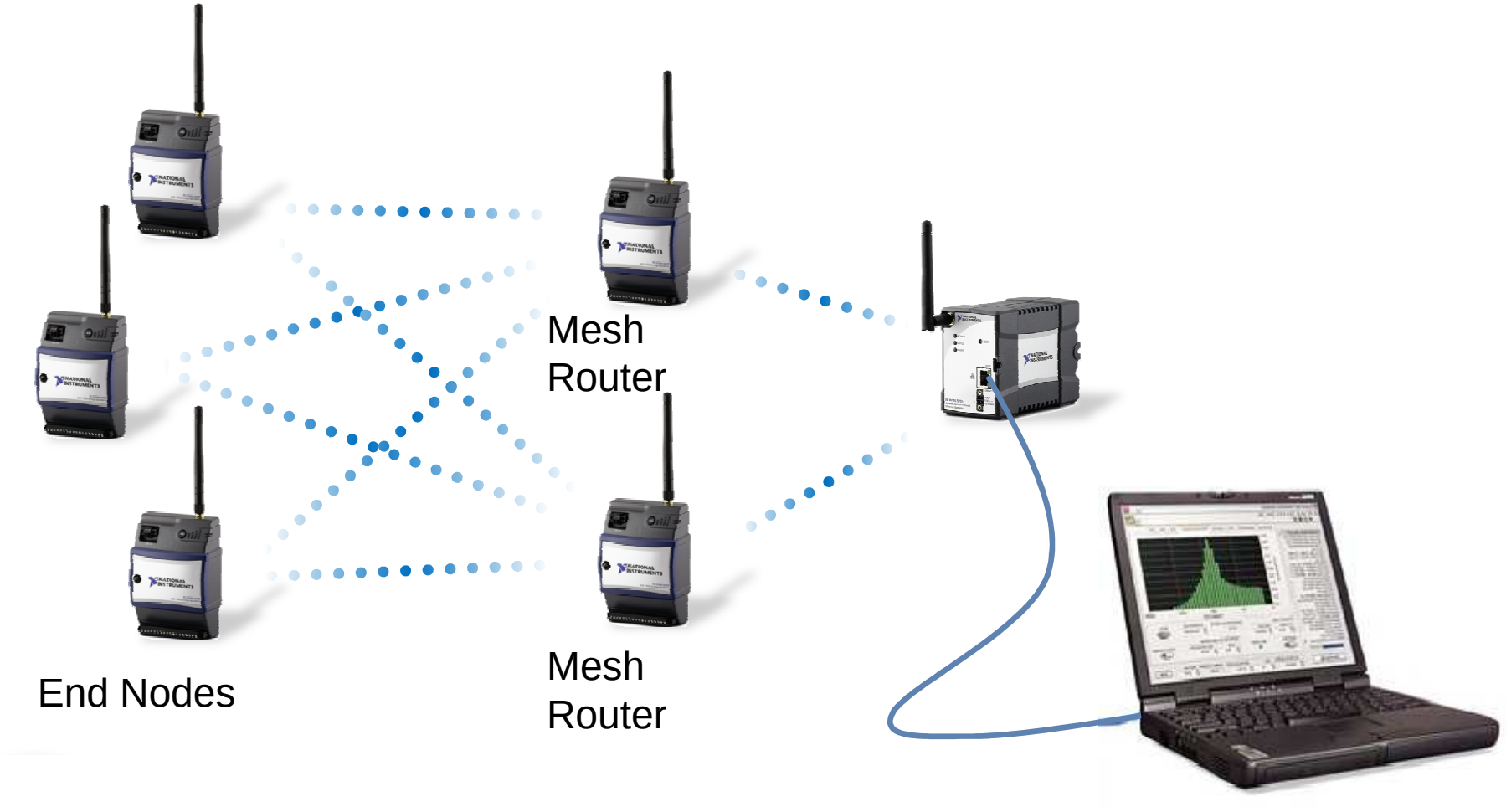

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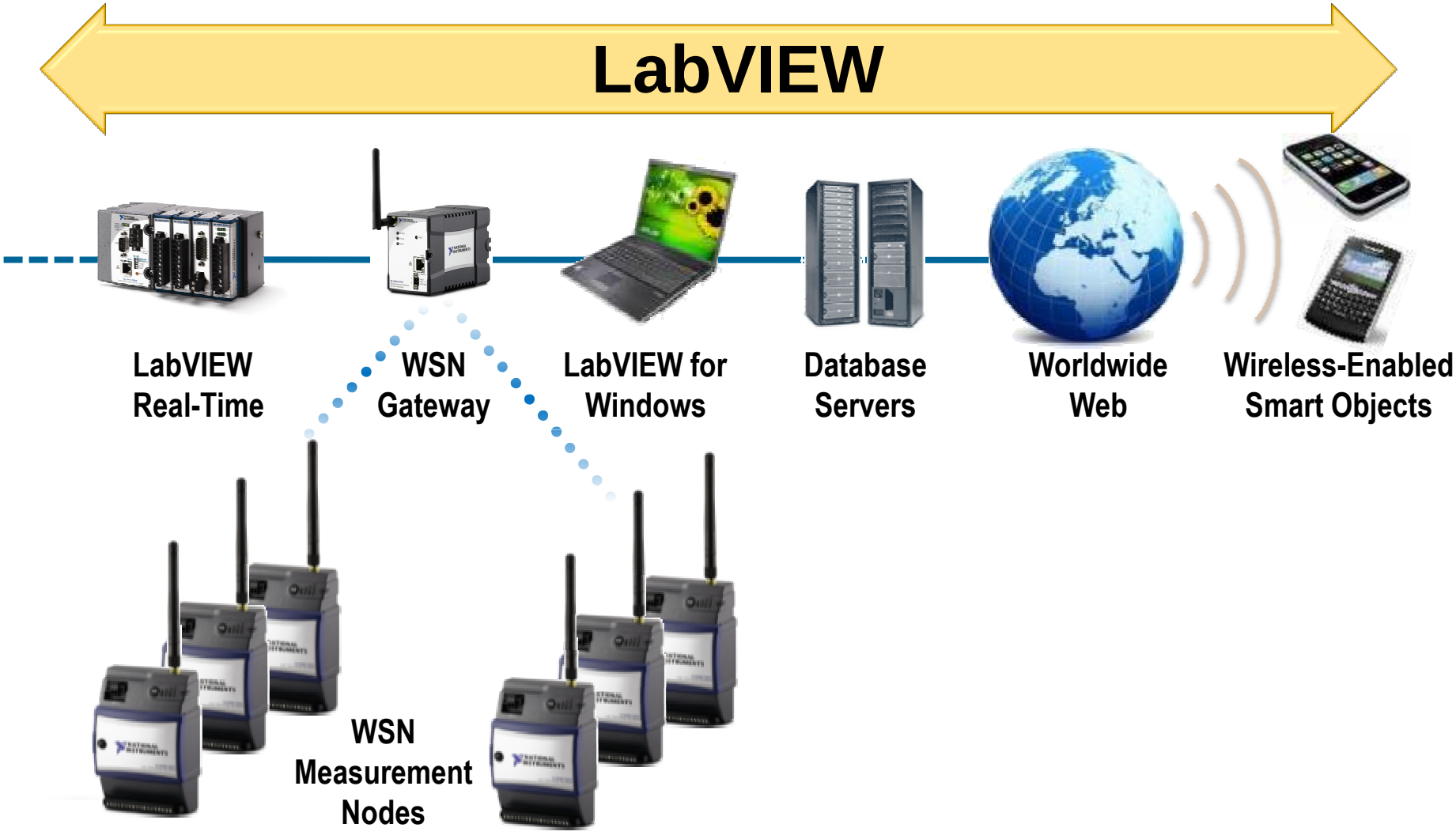
WSN System Architecture



NIC Pond Demo

NI WSN-9791

Wireless Sensor Network Ethernet Gateway

Features

- 2.4 GHz, IEEE 802.15.4 radio
- 10/100 Ethernet
- Connect up to 36 measurement nodes
- Outdoor range up to 300 m
- 9 to 30 VDC power input

Specifications

- 2U compact form factor
- Panel or DIN rail mounting
- Industrial ratings
  - Operating temperature -30 to 70 ºC
  - 50 g_{rms} shock 5 g vibration
- Status LEDs

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NI WSN-3202 and NI WSN-3212
Wireless Sensor Network Measurement Nodes

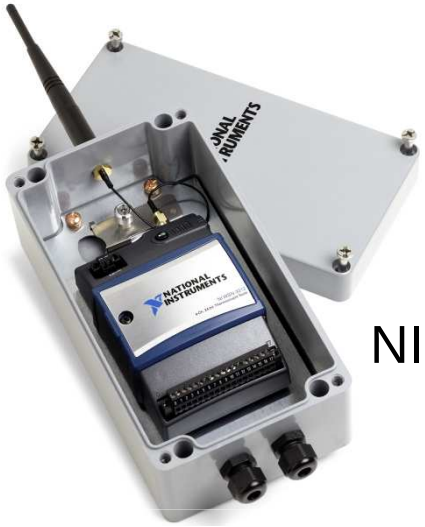
2.4 GHz IEEE 802.15.4 radio

- Outdoor range up to 300 m
- Up to 3-year battery life with 4 AA batteries
  - Optional 9 to 30 VDC power input
- Configurable as a mesh router
- Four bidirectional digital I/O lines
- Industrial ratings
  - Operating temperature -40 to 70 ºC
  - 50 g_{rms} shock 5 g vibration

Node	Analog Input	Digital I/O	Sample Interval (sec.)	Sample Rate (s/ minute)	Reso-lution (bits)	Features
NI WSN-3202 Analog Input Node	4	4	1	60	16	Sensor power: 20 mA at 12 V Input Ranges: ±10 V, ±5 V, ±2 V, ±0.5 V
NI WSN-3212 Thermocouple Input Node	4	4	2	30	24	Supports types J, K, R, S, T, N, B, E

NI WSN Accessories and Starter Kit

- Outdoor Enclosure
  - IP rating pending
  - I/O glands for wire feedthrough
  - External antenna

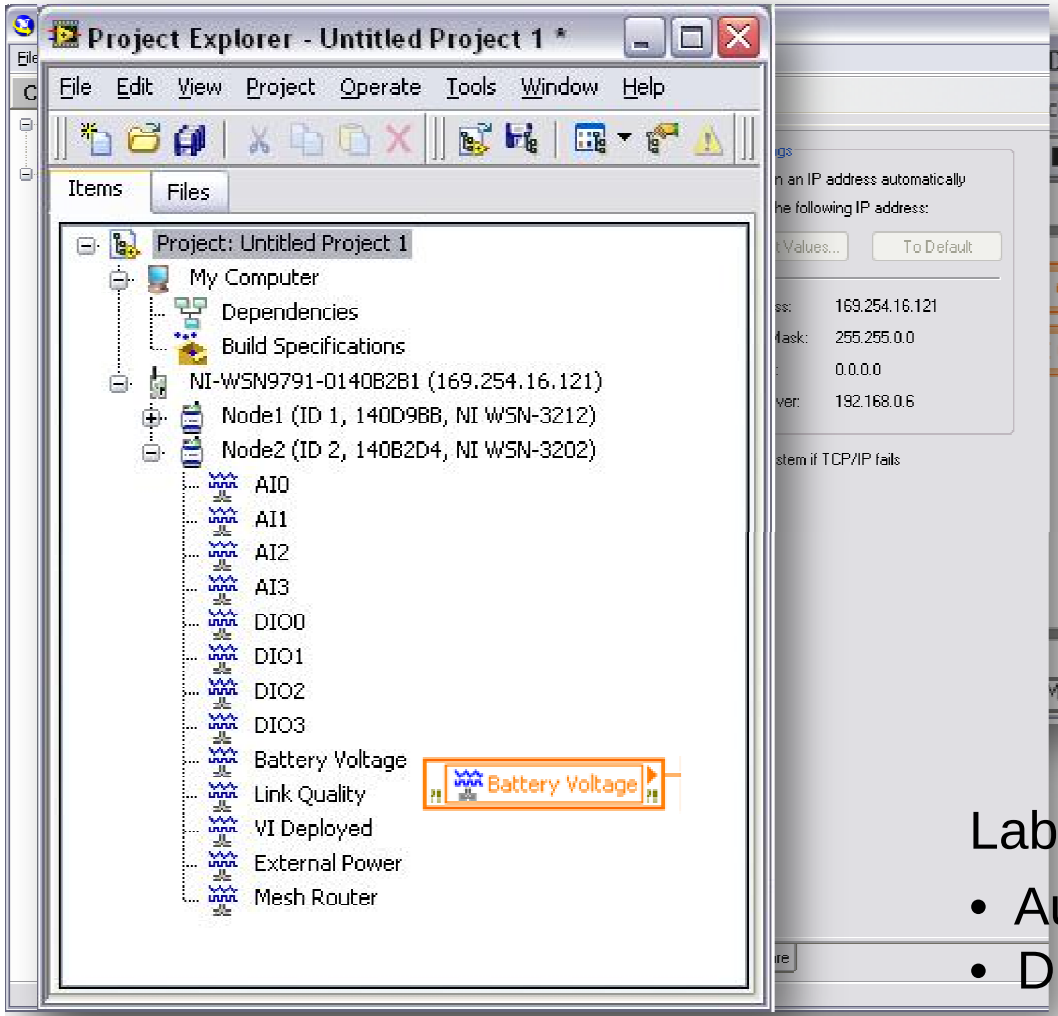


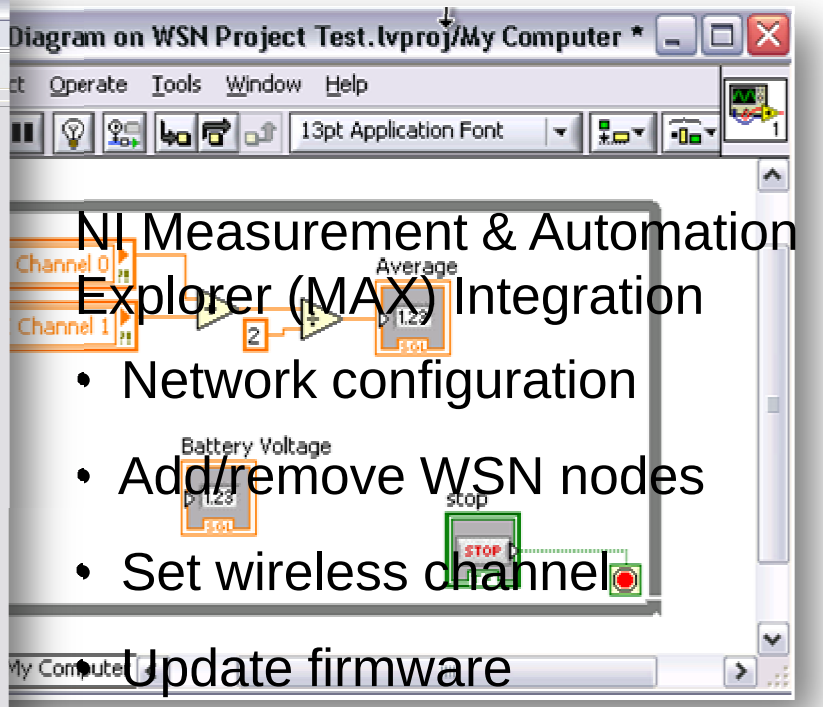
NI WSN-3291

- NI WSN Starter Kit
  - WSN-9791 Ethernet Gateway
  - 2 programmable nodes
  - Sensors and power accessories
  - LabVIEW Evaluation Software
  - Getting Started Guide

NI WSN Starter Kit

NI WSN Software





NI Measurement & Automation Explorer (MAX) Integration

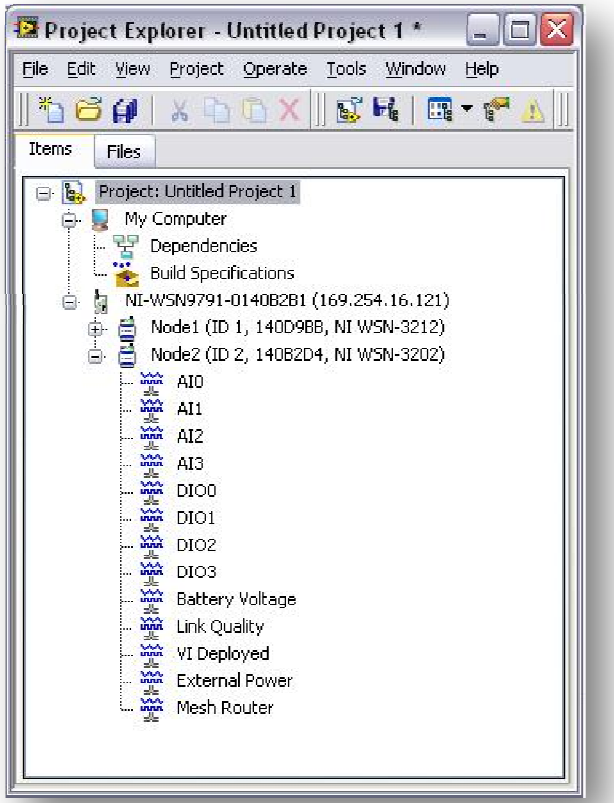
- Network configuration
- Add/remove WSN nodes
- Set wireless channel
- Update firmware
- Configure nodes as routers

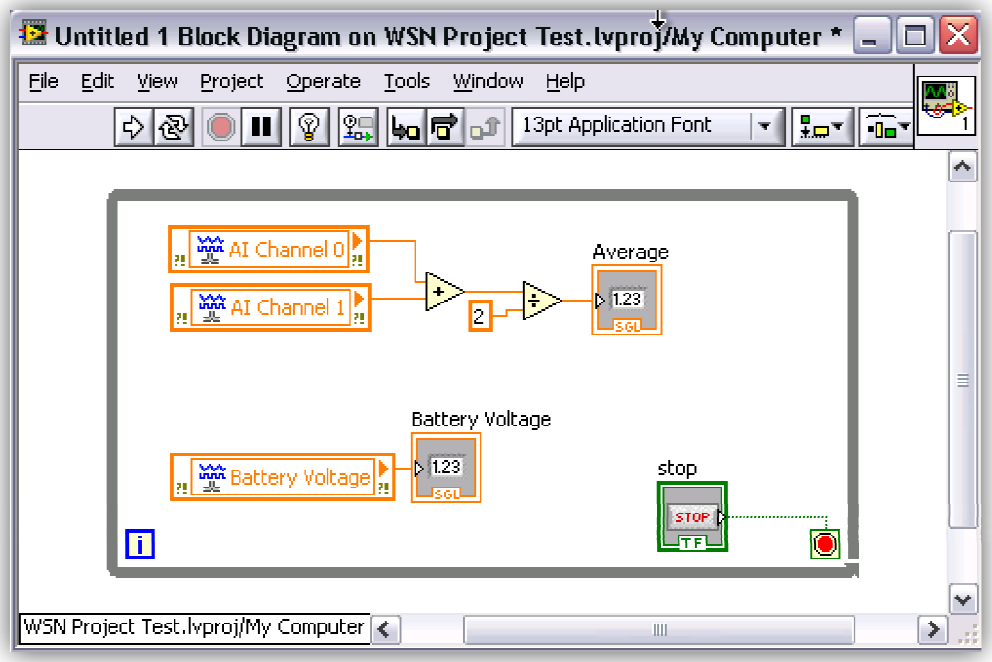
LabVIEW Project Integration

- Autodetection of WSN nodes
- Drag-and-drop variables

NI WSN Demo

- Configuring WSN in NI MAX
- Extracting data using LabVIEW





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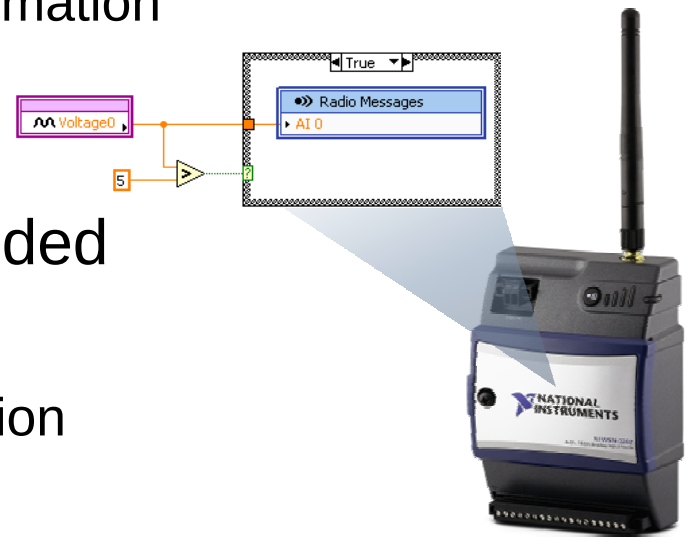
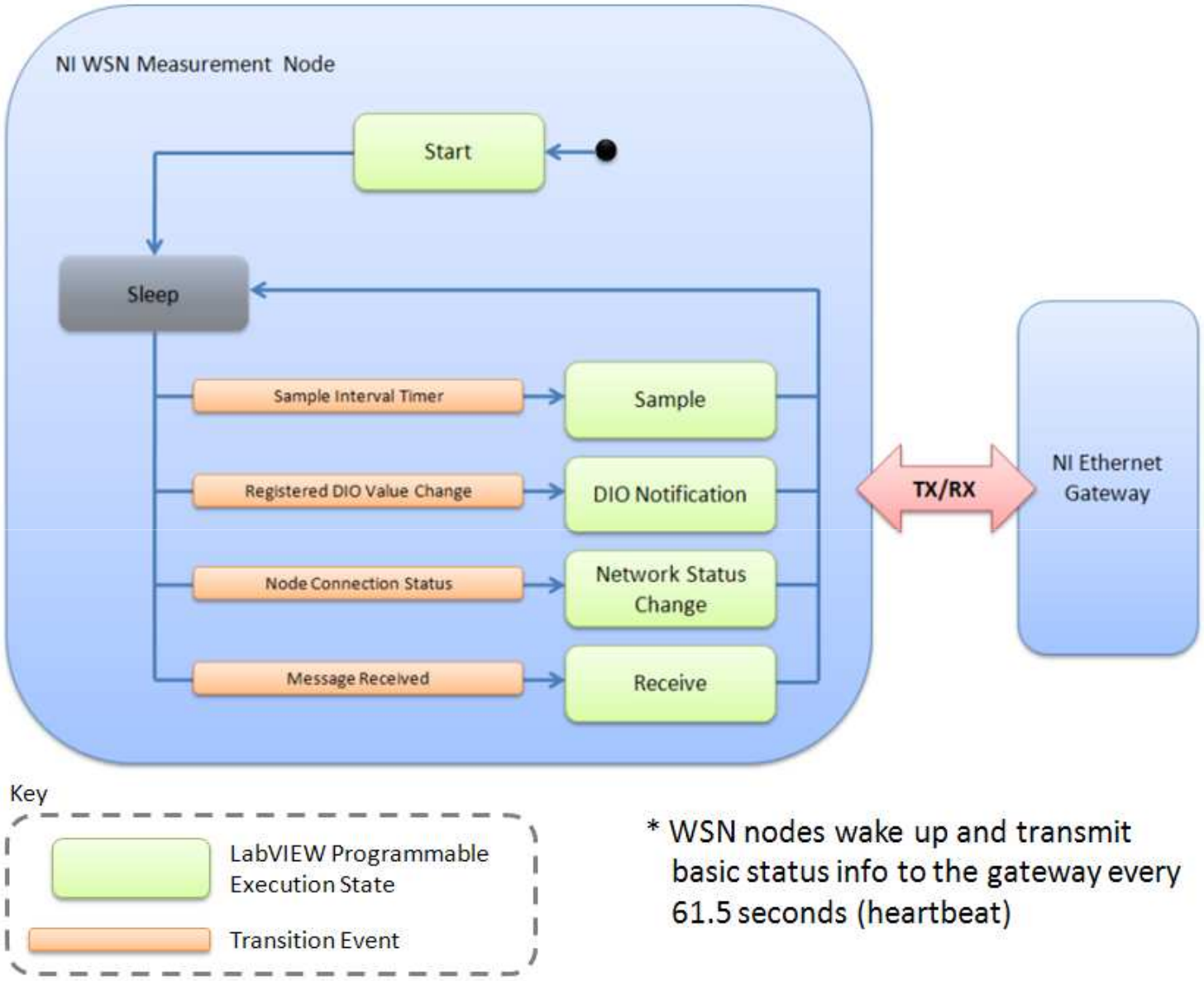
LabVIEW WSN Module

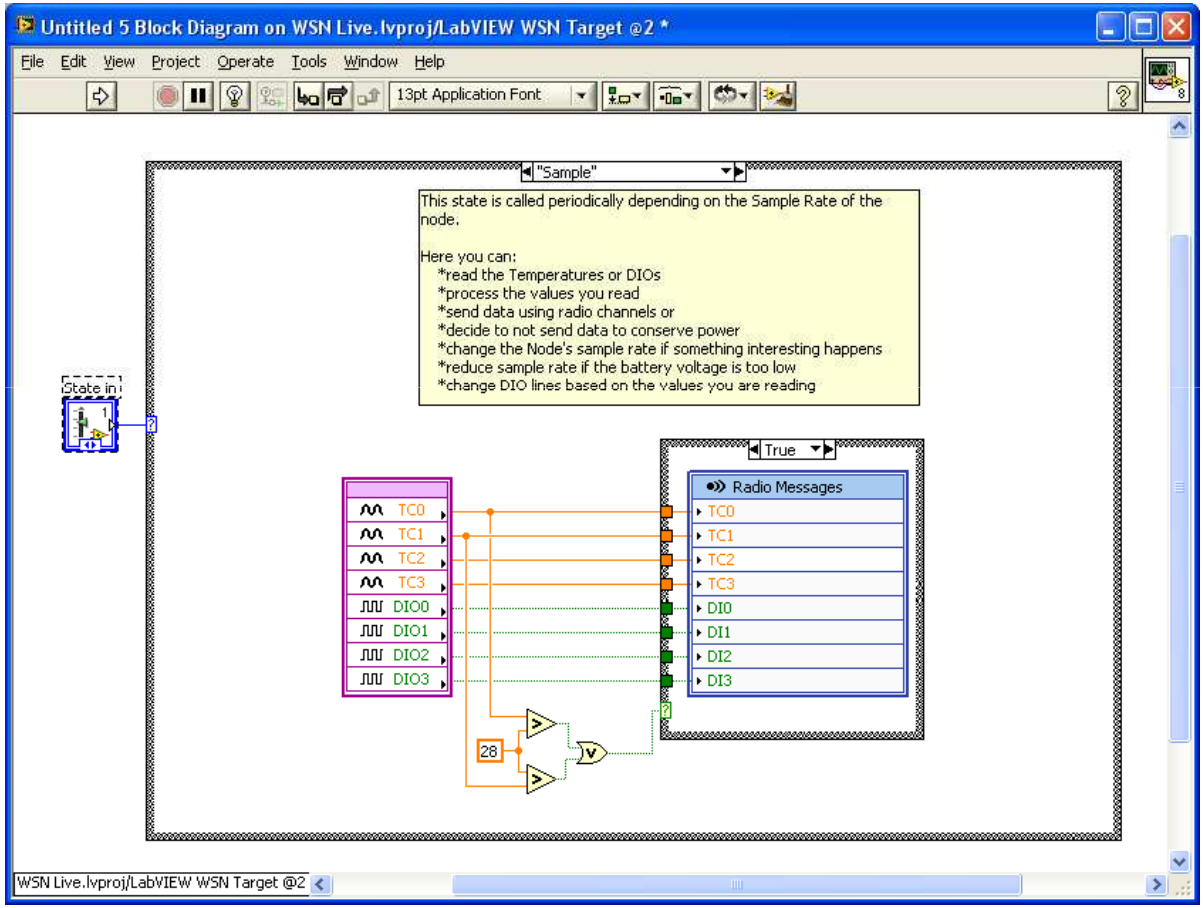
- Extend battery life
  - Transmit meaningful data (threshold, averaging, and deadband)
  - Adapt sample and transmission rates to operating conditions
- Perform custom analysis
  - Convert raw data into meaningful information
  - Interface to sensors
- Reduce response time with embedded
- decision making
  - Control actuators without host interaction





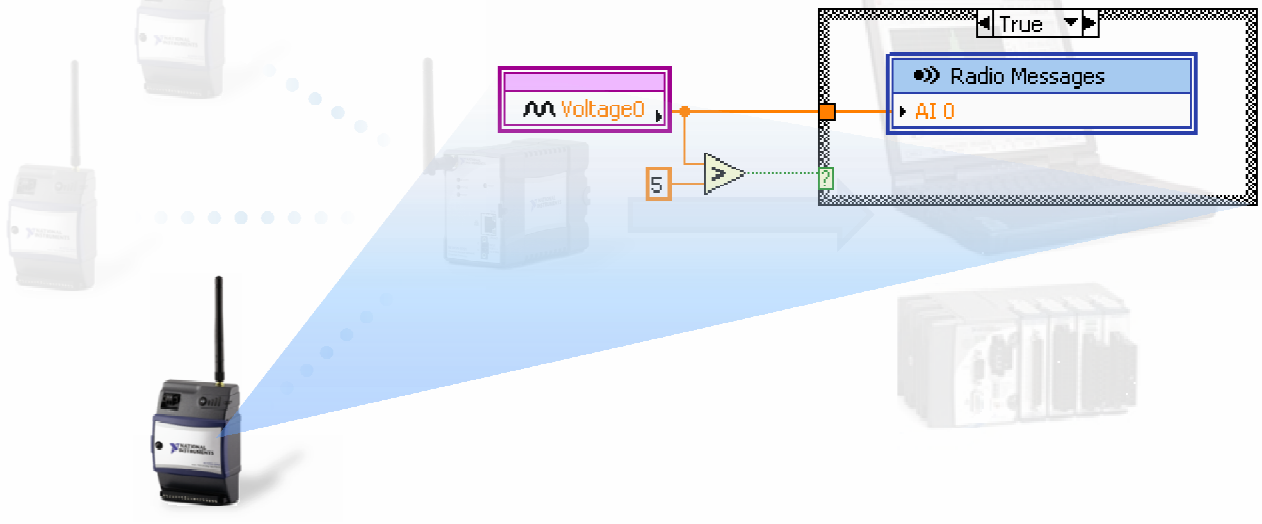
* WSN nodes wake up and transmit basic status info to the gateway every 61.5 seconds (heartbeat)

Programmable Node Demo



Using LabVIEW to Build a WSN System

Add intelligence with intuitive graphical programming



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Understanding WSN Applications

- Factors to consider:
  - RF communication and environment
  - Measurement types and sensor requirements
  - Channel count, range, and network topology
  - Power
  - Software (data access and representation)

NI-WSN, Based on IEEE 802.15.4

- 2.4GHz, Channels 11-24
- Defines joining, re-joining, mesh routing
- Device authentication
- Node sleep times, acquisition intervals, and heartbeats

Analyzing your RF Environment

- Outdoor or Indoor?
- Line of sight communication?
  - Obstacles
- Other wireless devices
  - Frequency band overlap?

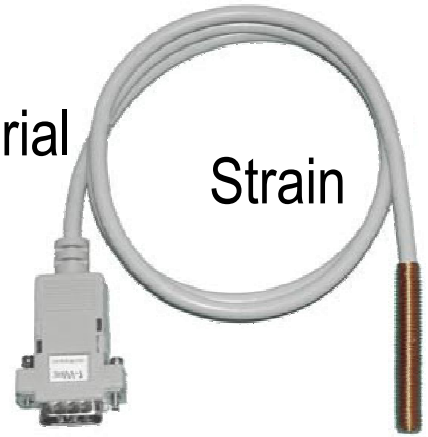
Measurement Types and Sensor Requirements

Pressure

Humidity

Voltage

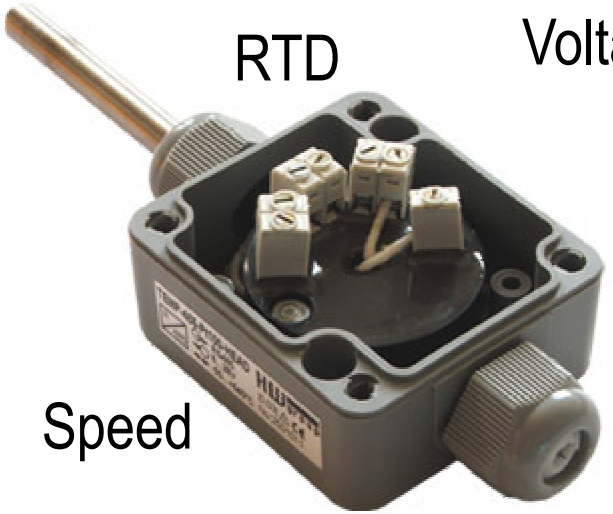
Serial



Strain

Flow

pH



RTD

Speed

Analog

Digital

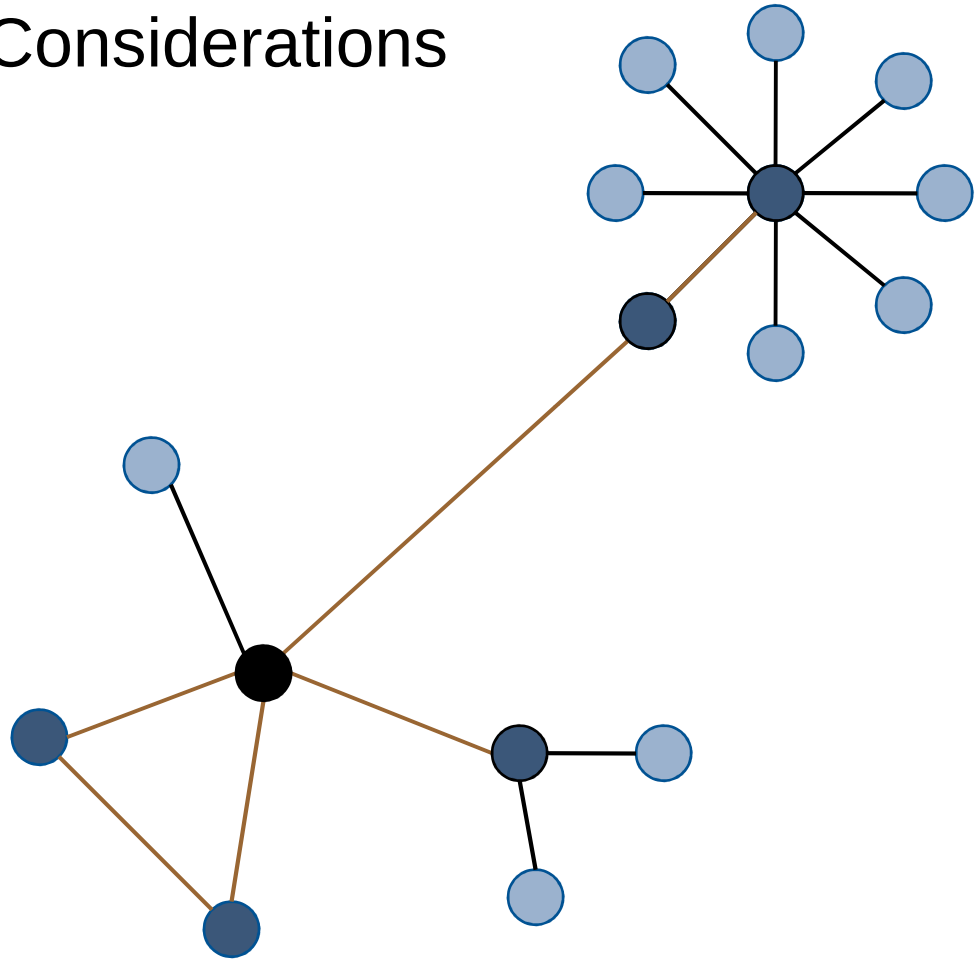
Temperature

Proximity

Current

Network Topologies

- System Design Considerations
  - Channel Count
  - Range
  - Power



Gateway

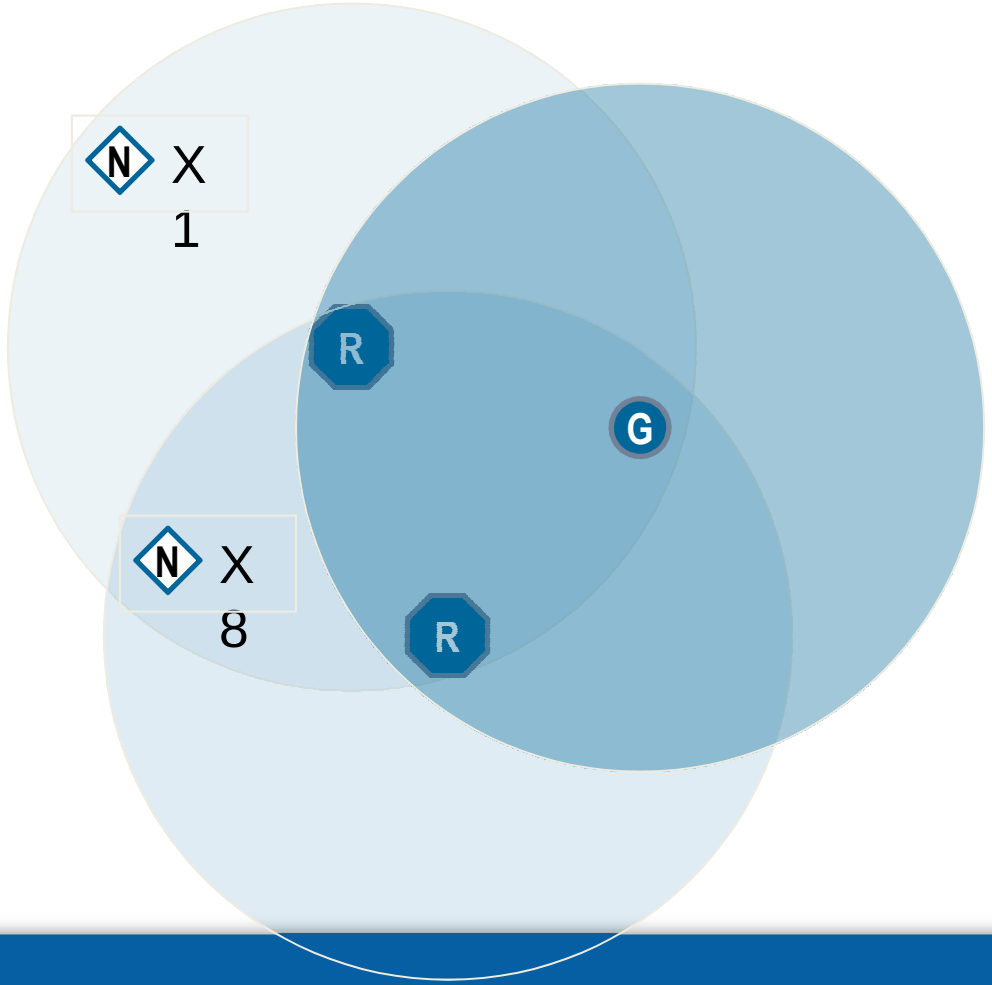
Router Node

End Node

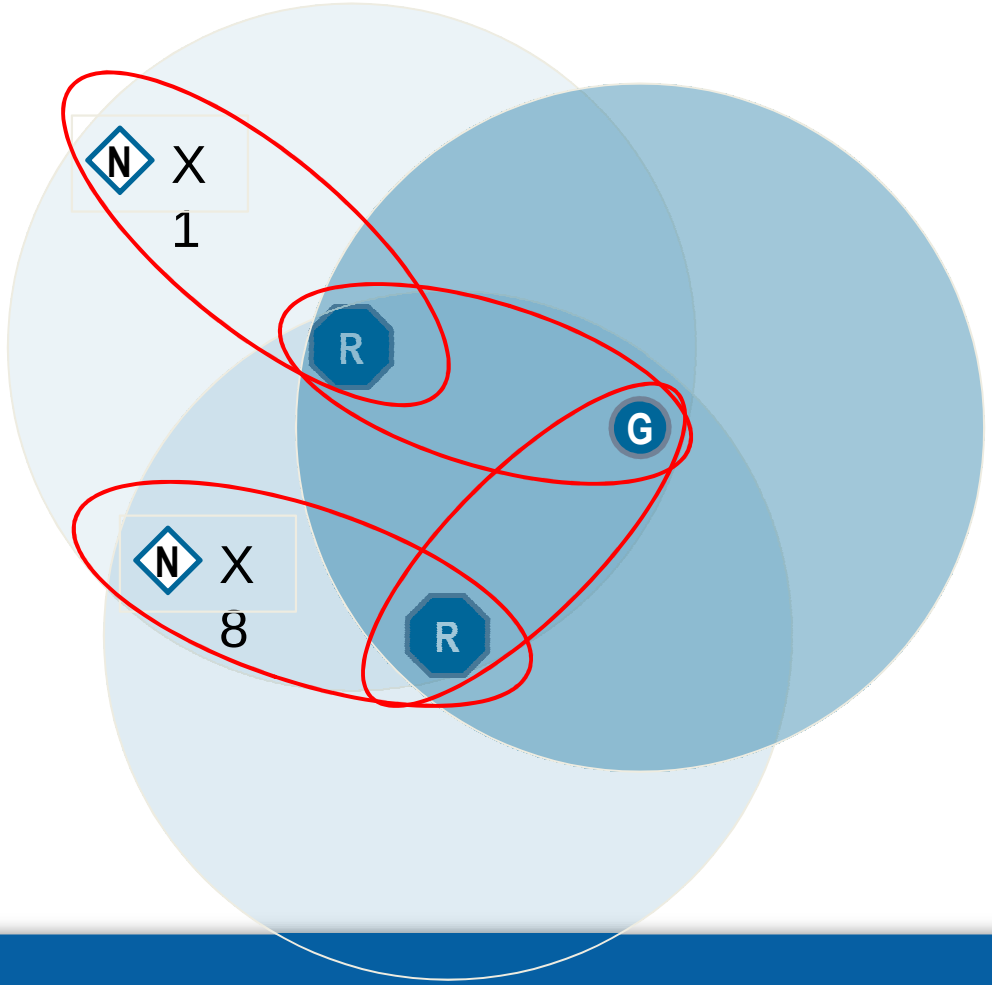
NI-WSN Meshing Guidelines

- Minimize number of routers
  - More routers may lead to inefficient meshing
- 8 End Nodes per Gateway and/or Router
  - Stranded Node
- 3 Hops from End Node to Gateway
- 36 total nodes per gateway
- Node joining restricted to link quality > 35

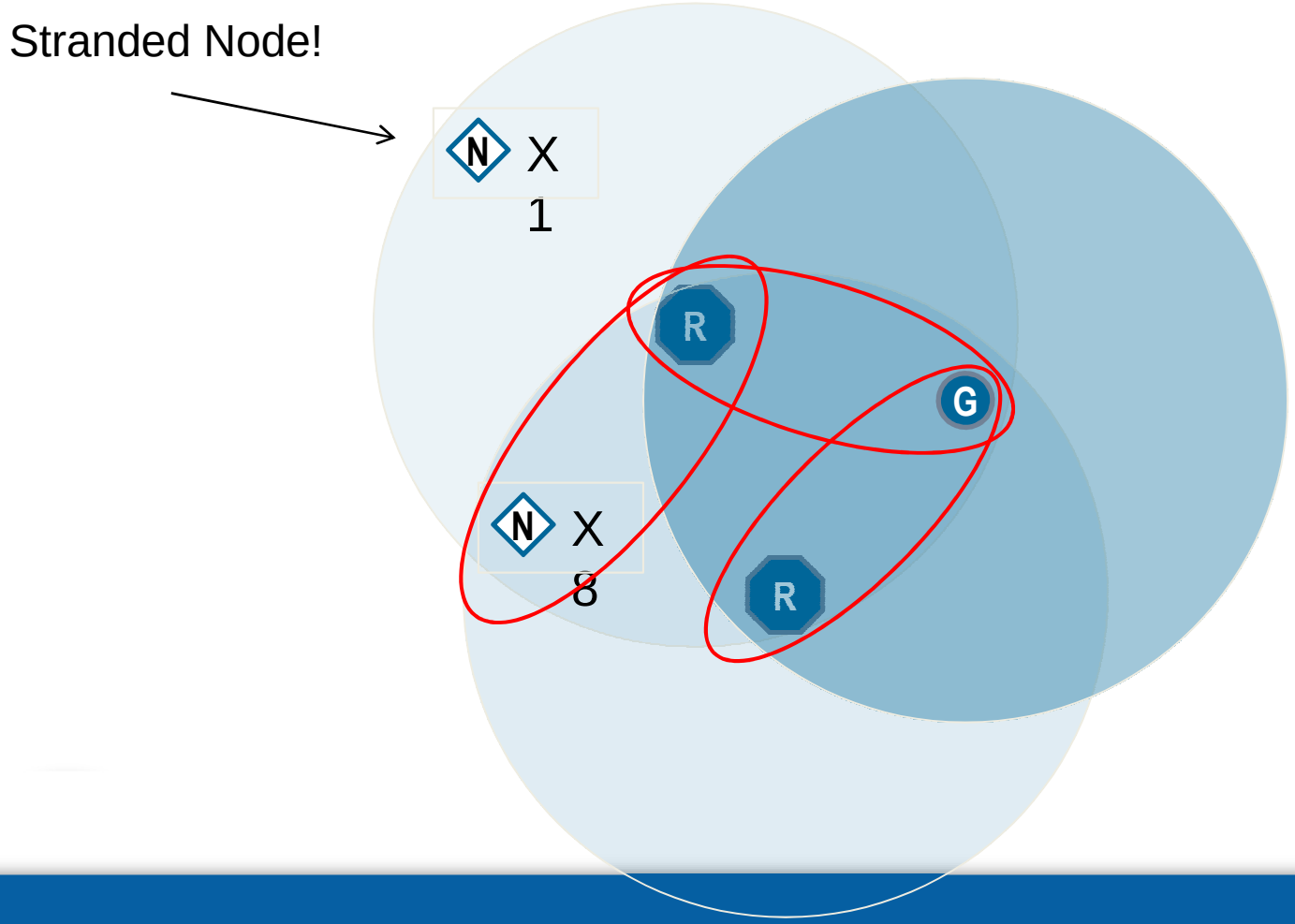
Stranded Node



Stranded Node



Stranded Node



Ronald Reagan Hospital Parking Monitoring – UCLA Campus

- Benefits
  - Get people to open spaces
  - Reduce traffic in parking garage
  - Reduce campus traffic due to people searching for parking spots

- Solution Components
  - WSN hardware interface with IR sensors to monitor traffic flow
  - Web service publishes parking information to students, faculty and staff

ni.com/wireless

NATIONAL INSTRUMENTS LabVIEW™

Wireless Test **Wireless Measurements**

PXI RF

Wireless DAQ

NI WSN

Third Party