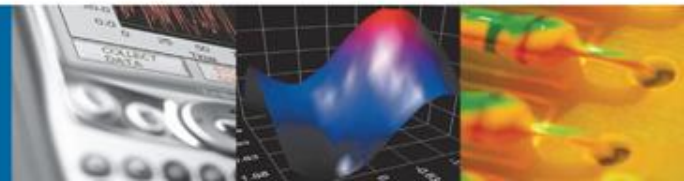


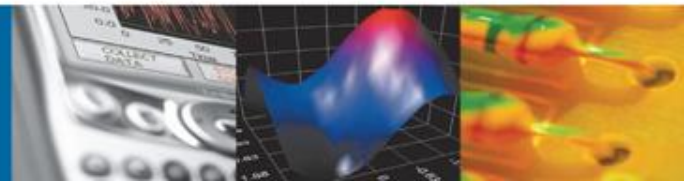
Introduction to Wireless Sensor Networks

Robert Berger



Agenda

- Wireless Standards and Technologies
- Wireless Measurements
- Wireless Networks
- Example Wireless Network and Demo



Wireless Is Everywhere



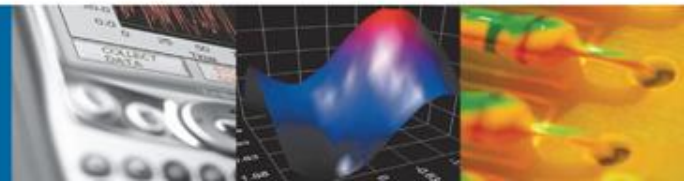
**Environmental
Monitoring**



**Resource
Monitoring**



**Industrial
Measurements**



Third Wave of Wireless Internet of Things



15 billion intelligent, connected devices

» The world is changing. Be a part of it.

The number of intelligent, connected devices will grow to 15 billion over the next six years. - IDC Report¹



30. The Internet Of Things

In September, a group of high-tech companies that includes Cisco and Sun formed the IP for Smart Objects Alliance. Simply put, the organization intends to create a new kind of network that will allow sensor-enabled physical objects — appliances in your home, products in a factory, cars in a city

ARTICLE TOOLS

- Print
- Email
- Sphere
- AddThis
- RSS
- Yahoo! Buzz

Sponsored Links

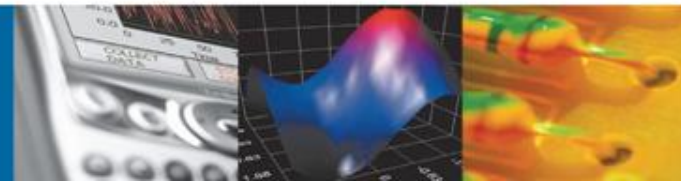
Ask a Lawyer Online
22 Lawyers Are Online! Ask a Question, Get an Answer ASAP.
Law.JustAnswer.com

[Buy a link here](#)



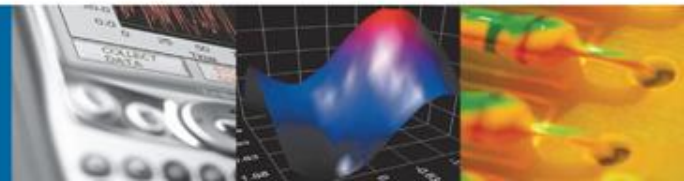
ILLUSTRATION FOR TIME BY CHRISTOPH NIEMANN

2009 NI Technical Symposium

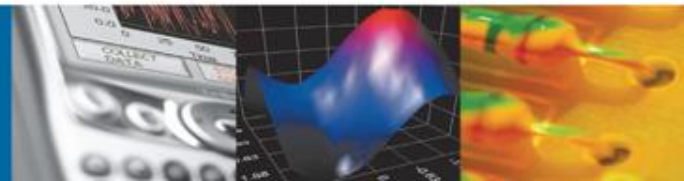
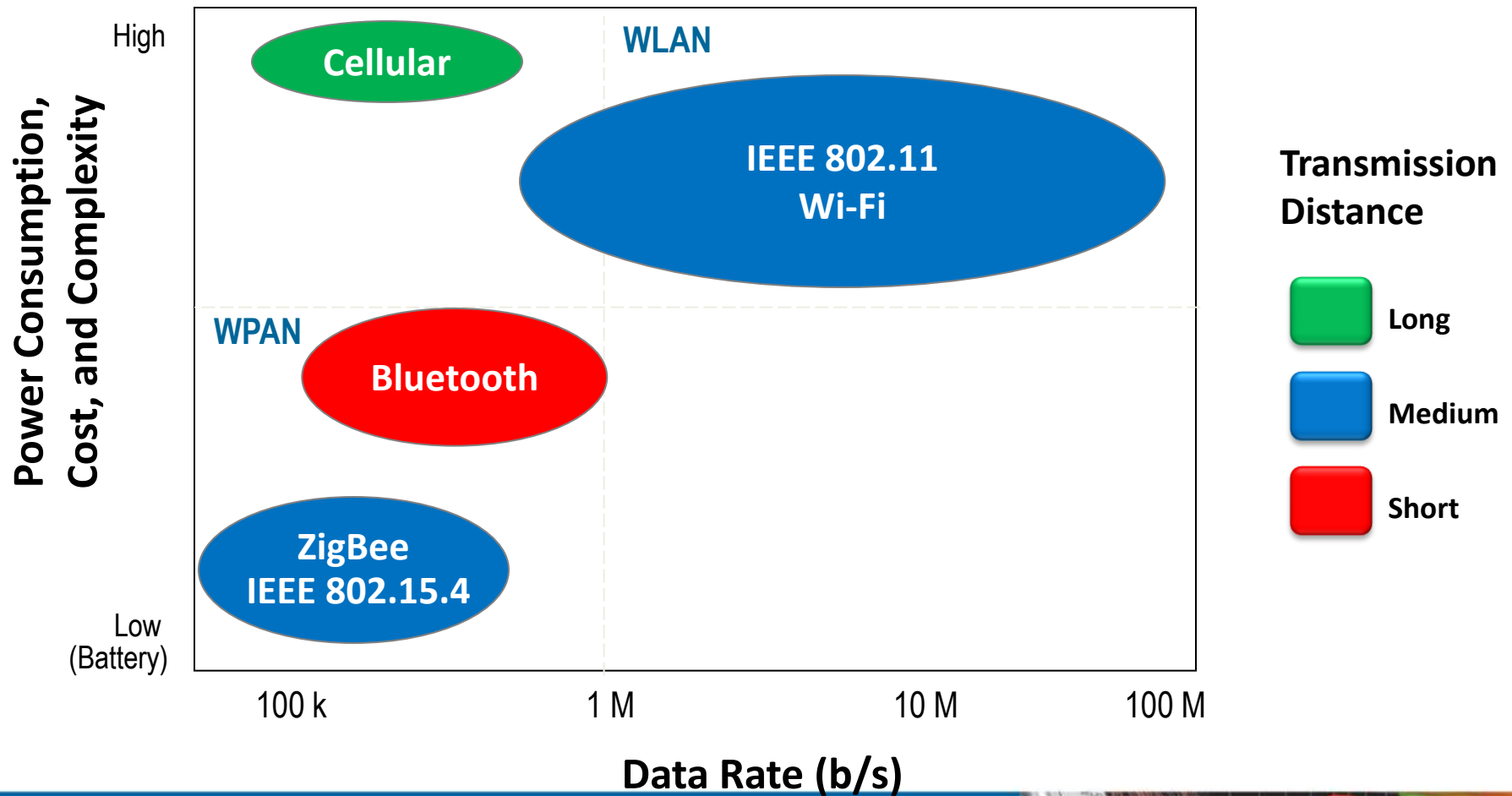


WIRELESS STANDARDS AND TECHNOLOGY

2009 NI Technical Symposium

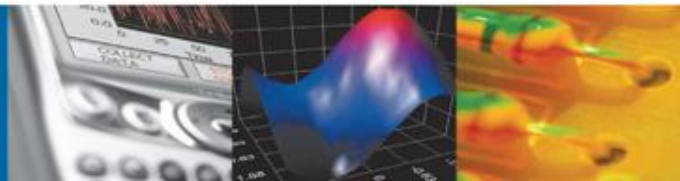


Wireless Standards



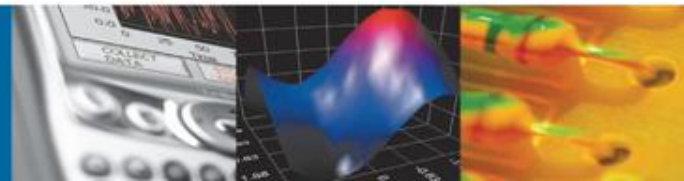
Power, Throughput, and Range

	Wi-Fi 802.11g	ZigBee (802.15.4)
Typical Battery Lifetime	1-2 days	2-3 years
Max Bit Rate	54 Mbit/s	250 kbit/s
Range (w/o repeaters)	30 m	300 m



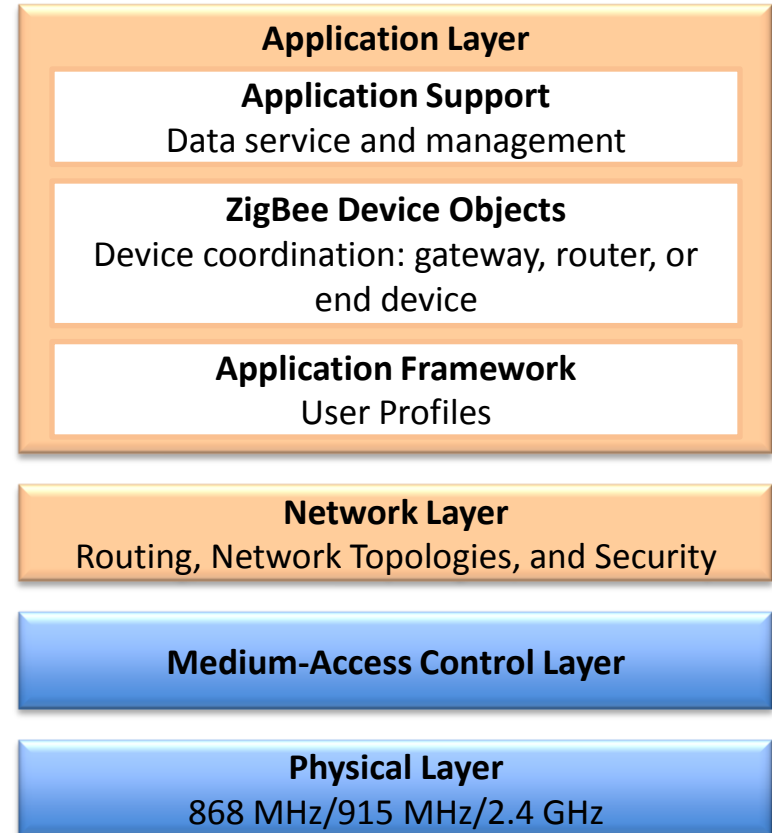
Wireless Terminology

- IEEE 802.11, WiFi
 - Access Point
 - Repeater
 - Client
- IEEE 802.15.4, Personal Area Networks
 - Gateway
 - Router
 - End Node



IEEE 802.15.4/ZigBee

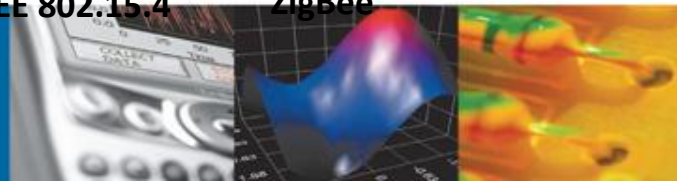
- Popular for WSN devices
- IEEE 802.15.4 defines:
 - 868, 915 MHz, and 2.4 GHz radios
 - Up to 250 kb/s
 - Low-power communication
- ZigBee adds:
 - Device coordination
 - Network topologies
 - Interoperability with other wireless products



IEEE 802.15.4

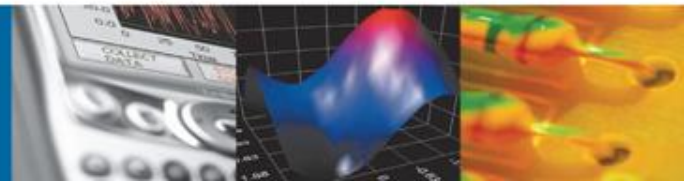


ZigBee



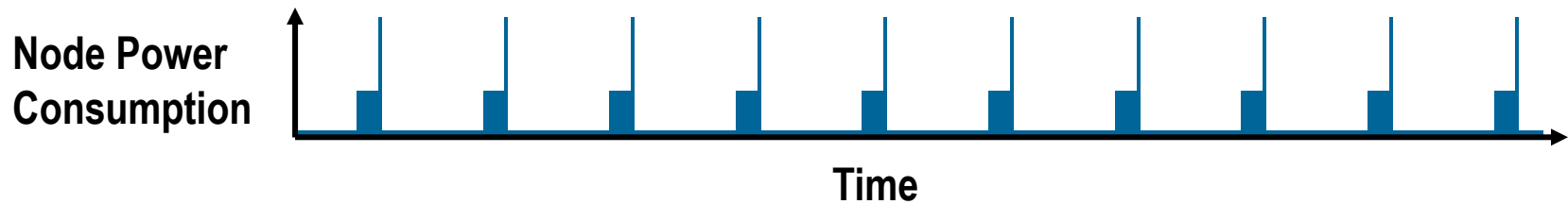
NI-WSN, Based IEEE 802.15.4

- Frequency: 2.4 GHz
- RF Channels: 14 Channels (11-24)
- Data Rate: 250 kbits/s
- Provides:
 - Mesh Routing - Ability for network to detect alternative paths
 - Sleep Mode – Ability end node conserve power and maintain reliable communication



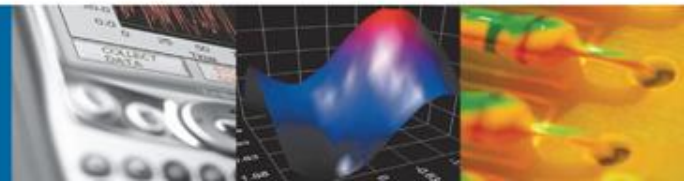
Power Considerations

- Nodes sleep most of the time to conserve power
- Must minimize processor and radio power



Microprocessor Trends and Options

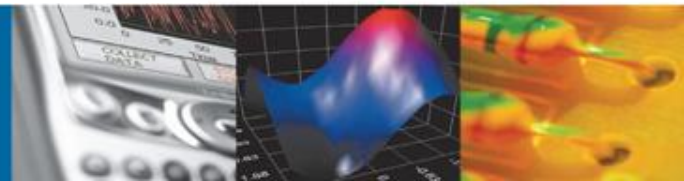
	Example	Power Consumption		Bits	Processor Speed	Embedded Memory
		On	Sleep			
Crossover	TI MSP430 F2419	8 mW	0.2 μ W	16	8 MHz	128 KB
	Freescale QE128	100 mW	1 μ W	8/32	50 MHz	128 KB
ARM	OKI ML674K	145 mw	50 μ W	16/32	33 MHz	512 KB
PPC	Freescale MPC8313	520 mW	300 mW	32	333 MHz	GB External
x86	Intel Core 2 Duo T7400	34 W	12 W	64	2.16 GHZ	GB External



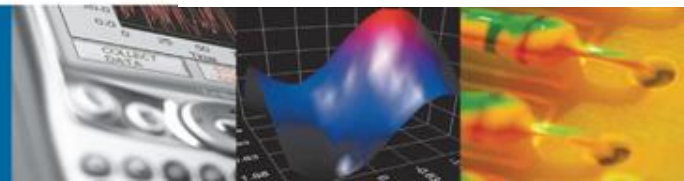
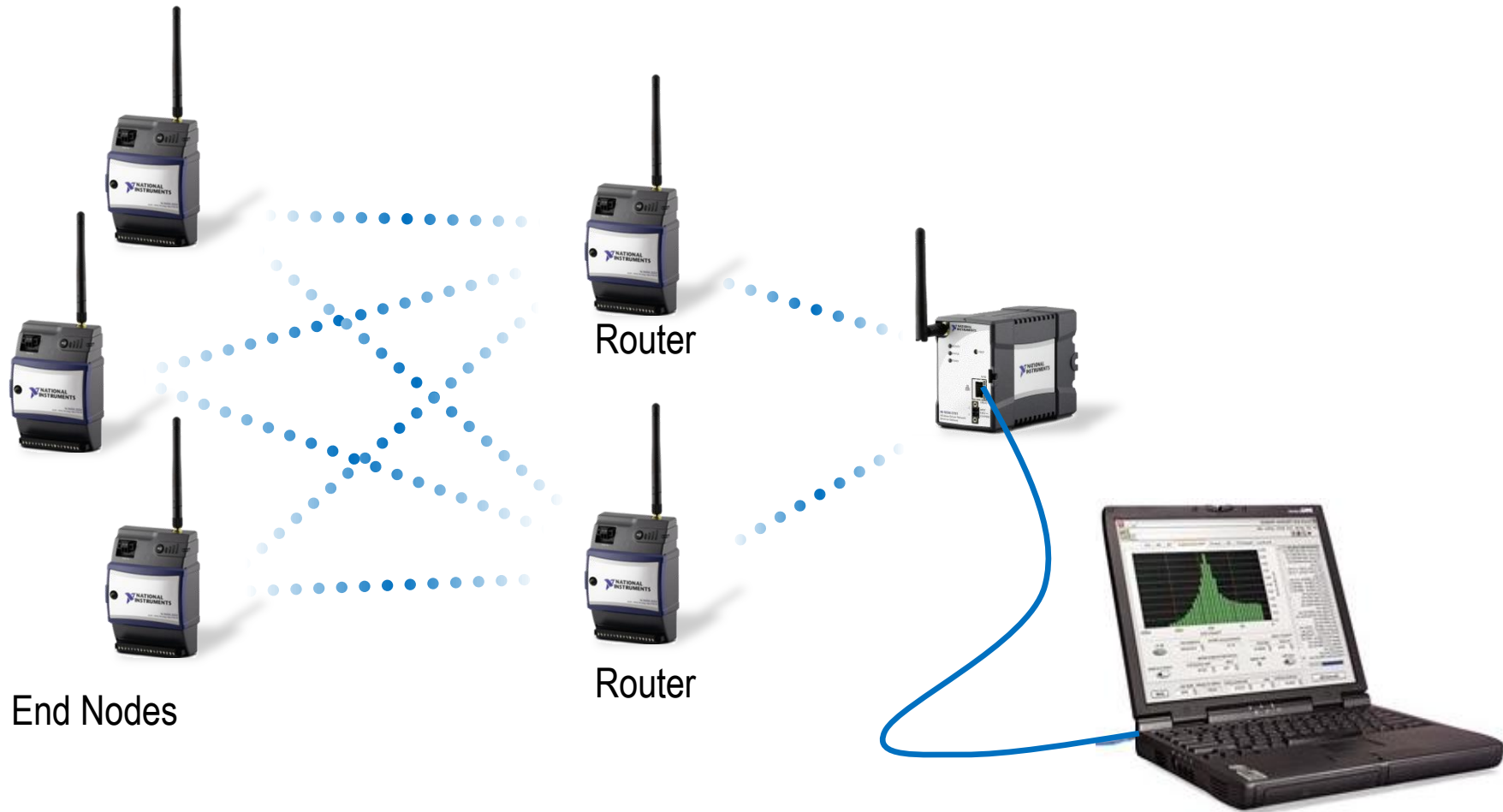
What is a Wireless Sensor Network (WSN)?



2009 NI Technical Symposium

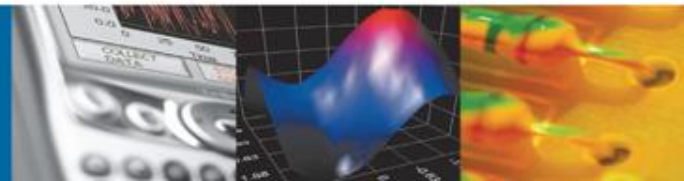


What is a Wireless Sensor Network (WSN)?



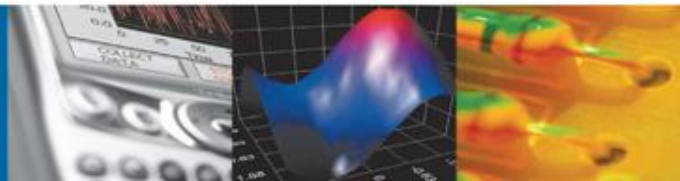
Key NI-WSN Terminology

- Minimum Sample Interval: Fastest system update in seconds (Sample Rate)
 - NI WSN-3202 analog input node: 1 second per sample (60 S/min)
 - NI WSN-3212 thermocouple node: 2 seconds per sample (30 S/min)
- Default Sample Interval
 - 2 seconds per sample
- Heartbeat Interval
 - Time between keep alive communications from Gateway to End Nodes
- Sensor Power (NI WSN-3202 voltage node only)
 - Power sourced from internal batteries to external sensors
- NI Network Topologies
 - Network configurations tested by National Instruments

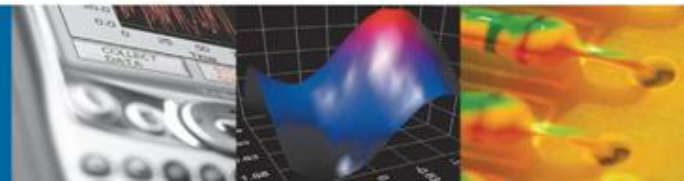
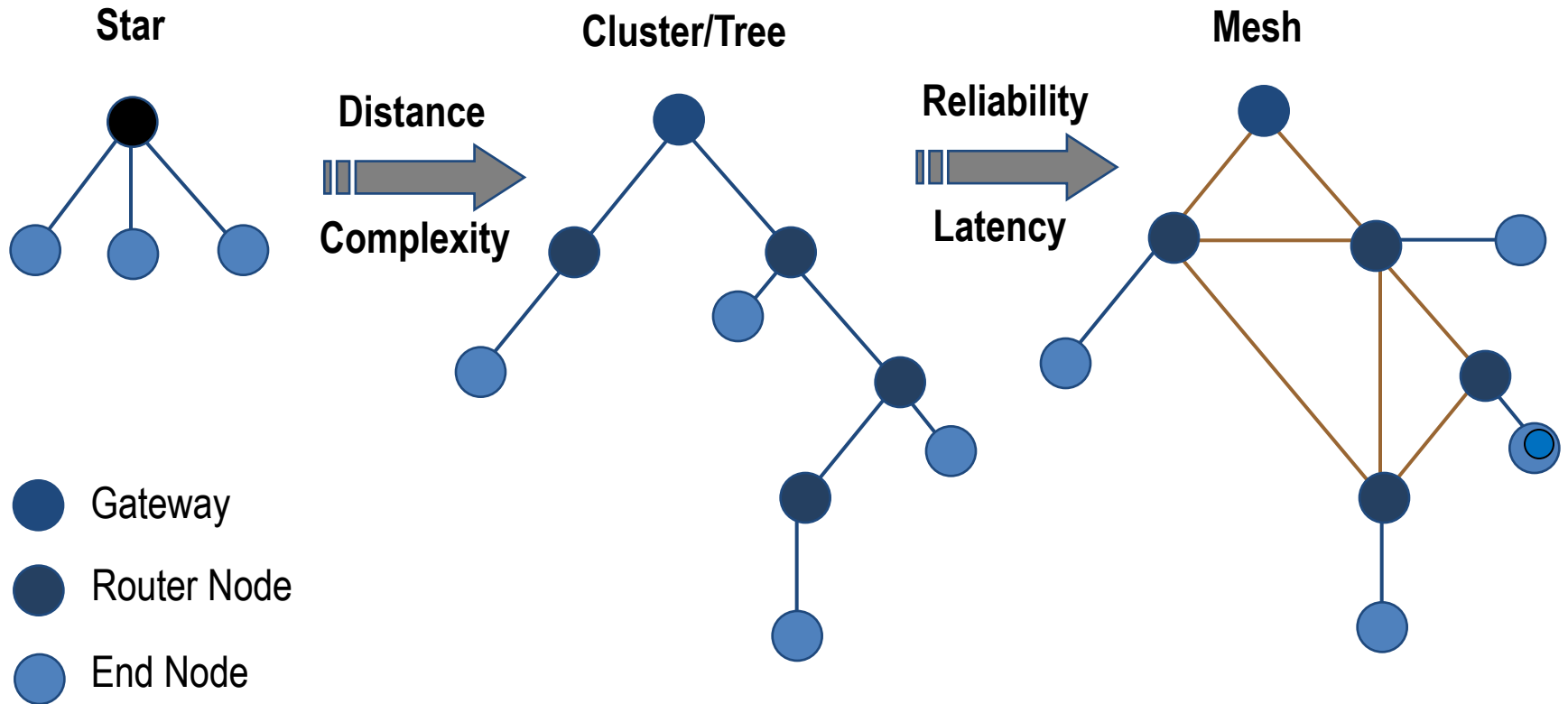


NI-WSN Topology Guidelines

- 8 End Nodes per Gateway and/or Router
 - Maximum 36 (End Nodes + Routers) / Gateway
 - 4 channels / node = 144 channels /Gateway
- 3 Hops from End Node to Gateway
 - 2 Routers between Gateway and End Node

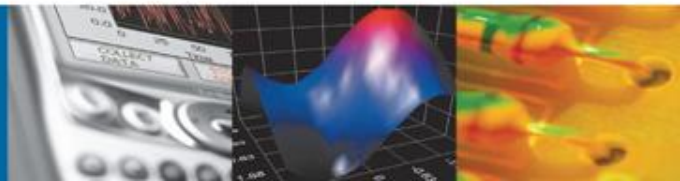


Network Topologies

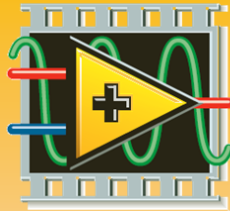


Network Distances

- Theoretical
 - Minimum connectivity strength
- System Reliability



Wireless Measurement Platforms



NATIONAL INSTRUMENTS

LabVIEW™

Wireless Test

Wireless Measurements

PXI RF



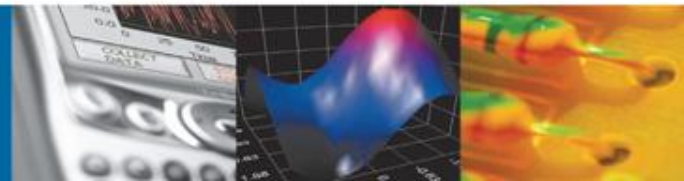
Peer to Peer Wireless DAQ



WSN



2009 NI Technical Symposium



The Benefits of Wireless Measurements

Reduce Costs

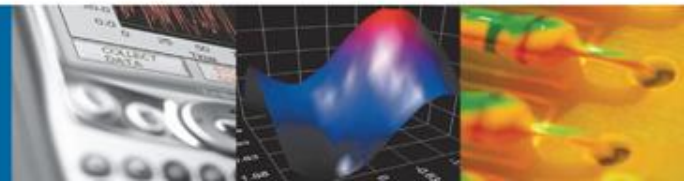
- Reduce installation costs and time
- Reduce maintenance costs

Increase Efficiency

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

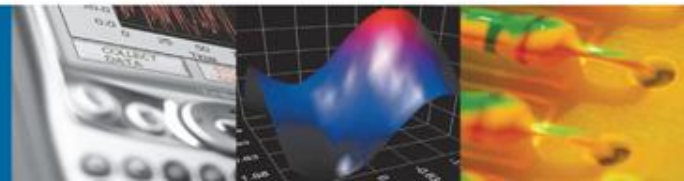
Monitor Anywhere

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



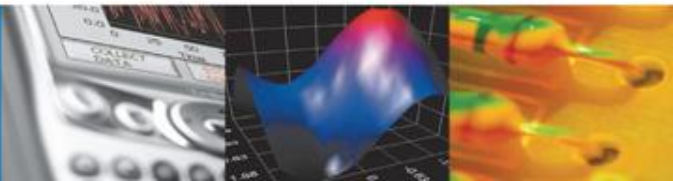
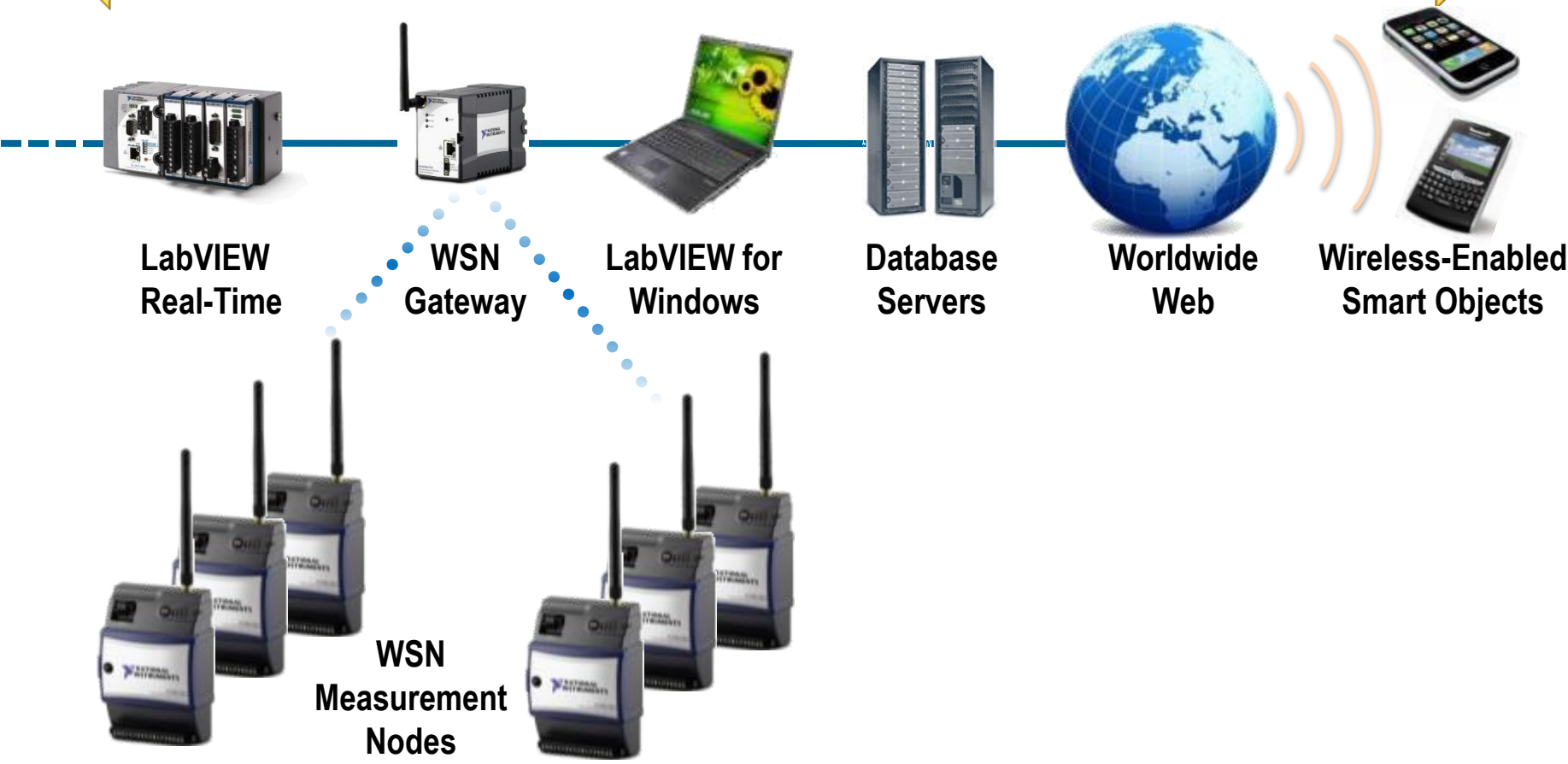
Low-Power. Reliable. Wireless Sensor Networks.

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



WSN System Architecture

LabVIEW



Today's Example System

NI WSN-9791

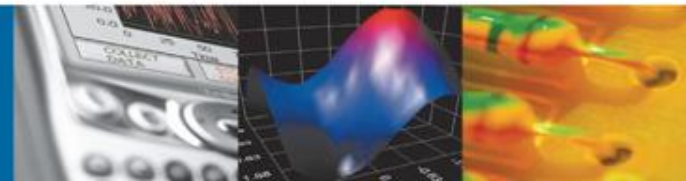
Wireless Sensor Network Ethernet Gateway

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 °C
 - 50 g_{rms} shock 5 g vibration
- Status LEDs



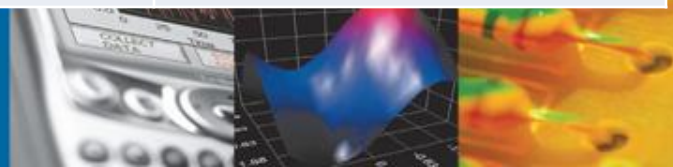
NI WSN-3202 and NI WSN-3212

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 °C
 - 50 g_{rms} shock 5 g vibration



Node	Analog Input	Digital I/O	Sample Interval (seconds)	Sample Rate (samples/minute)	Resolution (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 Starter Kit
 - WSN-9791 Ethernet Gateway
 - 2 programmable nodes
 - Sensors and power accessories
 - LabVIEW Evaluation Software
 - Getting Started Guide

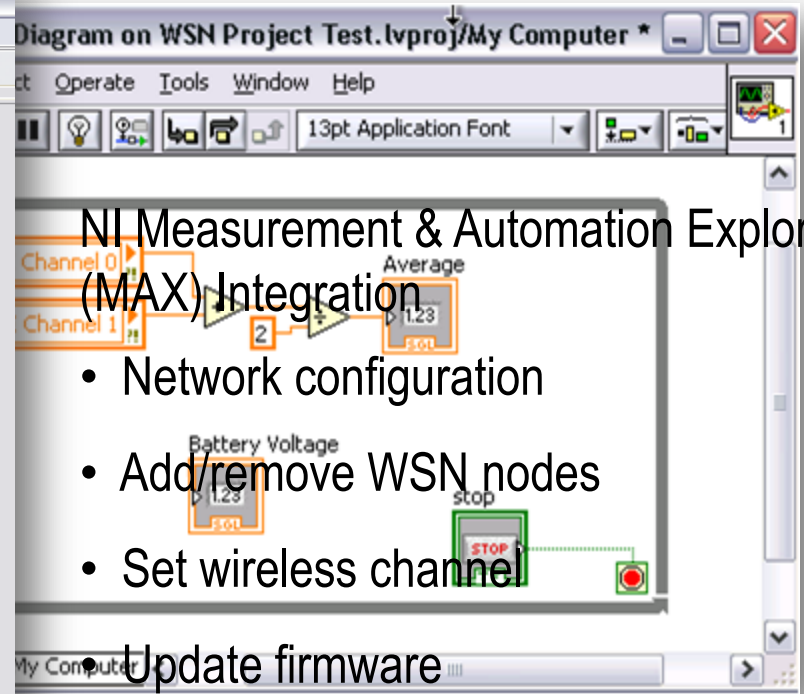
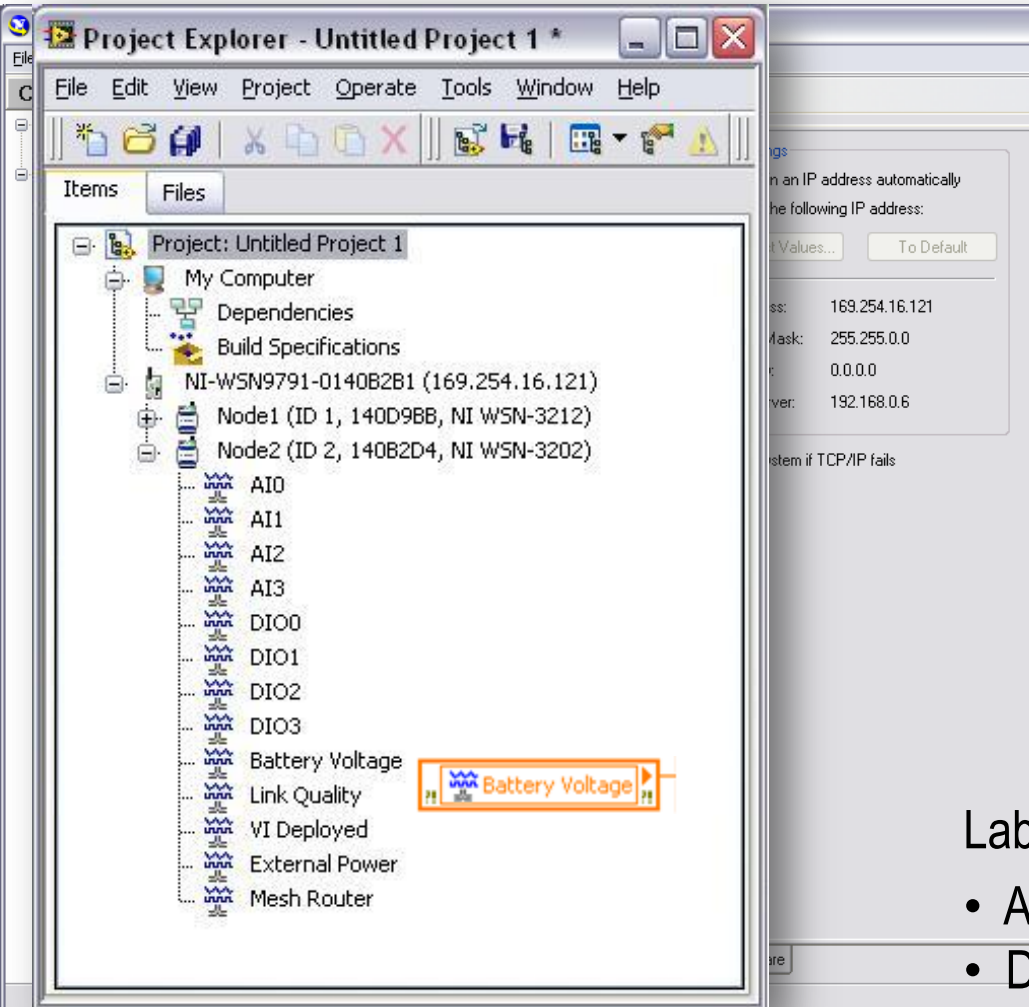


NI WSN-3291



NI WSN Starter Kit

NI WSN Software



NI Measurement & Automation Explorer (MAX) Integration

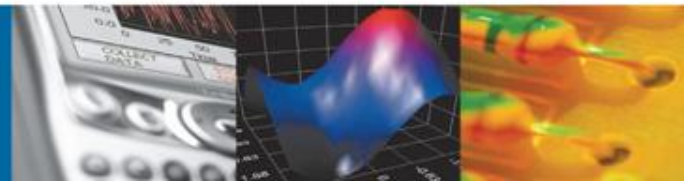
- Network configuration
- Add/remove WSN nodes
- Set wireless channel

• Update firmware

- Configure nodes as routers

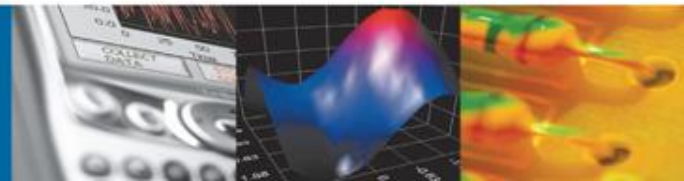
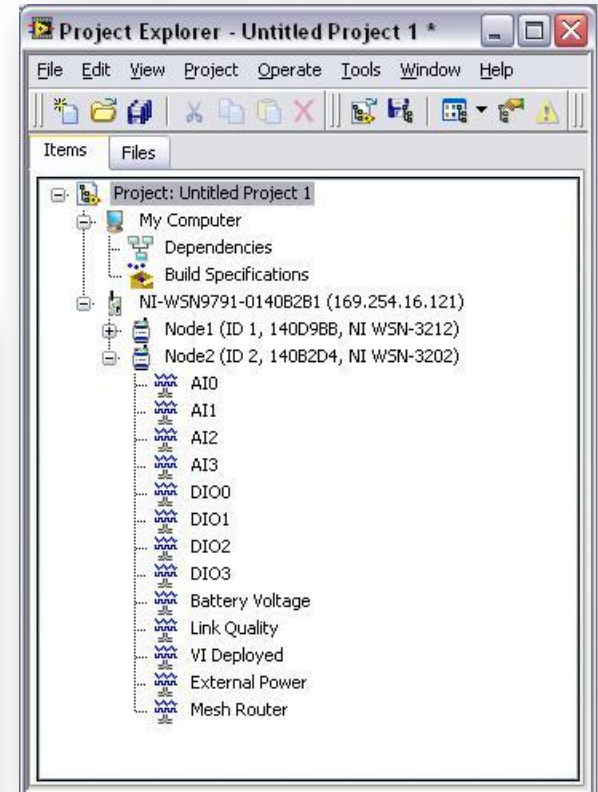
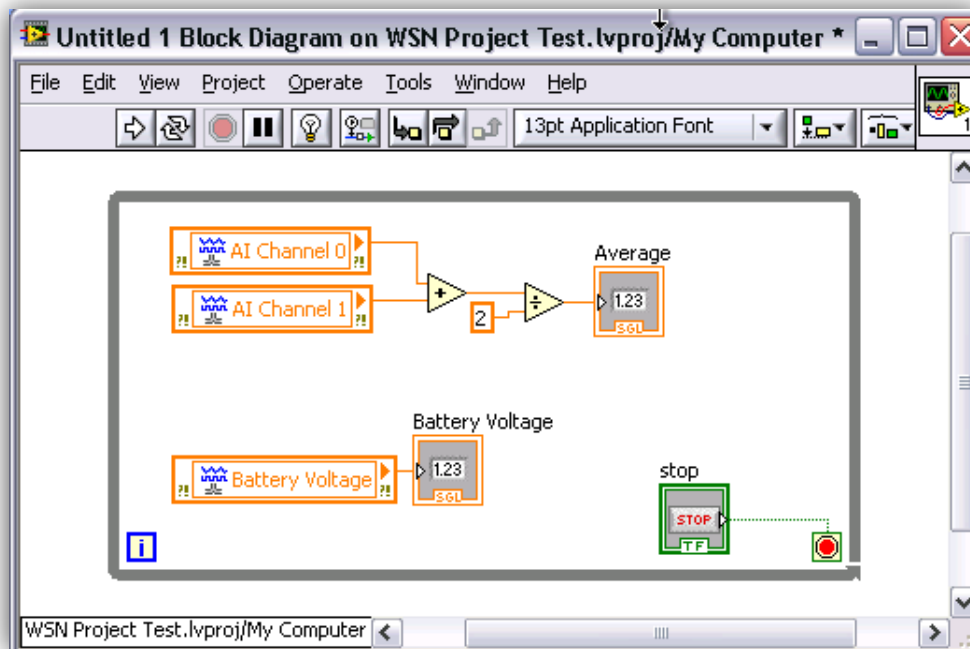
LabVIEW Project Integration

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



NI WSN Demo

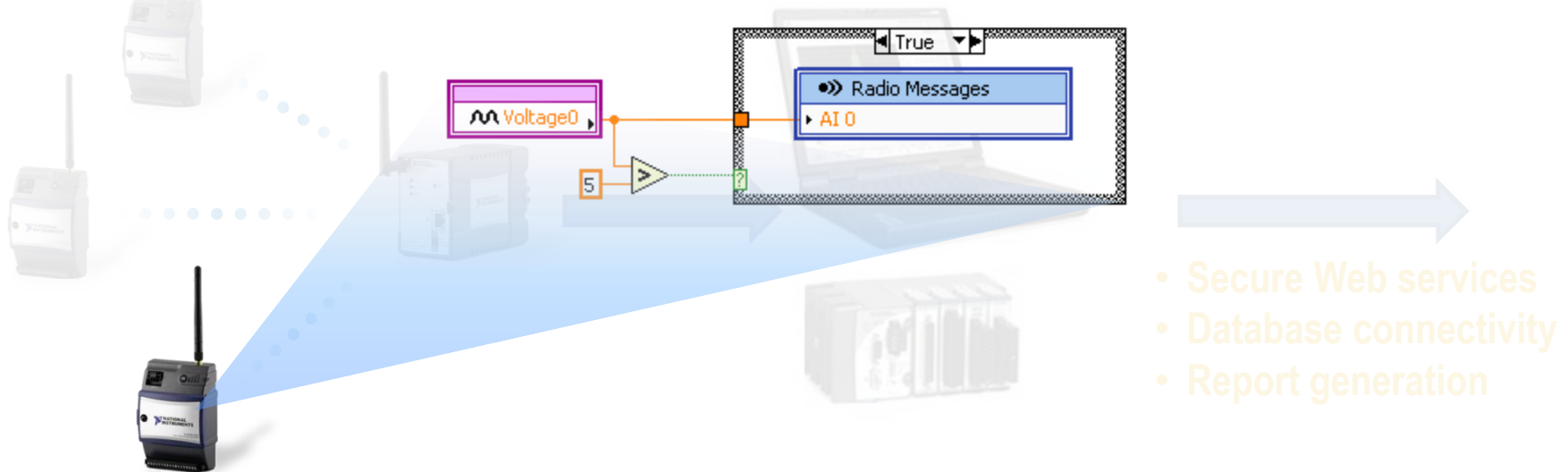
- Configuring WSN in NI MAX
- Extracting data using LabVIEW



Using LabVIEW to Build a WSN System

- Connect to NI and 3rd party WSN measurement nodes
- Integrate wireless measurements with NI PACs
- Hundreds of built-in functions

Add intelligence with intuitive graphical programming



- Secure Web services
- Database connectivity
- Report generation



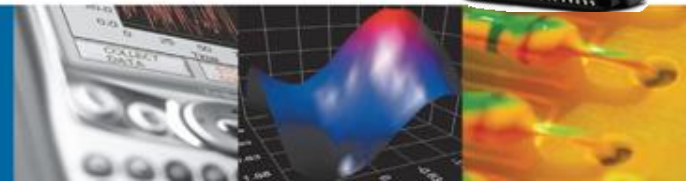
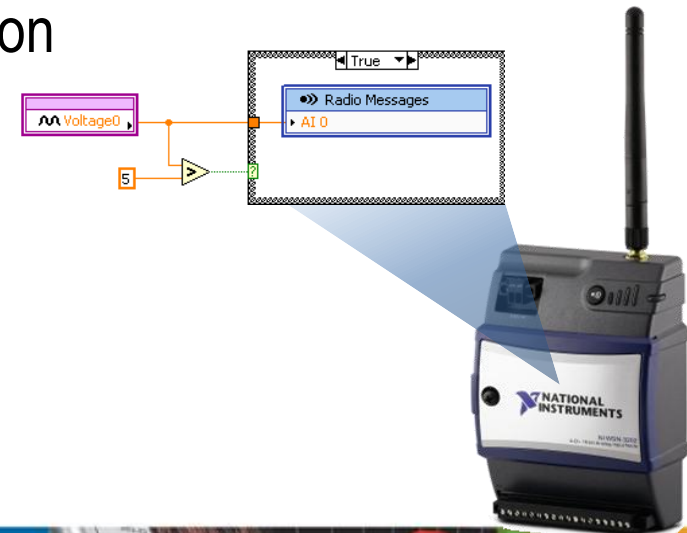
NATIONAL INSTRUMENTS

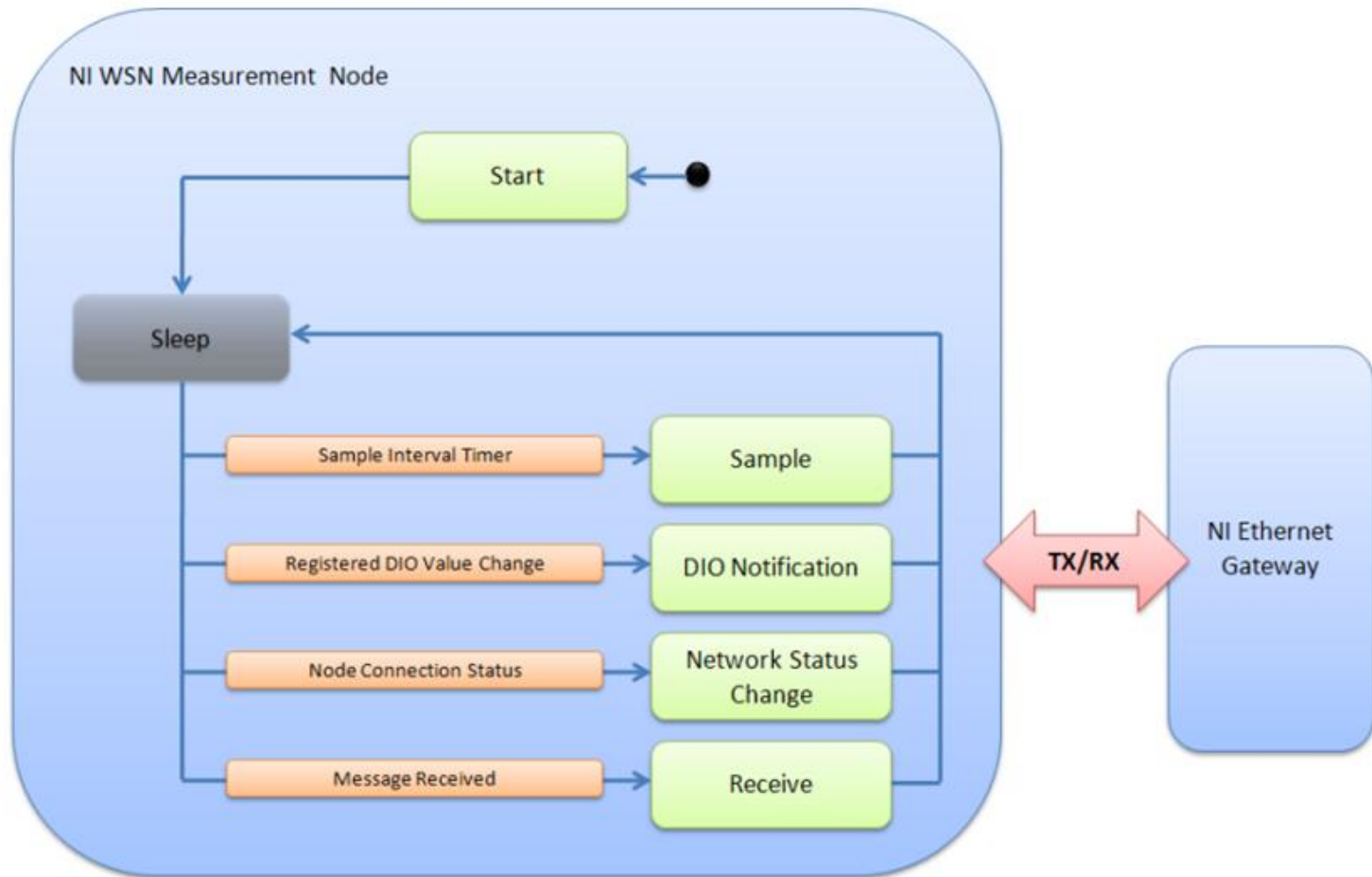
LabVIEW™

LabVIEW WSN Module Pioneer



- 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

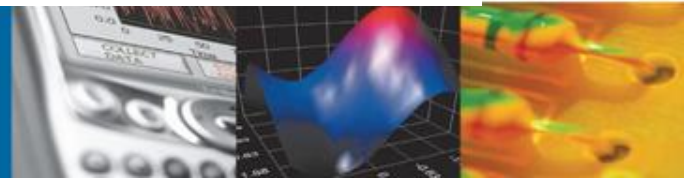




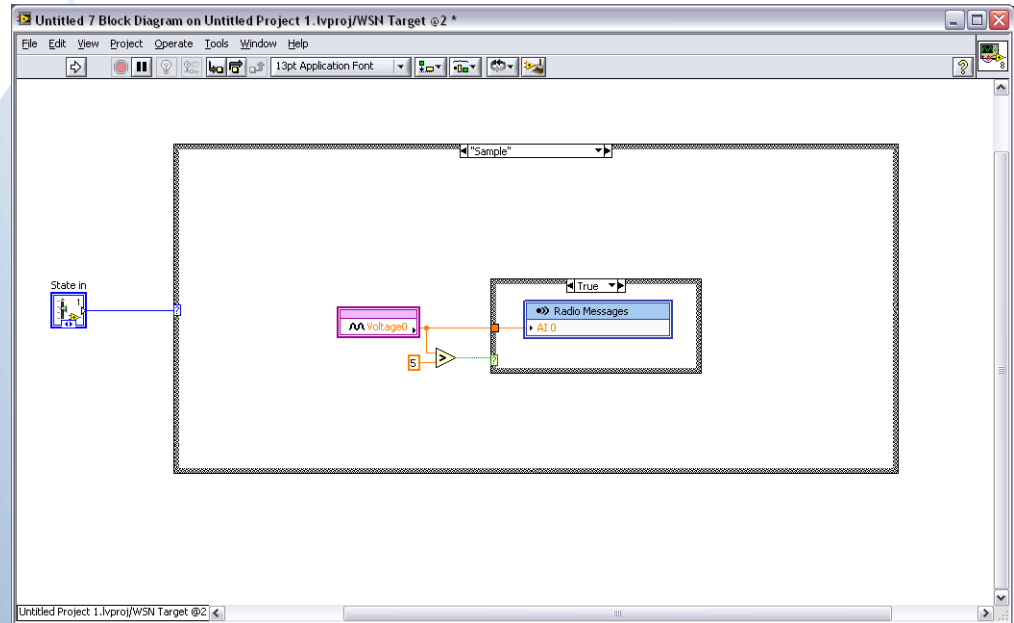
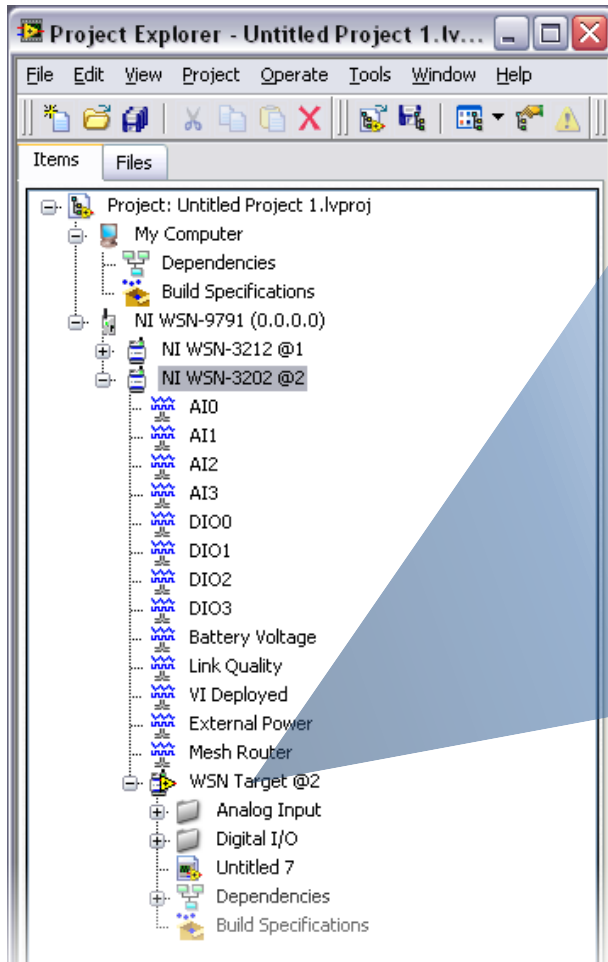
Key



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

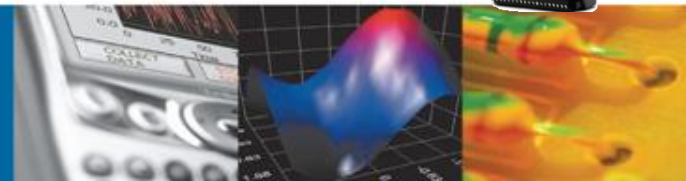


LabVIEW WSN Module Pioneer



Add intelligence with graphical programming

- Customize node behavior
- Download code updates over the air



Wireless Application Areas



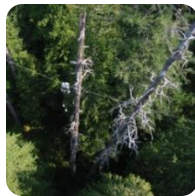
Environmental Monitoring



Resource Monitoring



Industrial Measurements



Air/
Climate



Water/
Soil



Indoor
Monitoring



Power
Monitoring



Solar
Monitoring



Wind Farm
Monitoring



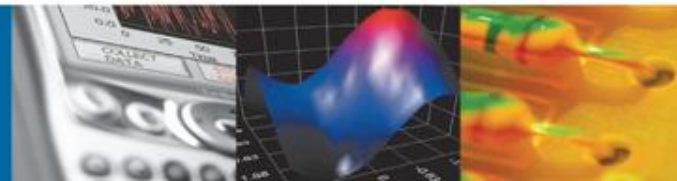
Structural
Health
Monitoring



Machine
Condition
Monitoring

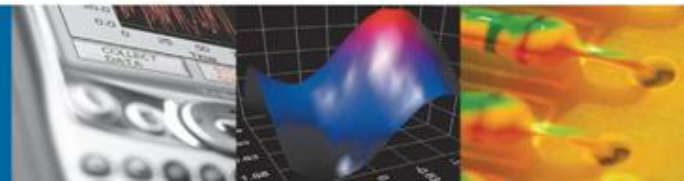


Process
Monitoring



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



Biofuels from Algae



- Algae converts sunshine into chemical energy
- Why algae as a fuel source?
 - Does not rely on commercial crops
 - Can be grown on arid land or in the ocean



“The newly released WSN product family combines many attractive features ... wireless networking, low power consumption, LabVIEW compatibility, and a flexible I/O portfolio.”



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

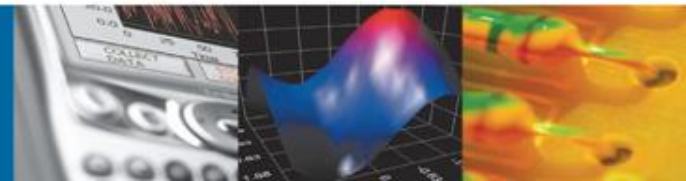
Products: LabVIEW and Wi-Fi DAQ

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



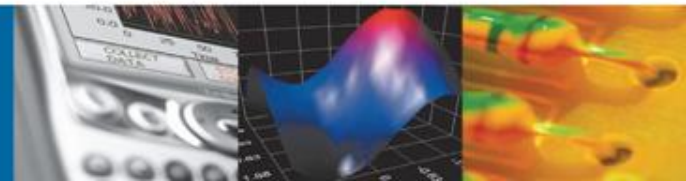
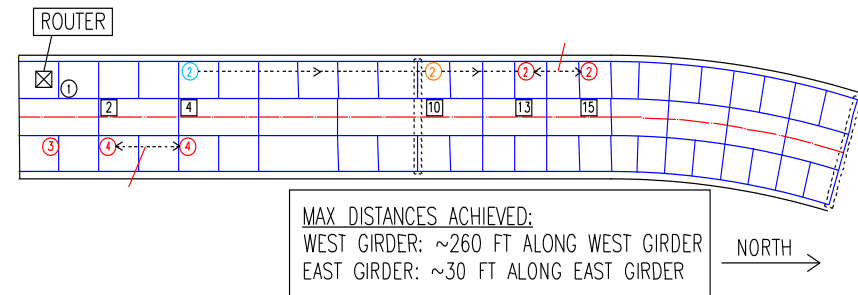
Inspection and Monitoring of Fracture-Critical Steel Bridges

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

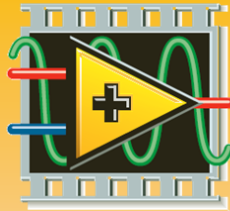
Challenge: Continuous, real-time monitoring of a loaded steel bridge several hundred feet long

Products: LabVIEW, Wi-Fi DAQ, and WSN

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



ni.com/wireless



NATIONAL INSTRUMENTS

LabVIEW™

Wireless Test

Wireless Measurements

PXI RF



Wireless DAQ



NI WSN



Third Party



2009 NI Technical Symposium

