Wiring Wireless in Smart Instrumentation

Documenting Wireless Instrumentation

John Dressel
Fluor SI SME
Introduction

- Wireless Instrument Standards
  - WirelessHART (IEC 62591)
  - ISA100.11a (IEC 62734)
  - Comparison of WirelessHART and ISA100.11a
- Wireless Instrument Systems
- Wireless Physical Design
- Documenting Wireless in Smart Instrumentation

(WIA-PA and WIA-FA Chinese Standards not covered)
Wireless Instrument Standards

- **WirelessHART** is a wireless sensor networking technology based on the Highway Addressable Remote Transducer Protocol (HART)
  - **Industry:** Industrial wireless sensor networks
  - **International standard:** IEC 62591, IEEE 802.15.4
  - **Developed by:** HART Communication Foundation
  - **Established:** 2004

- **ISA100.11a** is a wireless networking technology standard developed by the International Society of Automation (ISA)
  - **Industry:** Wireless Systems for Industrial Automation: Process Control and Related Applications
  - **International standard:** IEC 62734, ISA100.11a
  - **Developed by:** ISA-100 Wireless Compliance Institute
  - **Established:** 2009
WirelessHART (IEC 62591)

- All field devices performing field sensing or actuating functions are HART and must have the ability to route packets to the wireless mesh.
- Adapters or wireless THUMs can bind wired HART devices into the WirelessHART mesh network.
- Supports handheld devices carried by mobile users such as plant engineers and service technicians.
- Wired access points connects the wireless mesh to the gateway and network Manager.
- Simplex or redundant gateway that functions as a bridge to the host applications.
- The Network and Security may reside in the gateway device or be separate from the gateway.
WirelessHART (IEC 62591)

- WirelessHART devices need to be indexed and specified Smart Instrumentation just as wired instruments and I/O cards.
- WirelessHART components could include: Gateways, Instruments, I/O Adaptors, Wireless I/O cards, Converters, Routers and THUM Adaptors.
- Consider the purpose of the WirelessHART installation (Control, Indication, Asset Management, Moving or Remote Equipment) when selecting WirelessHART hardware.
ISA100.11a Wireless (IEC 61850)

- Field device interoperability is accomplished by defining the role of each sensor node
- Routers are always required to access mesh, star-mesh and star topologies to the backbone via gateways
- Adapters enable wired devices to access the ISA100.11a network (including HART devices)
- Non-routing sensor nodes require star topology
- Connection to a plant network requires a dedicated gateway and backbone
- Coexistence with other wireless networks, protocols and web services provides flexibility
- A set of services are defined for the Network and System Manager that is separate from the gateway and are not part of the standard
ISA100.11a Wireless (IEC 61850)

- All ISA100.11a Wireless components need to be indexed and specified in Smart Instrumentation.
- ISA100 Wireless components could include: Gateways, Instruments (routing and non-routing sensor nodes), Routers and Adaptors.
- Consider the purpose of the ISA100 Wireless installation (Control, Indication, Asset Management, Moving or Remote Equipment) when selecting ISA100 Wireless hardware.
Both standards use IEEE 802.15.4 radios and operate in the 2.4GHz ISM radio band
- Wireless instruments are off 97% of the time and “wake up” in a slot time to send/receive
- WirelessHART slot time is fixed at 10ms and uses TDMA channel hopping protocol
- ISA100 Wireless uses variable slot time, but defaults to 10ms with IPv6 protocol

### Comparison of WirelessHART and ISA100.11a

<table>
<thead>
<tr>
<th>Application</th>
<th>Command Oriented, Predefined Data Types and Application Procedures</th>
<th>Wired HART</th>
<th>WirelessHART</th>
<th>ISA100Wireless</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auto-Segmented transfer of large data sets. Reliable stream transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>Redundant Paths Mesh Network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td>TDMA, Channel Hopping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data link</td>
<td>Analog &amp; Digital Signalling 1.20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>IEEE 802.15.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEEE 802.15.4 (2.4GHz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISA native and Legacy Protocols (tunnelling)</td>
<td>UDP (IETF RFC 768)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6LoWPAN (IETF RFC 4944)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Data Link ISA100.11a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEEE 802.15.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEEE 802.15.4 (2.4GHz)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Selection of which Wireless standard will depend mostly on the selected Control System Vendor as different vendors have embraced different standards.
Crossover of WirelessHART and ISA100.11a

- Honeywell OneWireless™ Field Device Access Point (FDAP) is an industrial meshing access point for ISA100™ Wireless (IEC 62734) and WirelessHART (IEC 62591) field instruments.
- Emerson / Cisco dual-mode wireless gateway which supports both IEC 62951 WirelessHART and IEC 62734 ISA100.11a industrial wireless communications standards.
Wireless Instrument Systems

Safety Equipment Status Monitoring

- Wireless Safety Shower and Eye Wash Monitoring Solutions allow the use of safety equipment to activate remote alarms for emergency action.
- The Wireless Discrete Transmitter takes a variety of non-powered switch types such as pressure, flow, level and limit switches as input.
Remote Tank Gauging or Level Monitoring Systems

- Tank Gauging, level measurements and volumes using wireless adaptors and networks
- Increase personnel safety by reducing the need to visit and climb tanks
Wireless Instrument Systems

Equipment Maintenance Monitoring

- Wireless Heat Exchanger Monitoring Solution allows maintenance personnel to schedule optimal time to clean to sustain optimal heat transfer
  - Wireless DP Flow Rates for Efficiency Calculations
  - Wireless Temperature Monitoring for Efficiency Calculations
  - Wireless pH Monitoring for corrosion detection
Equipment Operations Monitoring

- Rotating Equipment Health Monitoring Solutions provide an early warning system for operations and maintenance staff.
- Equipment monitoring system detects vibration, lubrication issues, motor alignment, bearing faults, bent blades, louver drives, and duct or screen blockages.
Asset Management Systems

- Wireless equipment monitoring of pumps, seal pots, blowers, compressors, heat exchangers, fired heaters, corrosion, and cooling towers for Asset Management
- Wireless instrument asset monitoring the health of transmitters, controllers, valves, motoring elements and power supplies for Asset Management
Wireless Control Loops

- Wireless control loops are usually limited to Temperature or Level control loops due to the slow response time of wireless networks.
- Several manufactures have developed wireless actuators for on/off valves.
- Wireless control loops do not need to be completely wireless.
Wireless Physical Design

- Use the Smart Instrumentation Index to identify the Wireless devices
- Types of applications (e.g. monitoring, can use update rate of < 4 seconds)
- Radio range for the topography (e.g. dense areas have shorter radio ranges)
- Plot the location of Wireless devices, routers and Gateways on plan drawings
- Document the final design in Smart Instrumentation, plan drawings and S3D
- Utilize elevations when planning the location of routers and gateways
WirelessHART Physical Design

- **Scope** – Decide if you need to divide wireless field networks by process unit, subsection of a process unit or system
- **Design** – Apply design rules to optimize the mesh network:
  - Minimum of 5 WirelessHART devices within effective range of each gateway
  - Minimum of 3 WirelessHART devices within effective range of each other
  - Minimum of 25% of the devices within effective range of the gateway
- **Fortify** – Fix any potential weaknesses in the network design and optimize
ISA100 Wireless Physical Design

- **Scope** – Decide how you need to divide wireless networks and the type of topography (star, mesh, or star-mesh) you wish to use.
- **Design** – Apply design rules to ensure optimum connectivity:
  - Keep field instruments away from obstacles and in range of at least one routing device
  - Install routing devices in line of sight with an access points and as many field devices as possible
  - Consider turning on field device routing to access other hard to reach field devices
- **Fortify** – Fix any potential weaknesses in the network and use multiple access point gateways
Documenting Wireless in Smart Instrumentation

- Most SmartPlant Enterprise projects today use a combination of Conventional, Bus wiring and Wireless technology selected for best fit to project requirements
- Smart P&ID, Smart Instrumentation and Smart 3D have the unique ability to document all emerging technologies including Wireless with only minor user customization
Wireless devices and signals need to show on the P&ID just like any other instruments.

New symbols need to be created for the Wireless signals in Smart P&ID

Not all Wireless signals shown on the P&ID have loop destinations (e.g. Wireless THUM adaptors used to carry only digital data to an Asset Management System)

ISA 5.1-2009 specifies the use of sine wave or lighting bolt (zig-zag) symbol for wireless signals.
Documenting Wireless in Smart Instrumentation

- Smart Instrumentation customization for Wireless Networks
  - Consider the Physical Design of the Wireless network and hardware
  - Customized Instrument Types and Profiles for Wireless devices (Sensors, Routers, etc.)
  - Create Instrument Specifications for Wireless devices (Routers, Gateways, etc.)
  - Create custom symbols for Wireless devices for documents (Wireless Device Panels)
  - Create Loop Drawings and/or Wireless Network Diagrams from SPI

![Wireless Network Diagram]
Smart Instrumentation User Defined Fields for Wireless will vary according to standards, device types and manufacturer recommendations.
Wireless Instrument Types should be defined for each type of wireless hardware needed to compose the Wireless network.

<table>
<thead>
<tr>
<th>Instrument Type</th>
<th>Description</th>
<th>CS Tag Instrument Type Alias</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSH</td>
<td>HIGH-FLOW SWITCH</td>
<td>FSH</td>
</tr>
<tr>
<td>FSL</td>
<td>LOW-FLOW SWITCH</td>
<td>FSL</td>
</tr>
<tr>
<td>FT</td>
<td>MASS FLOW TRANSMITTER</td>
<td>FT</td>
</tr>
<tr>
<td>FT</td>
<td>HART FLOW TRANSMITTER</td>
<td>FT</td>
</tr>
<tr>
<td>FT</td>
<td>Fieldbus FT</td>
<td>FT</td>
</tr>
<tr>
<td>FT</td>
<td>D/P TYPE FLOW TRANSMITTER</td>
<td>FT</td>
</tr>
<tr>
<td>FT</td>
<td>Wireless HART Transmitter</td>
<td>FT</td>
</tr>
<tr>
<td>FT</td>
<td>Profibus PA flow transmitter</td>
<td>FT</td>
</tr>
</tbody>
</table>
Wireless Instrument Type Profiles should be defined for each Wireless Instrument Type defining the Specification Form, I/O Type, Location and Process data required.

A wireless Enhanced Loop Symbol path may also be defined.
Wireless Instrument Type Profiles

- Be sure to check the box to include the wiring. If this box is not checked when SPI generates loop drawings, the device cannot be added to loop drawings.

- Create the Wireless Gateway, Router and Adaptor Instrument Types, consider using the Functions XWG for a Wireless Gateway, XWR for a Wireless Router and XWA for a Wireless Adapter.
Wireless Device Specification Sheets

- Wireless spec sheets need to be created for each wireless device used in the wireless network with data such as “Scan Rate”, “Power Supply” and “Communication Type”
- New Spec Sheet Forms need to be created for THUM’s, Routers, Gateways and Adaptors
New Spec Sheet Forms need to be created for Routers, Gateways and Adaptors should contain a minimum of the following data fields:

- Tag Number
- Service
- Mounting
- Certification
- Standard Protocols
- External Ports
- Connections
- Area Classification
- Temperature Rating
- Power Requirements
- Data Rates
- Modulations
- Frequency Band
- Operating Channels
- Radio Approvals
- Manufacture
- Model Numbers
- Purchase Order

Some fields may have multiple data entries (e.g. Multiple Standard Protocols)
Once the Instrument Type is defined, the Device Panel Properties can be modified to include reference symbols.

One recommendation is to assign symbols for both the Enhanced Loop and the Cable Block Drawing.
Wireless Network Diagram Symbols

- The P&ID uses the sine or zig-zig symbol shown below is defined by ISA 5.1-2009
- Translated symbols can be created in Smart Instrumentation using the editing tools. Below are examples for Wireless field devices and a Wireless gateway
Individual Field Devices
- Wireless Field Device (it has no communication wiring)
- Wireless Field Adaptors or THUM are used to convert conventional Wired instruments to Wireless instruments that can send the digital information to the Wireless Network

Routers and Gateways
- Routers (used to gather or extend the wireless network)
- Currently there is no drawing that show all devices associated with the Router or Gateway, but we can filter and print an index listing that does same thing.
- There is a requirement for a drawing showing power and or communications wiring between Gateway and Host Network
A wireless loop may be created by assigning Tags to the I/O adaptor and wiring it to the DCS then give all the wireless transmitters in the loop special symbols.
Wireless Network Loop or Block Diagrams

- A Gateway Cable Block Diagram, would be to show all gateways assigned to an area on the same document for convenience.
Add Wireless field devices to same Plan drawings or 3D Model as wired devices
Add Wireless routers and gateways to Plan drawings or 3D Model
Consult the manufactures recommendations for Wireless Network Design
Both WirelessHART and ISA100.11a use Industry standard 128-bit AES encryption and define a set of security keys that are used to ensure secure communication.

Symmetric cryptography relies on both communication end points using the same join key when communicating securely.

Key generation differences:
- Wireless HART needs manual entry of the network security key
- ISA100.11a generates the security key at the gateway and sends it wirelessly to the field device

Security Information such as Network ID, Join Keys, and passwords generally should not be recorded in the SmartPlant Instrumentation database.

These should be managed by local security policy implemented by the Owner/Operator and maintained by the Plant network Security Systems.
Smart Instrumentation Wiring Methods

Questions?

John Dressel, Fluor SI SME
John.Dressel@Fluor.com
281-263-2764