# WirelessHART

## UNIK9700 – Radio & mobility

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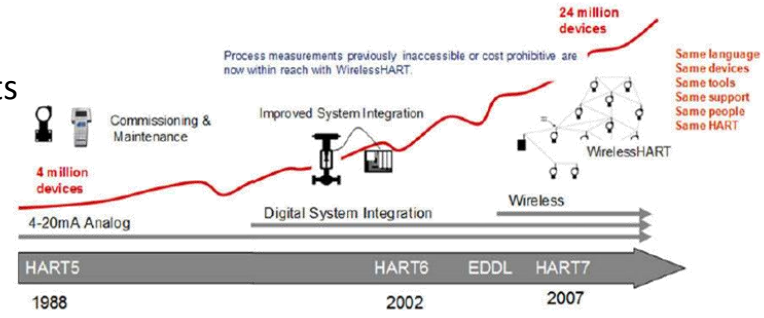
# Outline

- Introduction to WirelessHART
  - Background
  - Motivation
- Architecture
  - PHY layer / lower MAC (IEEE 802.11.4)
  - Upper MAC layer
  - Network layer
  - Network topology
- Comparing wireless network standards
  - Zigbee
  - ISA.100.11.a

# Background

## Highway Addressable remote Transducers (HART)

- Developed in the mid-80s as a propriatary protocol
- Wired sensor/control network
- Targeted automation and monitoring in industrial environments
- Increasingly popular standard
- The HART Communication Foundation created in 1990 to maintain and develop the standard
- Digitalized  in the mid-90s
- WirelessHART developed in 2007, defining new PHY, MAC and Network layers, but preserving the upper layers as defined by the HART




The HART standard evolution
Courtesy: HART Communication Foundation

# What is WirlessHART

- WirelessHART is a wireless transducer network

- Developed to meet the requirments need of an industrial environment:
  - Power consumption (battery life)
  - Latency (respons time )
  - Reliability (packet error loss)
  - Cost (CAPEX / OPEX)

- *Approved by the International Electrotechnical Commision* (IEC) as an standard in Mar. 2010 (IEC-62591)

- Approximately 30 million HART devices installed and in service worldwide, HART technology is the most widely used field communication protocol for intelligent process instrumentation (1)

1) http://www.hartcomm.org/protocol/wihart/wireless_overview.html, Accessed: 27/9/2012

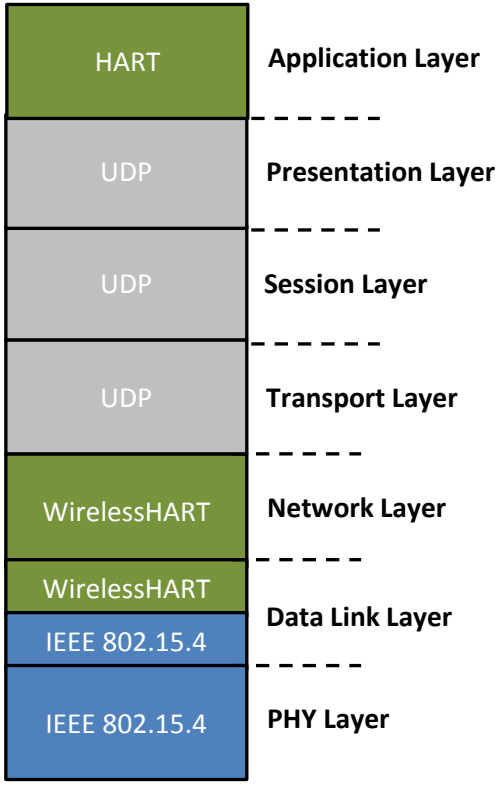
# Application Areas

- Industrial
  - Process and Automation
  - Medium speed
  - Medimum security
  - Medium reliability and latency
  - Noisy environment


- Coexistence
  - 2.4GHz ISM transceivers
  - 802.15.4 (ISA.100.a, Zigbee)
  - 802.11 (WLAN, Bluetooth)

# OSI architecture

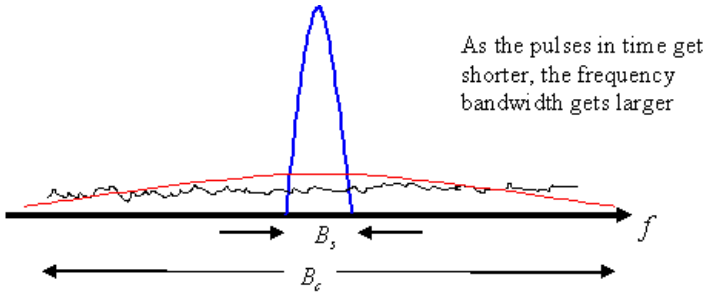
- Physical layer
  - IEEE 802.15.4
- Sub Medium Access Control (MAC)
  - Packet framing
- Logic Link Control (LLC)
  - Link control: TDMA / FHSS
- Network
  - Source to Destination handling
  - Routing
- Application
  - HART legacy
  - Control and data presentation



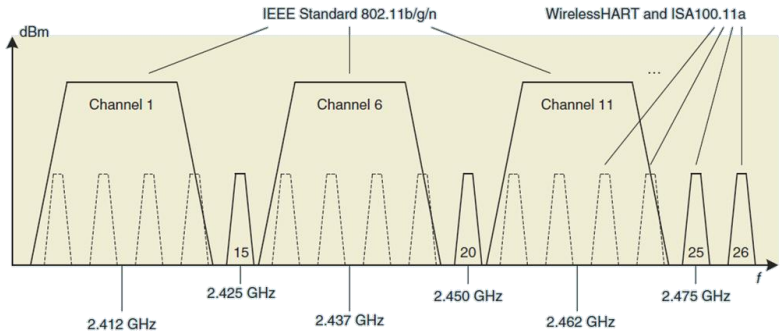

OSI model of the WirelessHART standard

# Physical Layer

- IEEE 802.15.4-2006
- 2.4-2.48GHz ISM band
- License free
- Ch.11-25
  - Ch.26 not covered
  - 2MHz bandwidth
- *Direct Sequence Spread Sequence* (DSSS)
  - Multipath-mitigation
  - Resistence to jamming
  - Multiple users on same channel
  - Resistence to interception
- O-QPSK modulation
- 250 kbit/s throughput




Direct Sequence Spread Spectrum
Courtesy: National Instruments

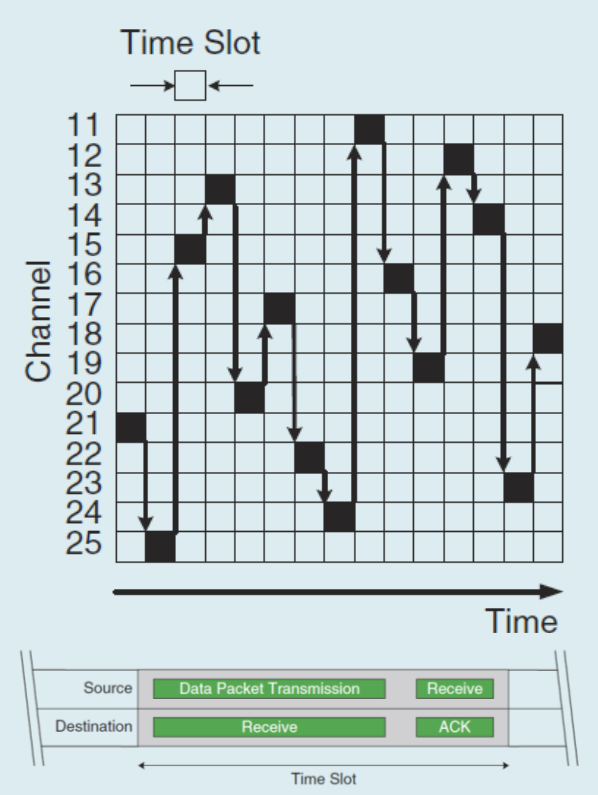



Channels in the 2.4GHz ISM band

# Data Link Layer

- *Medium Access Control* (MAC)
  - Connected mode
  - Packet framing
  - Security: AES-128 *Message Integrity Authentication* (MIC)
  - *Clear Channel Assesment* (CCA)
  - *Power control (noisy environment)*

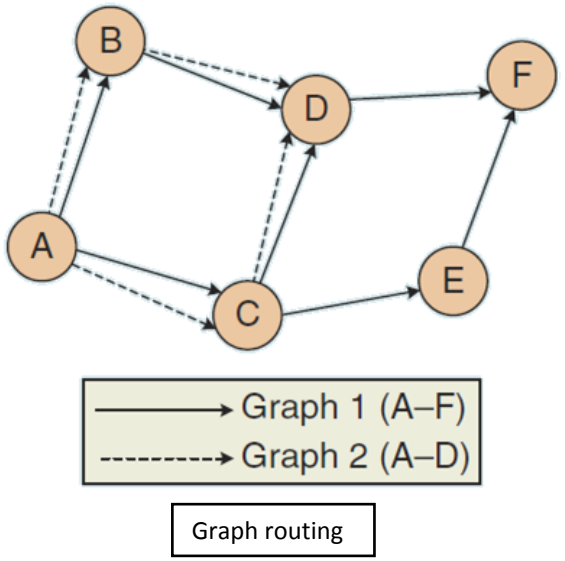
- Logic Link Control (LLC)
  - Time slots – 10ms
  - *Frequency Hop Spread Spectrum* (FHSS)
  - Channel black listing
  - TDMA super frame
  - Retransmission on a different channel




**TOP:** WirelessHART TDMA scheme
**Bottom:** 10 ms time slot

# Network layer

- Routing strategies managed by the Network manager
- Graph routing,
  - A set of routes predefined by the network coordinator
  - Each network device has a routing table
- Source routing
  - presets route between source and received
  - used for network diagnostics
- Security
  - AES-128 en-/decryption of payload data



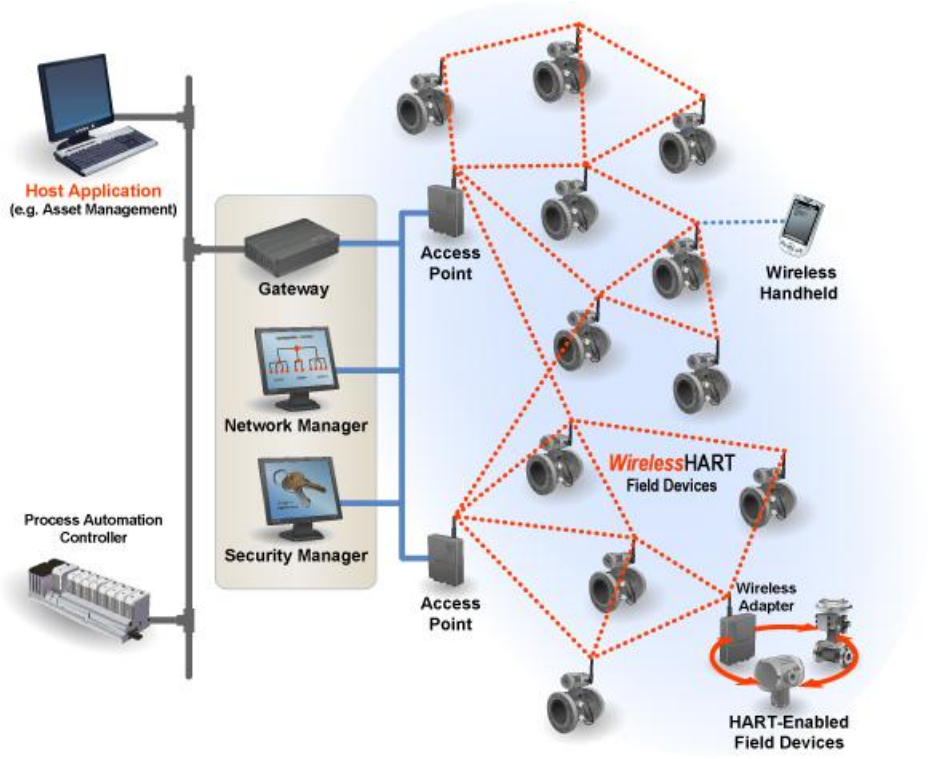

Graph routing

# Network Topology

## Network components

- **Wireless field devices**
  - HART devices connected to an wireless adapter
  - Dedicated WirelessHART devices
- **Gateways**
  - enable communication between these devices and host applications connected to a high-speed backbone or other existing plant communications network.
- **A Network Manager**
  - configuring the network
  - scheduling communications between devices
  - managing message routes, and monitoring network health.

**The Network Manager can be integrated into the gateway, host application, or process automation controller*




WirelessHART network
Courtesy: HART Communication Foundation

# Comparing Zigbee PRO and WirelessHART

- Technology
  - *Same physical layer (IEEE 802.15.4)*
  - Carrier Sense Multiple Access w/ Collision Avoidance (CSMA-CA)
  - *Ad-Hoc On-demand Distance Vector* (AODV) routing algorithm
  - No frequency hopping, suceptible to jamming and interference
  - Encryption of the payload data, but not all vendors support MIC on the MAC layer
  - TDMA no collisions (if no other WSN network is present)

- Cost, Determinism and Security
  - IEEE 802.15.4 PHY/MAC compliant, cost efficient
  - ADOV may create longer latency in the network
  - Requires less device memory and processing
  - No reliabilty and latency determinism
  - CSMA-CD increases the active periods for the devices, results in higher power consumption

# Comparing ISA.100.a and WirelessHART

| Layer | ISA.100.a | WirelessHART | Comments |
|---|---|---|---|
| **PHY** | IEEE 802.15.4-2006 DSSS | IEEE 802.15.4-2006 DSSS | Uses the same RF interface |
| **MAC** | IEEE 802.15.4-2006 Non-compliant | IEEE 802.15.4-2006 Compliant | |
| **LLC** | TDMA (Fast/slow hoping)<br>Message Integrity Coding<br>Graph/Source routing<br>Adaptiv black listing<br>Joining of new devices | TDMA (Fast hoping)<br>Message Integrity Coding | ISA.100.a has adjustable latency and power specifications<br>Adaptable network parameters |
| **Network (Transport)** | 6WLoWPAN<br>A-/symetric encryption | Graph/Source routing<br>Manual black listing<br>Symetric encryption<br>Joining of new devices | |
| **Application** | None | HART6 | |
| | | | |
| **Capacity** | 50-100 devices | 50-100 devices | |
| **Architecture** | Adaptable (optional features) / complex | Locked / lower cost | |

# Comparing ISA.100.a and WirelessHART

- WirelessHART
  - Approved IEC standard (Mar. 2010)
  - Legacy HART established protocol
  - WirelessHART installed in field applications

- ISA.100.a
  - Approved ANSI standard (Dec. 2011),
  - 1. generation devices not fully compliant with the standard

- Future
  - Expressed desire from both vendors and customers to avoid 2 competing standards
  - Both ISA and HCF is working on adapting the standards for friendly coexistence
  - Plans to converge the ISA.100.a towards WirelessHART
  - Both standards are working on features to allow other wired network buses (Fieldbus, Modbus, Profibus and so forth)

# References

1) IEEE 802.15.4-2006

2) WirelessHART - Applying wireless technology in real-time industrial process control, D. Chen et al., ISBN 978-1- 4419-6046-7, Springer Science+Business Media, LLC 2010

3) WirelessHART Versus ISA100.11a - The Format War Hits the Factory Floor, S. Petersen, S. Carlsen

4) A Comparison of WirelessHART™ and ISA100.11a, M. Nixon, Emerson Process Management

5) A Comparison of WirelessHART and ZigBee for Industrial Applications, T. Lennvall, F. Hekland

6) Comparison of Industrial WSN standards" P. Radmand et al.

Questions?