WirelessHART: Overview and PHY layer

Sensor Networks

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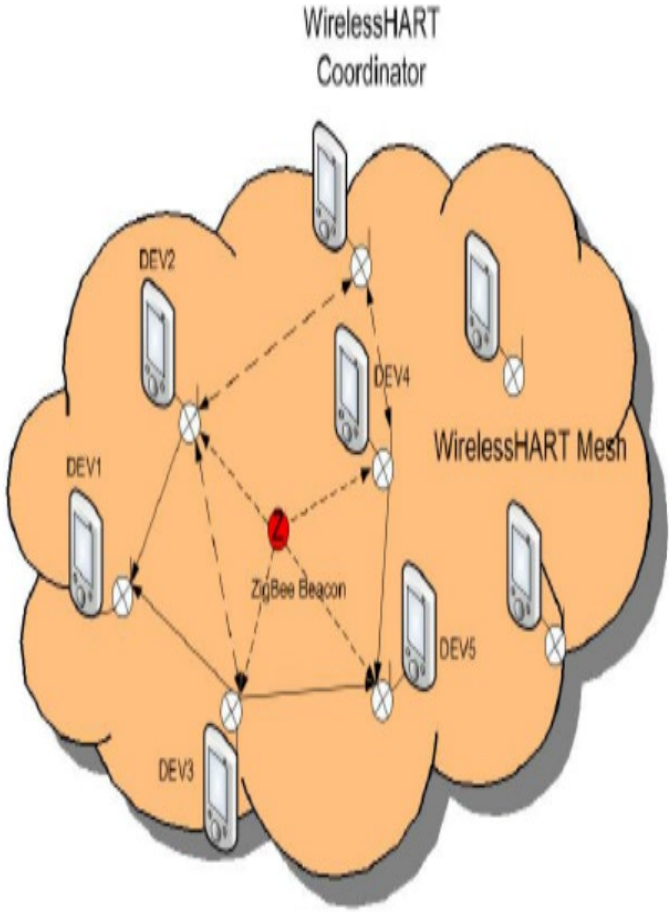
Introduction

- WirelesHART Designed for industrial process automation applications.
- Builds upon the HART protocol adding wireless capabilities.
- Uses mesh networking technology for self-healing and reliable communication.
- IEEE 802.15.4 standard (PHY and MAC layers for low-power, short-range wireless networks)
- Offers multiple messaging modes for flexibility and reduced power consumption.



Ref: researchgate.net

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Historical Context

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- Developed in 2007 by the HART Communication Foundation.
- Aimed to address limitations of wired communication in process automation.

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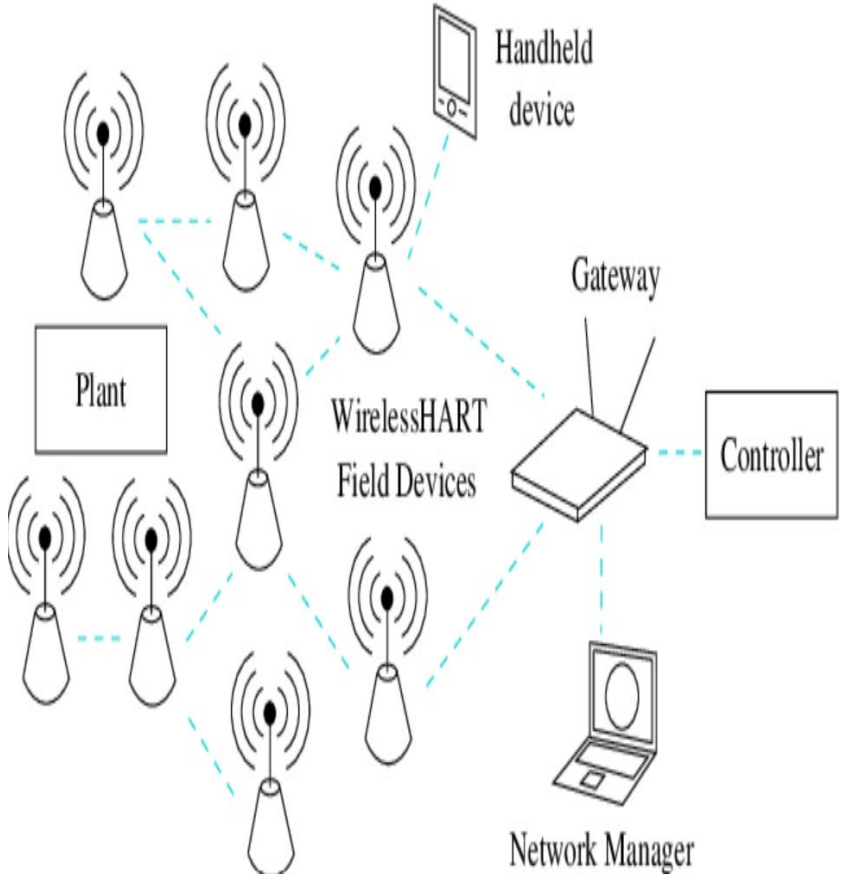
Architecture

Gateway: Acts as a bridge between the wireless network and the host system, managing network traffic and security.

Network Manager: Responsible for network formation, maintenance, routing, and scheduling of communication slots.

Field Devices: Instruments and sensors that collect and transmit process data.

Repeater: Extends the range of the network by forwarding messages between devices.



https://www.researchgate.net/profile/Alejandro-Maass/publication/335377407/figure/fig1/AS:795244073336832@1566612370293/WirelessHART-architecture.png

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Network Topology

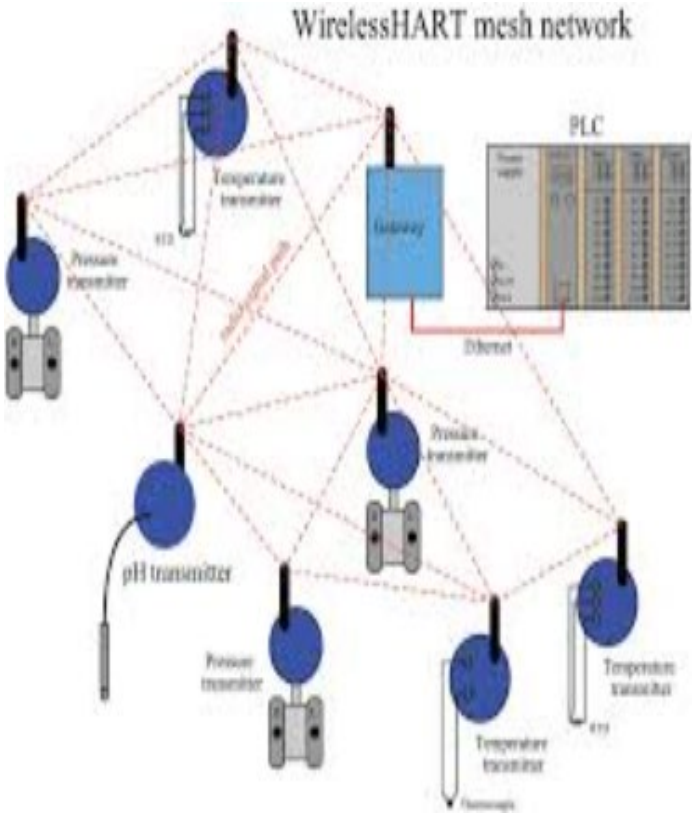
Mesh Network: Each device can act as a router.

Allowing for redundant communication paths and improved reliability.

The network can self-heal by rerouting messages if a path becomes unavailable.

“Hops” across channels to avoid interference.

Delivers high reliability in challenging radio environments.



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WirelessHART Physical Layer

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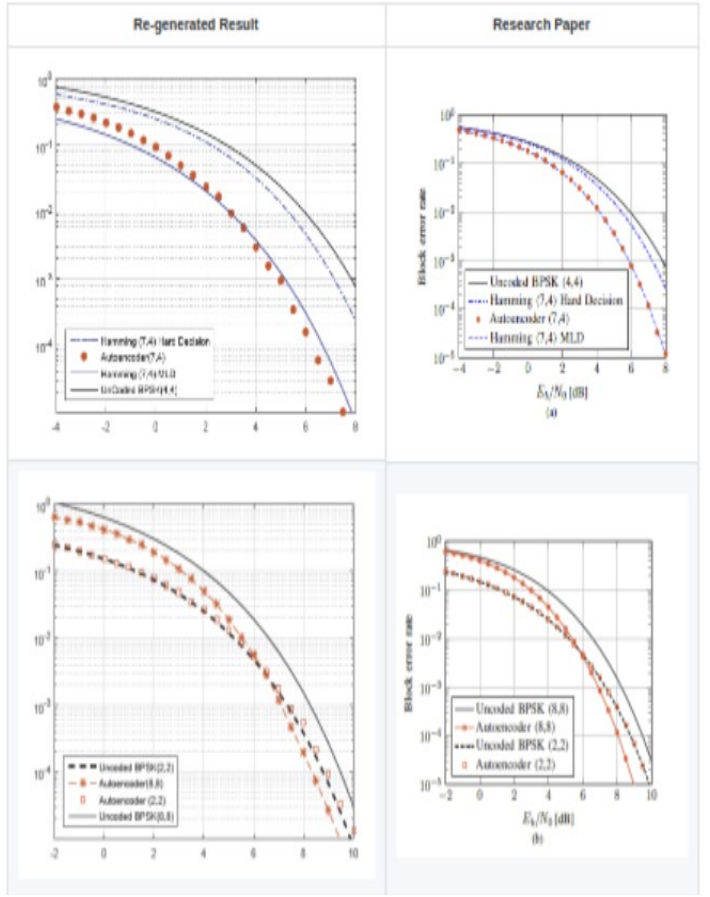
Focused on reliable data transmission using:

- Packet creation and formatting
- Radio wave transmission and reception
- Doesn't define communication protocols (data content, timing, triggers)



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Communication Modes

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WirelessHART's physical layer communication modes are designed to ensure reliable and efficient data transmission in industrial environments. Here are the key communication modes and their functionalities:

1. Periodic communication

2. Event-Driven communication

3. Ad-Hoc Communication

- **Detailed Mechanisms and Techniques:**

  Time Division Multiple Access (TDMA)

  Channel Hopping

  Direct Sequence Spread Spectrum

  Modulation Techniques

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WirelessHART PHY layer key features

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Operating frequency – 2.4 GHz ISM band

Modulation – Uses offset Quadrature phase shifting key (QPSK) with Direct sequence spread spectrum (DSSS)

Transmit power – Around 10 dbm

Data rate – Maximum 250 kbps

PHY protocol data unit – payload sizes 127 bytes

Time division multiple Access - Communication is organized into 10 ms time slots with collision free

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Security

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Protects Valuable Information – It's Automatic

Protects Wireless Network

Risk Assessment / Reduction

Wireless Sensor Network Security – 2 types

a) Data security

b) Network security

Ref: https://www.fieldcommgroup.org/sites/

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HART Implementation

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Step 1: Hardware Selection

Transceivers: Select IEEE 802.15.4 compliant transceivers.

- Ensure they support DSSS and O-QPSK modulation.
- Examples: TI CC2420, Atmel AT86RF230.

Step 2: Firmware Development

Frequency Hopping: Implement Frequency Hopping Spread Spectrum (FHSS) algorithms.

- Pseudo-random sequence hopping.
- Reduces interference and enhances security.

Error Handling:

- CRC (Cyclic Redundancy Check): Integrate for error detection.
- Forward Error Correction: Implement to correct errors without retransmission

HART Implementation

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Step 3: Network Configuration

Channel Plans: Set up channel plans to optimize frequency usage.

- Allocate channels to minimize interference.

Power Settings: Configure transmission power to 10 dBm (10 mW) or as per regulatory limits.

- Balance between range and power consumption.

Step 4: Testing and Validation

Range Testing: Verify communication range in different environments.

- Indoor vs. outdoor, presence of obstacles.

Error Detection: Validate CRC and error correction mechanisms.

- Ensure data integrity and reliability.

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APPLICATIONS

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Key Application

Industrial Process Control:

Sensors: Monitor pressure, temperature, flow, and level.

Actuators: Control valves and actuators.

Asset Management:

Condition Monitoring: Track equipment health.

Predictive Maintenance: Early failure detection.

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Key Benefits of HART Implementation

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Dual Communication: Supports both analog (4-20 mA) and digital communication on the same wiring.

Remote Monitoring: Enables remote configuration and monitoring of field devices, reducing maintenance costs.

Enhanced Diagnostics: Provides detailed device diagnostics for proactive maintenance and troubleshooting.

Backward Compatibility: Integrates seamlessly with exiting analog system, preserving investment.

Industry Standard: Widely adopted international standard (IEC 61158), ensuring compatibility and support.

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Conclusion & future trends

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- Leverages IEEE 802.15.4 standard for reliable data transmission.
- Potential for coexistence with other wireless technologies in industrial environments (e.g., 5G) requiring careful channel management.
- Continued focus on security and robustness to address evolving cyber security threats in industrial automation.

Reference

- https://ieeexplore.ieee.org/abstract/document/6895027
- https://www.sciencedirect.com/science/article/pii/S0045790614001311
- https://instrumentationtools.com/wireless-hart-communication-protocol-overview/

THANKS FOR ATTENTION!

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