*Wireless*HART + HART-IP

SINGAPORE USERS CONFERENCE

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Discussion Points

- **About HART - The HART Mantra**

- **WirelessHART**
  - Thoughts on wireless communications
  - WirelessHART principles
  - Experiences

- **HART-IP**
  - Access HART Data anywhere over the Internet
  - I/O System support to wired and wireless
  - Migration to Publish - Subscribe

HART doesn't seem to go away ?

- **HART market share was expected to decline and be replaced …**
  - Lots of fieldbusses in 1990s.
  - fieldbus (small f) was supposed to displace

Today - HART adoption continues to grow and expand

  - Lots of developers, device types
  - All major DCS and PLC vendors support HART
  - HART WG still active - folks still want to do more with HART.
- **Even evolving to address new communications / Applications**
  - Wireless sensor networking supported with WirelessHART
  - Internet addressing supported with HART-IP
  - Discrete applications (distributed discrete control)

- **What happened?**

From Honeywell Presentation …. 2003

HART - The Message

Introduction

HART is:

- Simple!
- Easy!
- Inexpensive!
- Feature Rich!

For:

- The HART Device Vendor
- The Control System Vendor
- The End User

Some Additional Benefits:

+ Ability to select from a wide range of device types and manufacturers!
+ A very large installed base!

What is HART?

- **It is a technology**
  - Tightly specified Application Layer applicable to many product types
  - Multiple Process Values per device
  - Continuous health and status feedback
  - Proven multi-vendor interoperability and backward compatible

- **It is a philosophy**
  - 25 years young - still vigorous HART community
  - Successful culture and strong camaraderie
  - Focus on KISS (Keep It Simple ...), etc.
  - Reliable, easy-to-use

WirelessHART

Wireless is HARD

- **Radio Communication is fundamentally unreliable**
  - Individual packets will be lost
  - Communications channels not closed, dedicated like wiring
  - Communications intermittent - devices sleep most of the time.

- **Detailed site-studies provide limited benefit *for commercial deployments***
  - RF environment changes continuously (e.g., fading effects)
  - Not practical to survey whenever a Field Device or WiFi Hotspot is added.

- **2.4 GHz ISM band is unlicensed … any 2.4 GHz radio can use it**
  - Excellent coexistence essential
  - Must succeed while sharing the space

- ***Outstanding reliability is key to plant acceptance and use***
  - Plant operators hesitate to use new technology
  - 99% reliability is not good enough

Fundamental WirelessHART Choices

- **Must be "HART"**
  - Technology (e.g., same Application Layer)
  - Philosophy (same "feel")

- **Must be Frequency Hopping**
  - Tolerant of fading effects, hard to disrupt
  - Maximizes coexistence with others (e.g., WiFi)

- **Must Be a Sensor-Mesh**
  - Internet TCP/IP has proven that mesh networks are strong, resilient …. The WWW is a mesh!
  - **Simple** - All field devices same capabilities
  - **Reliable** = Self adapting - messages are routed around interference
  - **Easy** - inexpensive to expand, add more instruments and controls

All other WirelessHART design decisions follow from these three principles

WirelessHART Released 2007
Products introduced 2008
Successful BASF trials 2009

Command Summary
Common Tables
Command Response Code

Core Command Requirements
Backward Compatibility Requirements
Host Conformance Classes
Codes used in Commands
Codes used in commands errors

Common Practice Command

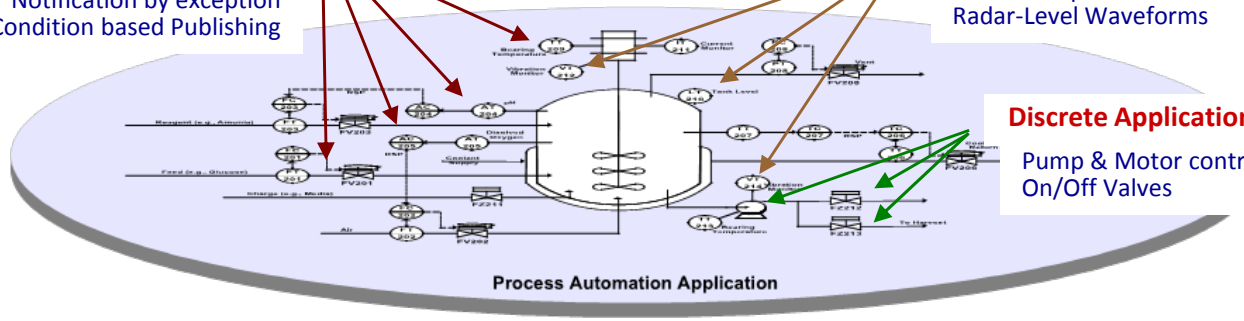
Monitoring & Control
Notification by exception
Time & Condition based Publishing

Block Data Transfer

Vibration Spectra
Radar-Level Waveforms

Universal Command

Device Identification
Process Data & Status
Device Health & Status
Device Revision Information



Discrete Applications

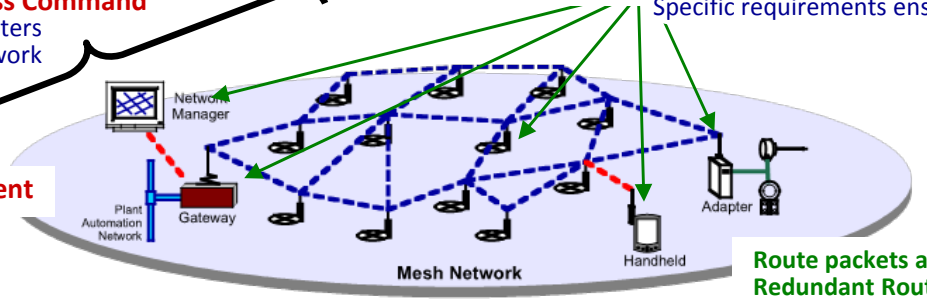
Pump & Motor control
On/Off Valves

Wireless Command

Access by all HART tools to all parameters
Only Network Manager can configure network

Wireless Devices

Specific requirements ensure interoperability



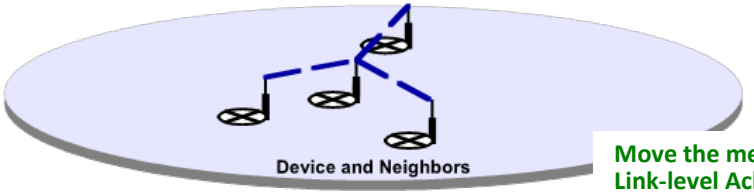
Network Management

Source and Graph Routing
End-End Security, PDU Encipherment
Continuous network optimization
Joining Process

Route packets across the mesh
Redundant Routes
End-End acknowledgements
Integrated support for Adapters

TDMA Data-Link Layer
2.4GHz DSSS O-QPSK Physical Layer

TDMA + Channel Hopping
Dedicated and Shared Slots
Unicast and Broadcast



Move the message One-Hop
Link-level Acknowledgments

Simple Network Design Rules

- **4 Basic Rules**
  - Follow the rules and it just works!
- **Conservative - Communications often work better**

1. Rule of 5 minimum
Build the mesh network

2. Rule of 3
Make sure all devices are meshed

3. Rule of percentages
25% of devices should be 1 hop from the Gateway

4. Rule of maximum distance
Devices with fast (≤ 2 sec) updates should be within 2 hops

Network Rules

Simple to deploy

- **It's HART**
  - Same tools you use today work with WirelessHART devices
  - 90% same know-how for basic setup and deployment as wired-HART
  - Add Network ID, Join Key
- **Quick and Easy commissioning**

"This training session took about five minutes over a cup of coffee in my office. Except — oops! — we forgot the new issues of join key and network ID. That took 5 more minutes of training, and the coffee was still warm."

Once instruments and batteries were installed and called in to the remote control room to check, Ostling says data appeared on the wireless gateway — which was configured remotely by the automation engineers. "As fast as they could power them up, field check out was completed without a hitch." It took only "a minute or two."

- Hoag Ostling, Hoaglund Engineering
  About WirelessHART on the North Slope

Reliable

- **RF Environment changes continuously**
  - The **MESH** is key - it continuously adapts
- **Problem device?**
  - Probably breaking Rule #3
  - Fortify the mesh by adding another device
  - More devices = stronger mesh
- **Device *only* 99% reliable?**
  - Reliability should be > 99.99%

Ben Springer reports that the mill's new *Wireless*HART network achieved 100% data reliability that was on-time and validated. "It was much better than we expected," he says. "It's easy to get data out of the system. The WirelessHART signals go through buildings without any problems, and its meshing provides for a strong network with only a few routers needed, which help make the network even stronger. Depending on the application, we also saved 50-80% with *Wireless*HART compared to the costs of a wired system."

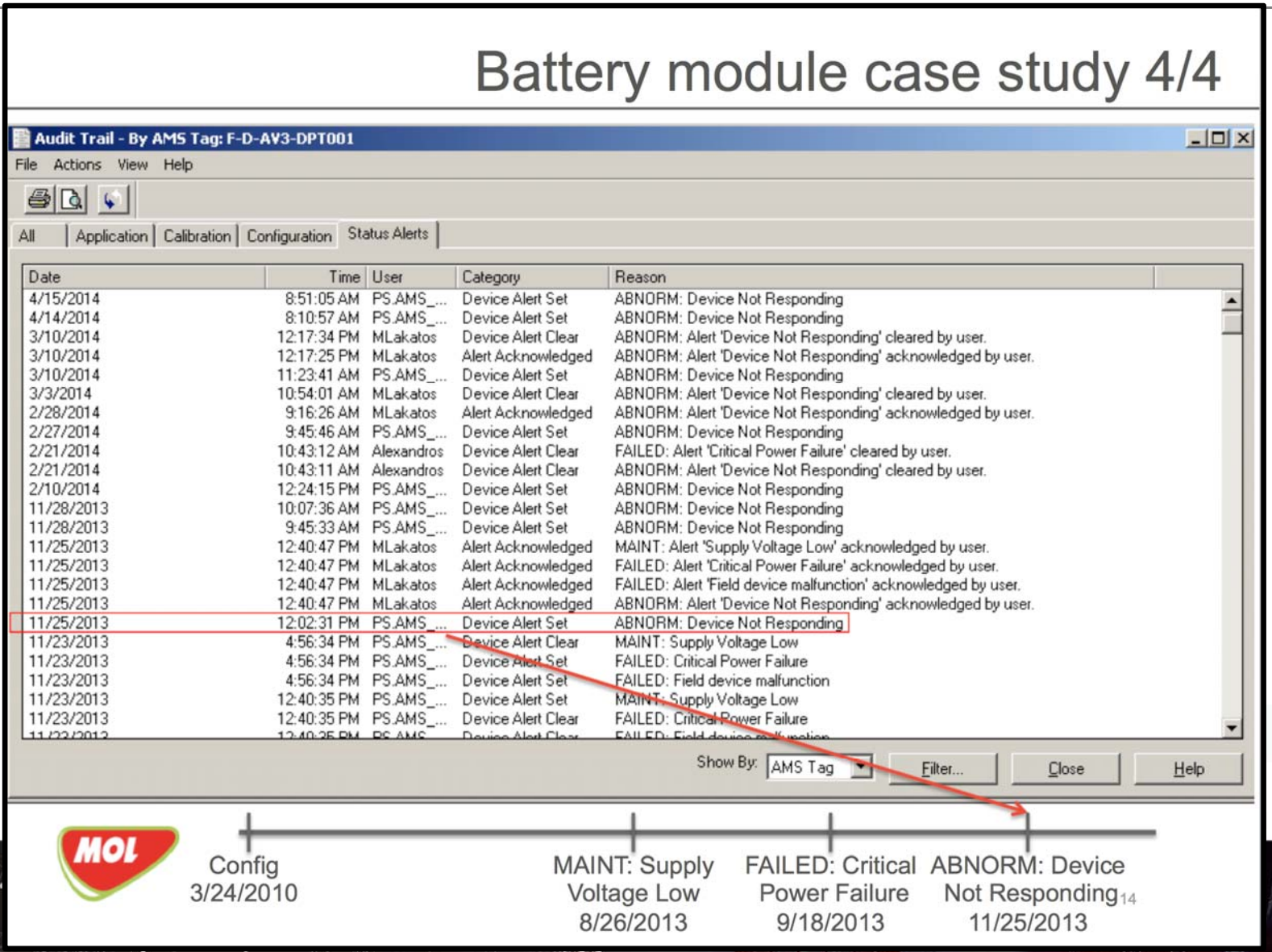
- Nucor Steel
  2014 Plant of the Year

A word about Speed and Power

- **WirelessHART will provide < 1s update rates**
  - It's not free
- **Batteries have fixed number of Coulombs**
  - Every packet costs Coulombs
  - A battery only holds so many packets.
  - Not magic.
- **Choose the update rate you need - not the fastest you can go.**
  - Make good choices....
- **WirelessHART devices all report battery life left in days**
  - You can monitor and schedule maintenance

From MOL Danube Refinery presentation 2014

Battery module case study 4/4



Experiences

- **End users enthusiastic - many testimonials**
  - Far more reliable and easy to use than expected
  - Killer applications different than expected, too
  - Big cost savings
- **Excellent Coexistence**
  - Sharing space with WiFi everywhere - no field issues
  - Overlapping networks with >500 WirelessHART packets/second
- **Must use the Mesh**
  - Simple rules (e.g., 5+ devices, all devices have 3 neighbors ...)
  - Result:
    - Easy to install, startup
    - Very reliable (>99.99%)
    - Unexpected network topologies - can't easily predict what works
- **Adjacent Out-of-Band interference can be a problem. e.g.,**
  - 50Watt business band radio
  - kWatt class LTE cell towers
  - **Solved: add BAW Filters**.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Process Automation

HART-IP

HART-IP

- **Elegant**
  - HART-IP specifications are ingenious, concise (not many pages needed).
  - Directly leverages the HART Application Layer
- **Simple**
  - It's the Internet Protocol - making the connection is easy
  - Easy access to the HART devices, uses well-known HART packets
  - Supports standard internet security (SSL, TLS, VPN, ...)
- **Profound**
  - HART Data can be accessed anywhere there is an Internet connection
  - Enables HART to bridge from Operations Technology (OT) to Information Technology (IT)
  - Just starting to see the implications

... Must move out of the mind-set that data stops at the operator console ...

I/O Systems

Old-view: RS-485

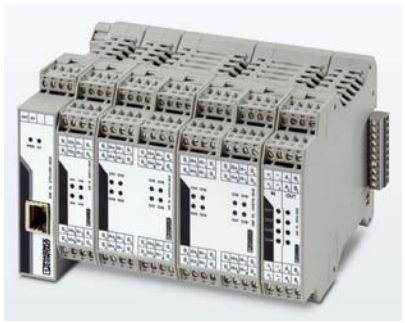
- **Single Client**
- **Installation**
  - Wire the Mux
  - Check the RS-485 polarity
  - Set the dip switches (address)
  - Wire the RS-485 - RS232 adapter
  - Set the baud rate
  - Trouble Shoot
- **One Protocol:**
  - HART over RS-485

New-view: HART-IP

- **Multiple Clients**
- **Installation**
  - Plug-in Ethernet cable
  - Set the IP-Address
- **Multiple Simultaneous Protocols**
  - HART-IP
  - Modbus TCP
  - Web Interface
  - Etc

HART-IP for Wired and Wireless

- **HART-IP I/O Systems Available**
  - Wired (multiplexer replacement)
  - WirelessHART gateway
- **I/O options quickly, quietly growing**



A few possibilities

- **2009 - HART-IP @ BASF Ludwigshafen Field Trials**
  - HART-IP connections to all WirelessHART networks
  - VPN security
- **OSIsoft "Pi System" has direct support for HART-IP**
  - HART-IP potential already being recognized by Data Historians
- **Remote device support**
  - It's an IP address - don't need physical presence
- **Connects via Ethernet, PoE, Cell Networks, Satellite, WiFi ...**

HART-IP and Publish-Subscribe

- **Traditional - Request Response**
  - Good for Asset Management, Data Acquisition, Status Monitoring

- **HART Migrating to Publish by Exception**
  - Publish (Burst) multiple Process Values (PV) with time-stamps
    - Smart Triggers - Periodic, Windowed, or Level
  - Notify by Exception
    - Changes to device status with positive acknowledgement
  - Smarter, simpler use of communications

- **HART-IP**
  - Pass-through device-published data
    - Event/Status Management (HART 7.4)
    - Condensed Status (HART 7.4)
    - Client Subscriptions (HART 7.6)

- **HART has the data - HART-IP making easier to use the data**

Some Closing Thoughts

HART's role in the Industrial Internet of Things

- **HART is pervasive**
  - > 40-45 million traditional wired HART Field Devices
  - > 30K WirelessHART Networks, ~400K devices
  - Adding 2-3 Million field devices per year
    Adding 6-8k WirelessHART Networks per year
- **HART is everywhere**
  - Many HART developers in Japan, China, Europe, North America.
  - Large installed base on every continent
- **Continuing to enhance connectivity to enable access**
  - HART, WirelessHART, HART-IP, FDI

Get industry to use the data they have in their devices and Existing pervasive HART information will fuel IIoT

On My Desktop:

simple,
easy-to-use,
reliable,
high-value and
backward compatible

are core HART values.

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