802.11 Wireless Ethernet as a Process Control Network Backbone

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  – **Strategic Product Manager - Wireless**
  – Over 16 years in Industrial Wireless market
    – Field Engineering/Support
    – Wireless System Design
    – Sales
    – Product Marketing
  – Resides in Pittsburgh, PA
  – Married with 2 teen children
    – Eldest a freshman in the EE program at WVU
Topics

- Ethernet in Process Control
- Benefits of 802.11 Wireless Ethernet
- Comparison of 802.11 wireless standards
- Wireless design considerations
- CFE Geothermal Power Generation Project
- Frontier Well Head & Refinery Wireless Project
- Questions?
Popularity of Industrial Ethernet

• Industrial Ethernet popularity growing…
  – Field proven
  – ModBus TCP/IP, EtherNet/IP protocols

• High speed, low latency network
  – 100/1000Base-T

• Open standard, commercially available hardware (lower cost)

• Accommodates multiple data types
  – Process, commands, workstation, video, IT
Challenges of Ethernet Infrastructure

- Older plants = No network infrastructure
- Ethernet copper links limited in distance
  - 100 meter limit
- Longer runs require Fiber Optics
  - FO Cables, FO Repeaters/Switches
- Very high cost of conduit design & installation
- Fiber cable subject to environmental damage
  - Where is the break? Time to repair?
- High cost may limit system scope
Benefits of Wireless 802.11

- **Saves money by reducing plant wiring costs**
  - Plant wire installation may cost as much as $100 to $2,000 per foot!
  - 802.11 supports long links (2+ km)

- **Saves time**
  - No cable to install

- **Redundancy**
  - Economic self-healing networking

- **Support for mobile workers**
  - Wi-fi enabled workstations, laptops, SmartPhones, etc
IEEE 802.11a/g/n Technologies

• Open standard – “Wi-Fi”
  – OFDM modulation
  – 20 MHz Wide channel = fast data rate (up to 150 mbps)
  – Low latency - microseconds
  – CDMA (collision detection – listen first)
802.11g/n Frequency Channels

RF Bands –2.4 to 2.483 GHz (83 GHz of bandwidth)

Only 3 non-overlapping channels in 2.4 GHz!
802.11a/n Frequency Channels

RF Bands – 5 GHz

- 5.150 to 5.825GHz – 700MHz of Bandwidth

Over 20 non-overlapping channels in 5 GHz band
# 802.11n – What’s New

<table>
<thead>
<tr>
<th>Feature</th>
<th>802.11a/g</th>
<th>802.11n</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Rates</td>
<td>6-54 Mbps</td>
<td>6-300 Mbps</td>
</tr>
<tr>
<td>Antennas</td>
<td>1(2)</td>
<td>1 - 3</td>
</tr>
<tr>
<td>Bands</td>
<td>g (2.4GHz)</td>
<td>ng (2.4GHz)</td>
</tr>
<tr>
<td></td>
<td>a (5 GHz)</td>
<td>na (5GHz)</td>
</tr>
<tr>
<td>UDP Stream</td>
<td>3,500 pps</td>
<td>13,000 pps</td>
</tr>
<tr>
<td>TCP/IP Rates</td>
<td>1,000 pps</td>
<td>4,000 pps</td>
</tr>
</tbody>
</table>

802.11n offers significant higher packets per second (pps)!
802.11n – Streams

• More than one data streams
  – 802.11n radios can send 2 streams of data at a time if the conditions are right.
    – At least 2 antennas must be connected to each radio.
    – Multipath is important to keep the streams separate – the different streams take (slightly) different paths
  – The packet is divided between the streams to speed data transfer.
802.11n – MIMO Antennas

- Multiple Input Multiple Output (MIMO)
  - One antenna, three elements
  - Intentionally creates multiple paths (reflections)
  - Required for multiple streams
  - Three antenna leads
  - Omni-directional & directional
802.11n – Channel Bonding

- Channel Bonding
  - 2 Adjacent Channels can be used at the same time
  - Twice the data can be sent at a time
802.11 Security

• Security components
  • Authentication – allow those certified
  • Encryption – scramble data to make it unreadable
  • Integrity – protect against false data

• Standards Progression
  • WEP 64 & 128 (2000) – Weak, known faults
  • WPA – TKIP (2004) – Software patch to WEP
  • WPA2 – AES (2006) – Robust standard
    • adopted by NIST & US Govt.,
    • approved by NSA for secure communications

• 802.11i & WPA2
  • Passphrase – WPA2-PSK
  • RADIUS Service – WPA2-Enterprise
802.11 Diagnostics

- Web server
- PC Utility
- Process Values/Tags
- OPC
- HMI Faceplate
- RF Connection/Link
- Signal/Noise
- Traffic (packets)
- Network
  - Available Channels

![Diagram of 802.11 Diagnostics](image-url)
802.11 Industrial “Best Practices”

- Perform site testing
  - Existing wireless systems
  - RF paths/Antenna placement
- Use a “clear channel”
  - Consider 5 GHz band
  - Coordinate with IT (spectrum management)
- Design redundant RF paths, self-healing
- Select 802.11i security, turn it on!
- Select hardened hardware (environment/vibration)
- Weatherproof all connections
- Utilize diagnostics (monitor RF health/packets)
Oil & Gas - Refinery

Highlights
- Backhaul process data to control room
- Video for monitoring plant
- Mobile worker

DCS

802.11n
CFE - Cerro Prieto Geothermal Field

Cerro Prieto, Mexico
Geothermal Power Generation

- Geothermal Area
- Injection Well
- Production Well
- Sealing Layer
- Deposit
- Base of Deposit
- Heat Source
Plant History

- Installed Wireless HART devices and Foundation Fieldbus
  - Monitoring 17 steam wells
- Data sent back to DCS
- Reliability of fiber was not meeting requirements
- 8,000 meters of fiber replacement too expensive
- Fiber survives only 4-6 months and the time for repair is around 3 months.
Central Control Room communicating to 4 gateways over the 802.11g
Solution Installed
CFE Network Results

- Wireless performing very well for over 2 years
- Plans to add 5 more Access Point
  - Ease of expandability - reduced costs to improve monitoring
Objectives
- DCS Connection: 2 Offices / 2 Master PLCs
- Wellhead production monitoring: 40 sites / Remote PLC
- Tank Level monitoring: 14 sites / Remote PLC / 750ms update
- Mobile Worker connectivity
- Redundancy
Network Design Steps

- Preliminary System Design
  - PWD Software Design
- Site Verification Process
  - Visual Inspection of Sites
  - Channel Availability
  - Critical Link Verification
    - Verify Estimated Signal Strength
    - Battery power unit
  - Bill of Materials Generation
- Effort Estimate
  - System Design: 1 day
  - On-site testing: 2 days
  - On-going Support: 2 days
Tank Level System
Well Head System
Questions?

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