Wireless Ethernet for Industry:
Trends and Implementation Considerations

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THE BENEFITS OF ETHERNET as a high speed, low cost, open, common transport medium have led to increasing rates of adoption for industrial applications. Use of wireless technologies as the Ethernet physical media increases industrial Ethernet connectivity and flexibility, often with a substantial upfront and lifetime cost savings. Wireless Ethernet technologies have advanced in a similar manner to their cable and fibre tethered counterparts, and wireless is now a practical option in the factory.

Once the question of whether wireless can be used is answered, the question becomes which of the many wireless technologies is suitable for industrial Ethernet. The answer depends to a great deal on the applications environment, throughput and latency requirements, distance between nodes, and the local wireless regulatory situation. Proper wireless industrial Ethernet network planning & installation is key to satisfactory performance.

Know Your Local Wireless Regulatory Rules

All wireless technologies are subject to local government regulations – permitted frequency bands and effective radiated power (radio transmit power plus antenna gain) varies by country. Fortunately in Europe, the EC has promoted harmonization of radio communication standards, particularly radio local area networks, or R-LAN, as a means of public Internet access. France and Spain have been slower to harmonize, but some of the new EU member states have already adopted standards such as ETS 300 328 for spread spectrum modulation in the 2.4 GHz band. Globally, a number of countries follow unlicensed radio standards set by the European Radio communications Committee (ERC) of the European Conference of Postal and Telecommunications Administrators (CEPT).

Operation of wireless industrial Ethernet within Europe still requires some adjustments either for frequency band, allowed effective radiated power, or both as the approval authority remains with each country.

“When developing industrial wireless Ethernet applications, particularly in Europe, it is imperative that the purchaser be aware of the regional variations in radio communications standards and regulations,” says Francoise Mailharein, Application Engineer for ProSoft SARL in France. “In France, the indoor regulation is the same as the rest of Europe (maximum IERP power of 100 mW across the entire 2.400-2.4835 GHz frequency band). However, outdoor use in France is restricted. With a maximum power of 100 mW, frequencies must be between 2.400-2.454 GHz or with 10 MW power at 2.454-2.483 GHz.”

Typical Wireless Technologies

1) License free spread spectrum radios are the current radio of choice for industrial wireless Ethernet (and serial through serial conversion/encapsulation) applications. They operate in the 915 MHz and 2.4 GHz ISM bands, support data rates ranging from 9.6 kbps to over 300 kbps and offer latencies of typically less than 100 msec. Some have very secure, built-in, hardware based data encryption. The 915 MHz band has limited international unlicensed use (not allowed in Europe) and one-third the bandwidth of 2.4 GHz but is less line of site. Radios in both bands will support industrial Ethernet, particularly in harsh environments.
2) GSM cellular and its 2.5 G General Packet Radio Service (GPRS) extension are the globally dominant cellular voice and data standards with support for both circuit-switched and packet-switched data at rates of 14.4 kbps (GSM) and 115 kbps (GPRS). Encryption is built-in, as is forward error correction – helpful in high EMI environment. With packet-switching GPRS, many users can share up to 115 kbps of bandwidth (eight time slots). GPRS costs, depending on data plans, about 2 to 3 cents per KB. Latency will depend on whether link needs to be established or is ongoing and number of time slots used, 500 to 1500 msec is one estimate for a 500-byte IP packet and one or two timeslots.

3) Subbands within the Short Range Device (SRD) band of 868 – 870 MHz are allowed for non-specific use in Europe subject to defined power levels and duty cycles. While three of the general SRD subbands have sufficient bandwidth to support Ethernet (up to 600 KHz for 868 to 868.6 MHz) either duty cycles of 1% or low power make use for Ethernet questionable. The 869.4 to 869.65 band allows 500 mW power and 10% duty cycle, but with only 25 KHz bandwidth.
4) Bluetooth is a low cost (current about US$15, target remains US$5), 2.4 GHz, fast frequency hopping spread spectrum media for short-range communications with about 720 kbps throughput. For industrial markets, extended temperature versions of Bluetooth are now available. Bluetooth drawbacks include power draw, complicated protocol stack, and relatively low receiver sensitivity could be an issue in presence of high EMI.

Practical Applications for Wireless Industrial Ethernet

Wireless enables industrial Ethernet connectivity for applications with moving equipment such as gantry cranes, stacker/reclaimers, and automated guided vehicles. It also improves communications speed versus slip rings for rotating turntables, drums or even ship turrets. Wireless industrial Ethernet connectivity is also used to bridge hazardous location or clean room (pharmaceutical) containment areas – allowing data access or device programming without risk of exposure and saving time. Last kilometre connections to remote sites, buildings or pipelines/storage vessels has been a traditional use of wireless technology and today's modern factories require links to devices with built-in web servers for remote monitoring and preventive maintenance/support. Modern day factories have industrial hot spots providing mobile PDA or laptop wireless connectivity and can serve as data collectors for wireless sensors.

Height is Everything (or Installation 101)

Proper planning and deployment of wireless industrial Ethernet is critical for reliable operation. For outdoor applications, terrain considerations are paramount and for establishing longer links, the utilization of computerized path studies and physical survey of sites may be required to determine required antenna height and network topology including potential repeater locations. At higher frequencies, line-of-site becomes increasingly important and towers may be needed to provide a clear radio signal path. Use of quality, low-loss transmission lines, lightning protection, grounding, and proper antenna installation are critical as the distance between the wireless device and the antenna increases.

Riverstone Quarry, Missouri, USA

In order to improve quarry efficiency and coordinate the dredging with the classifying plant, a fully automatic system including wireless industrial Ethernet switches in the dredge, pumps and the classifying plant was developed. The classifying plant is one kilometre away from the dredge, which sits down in the water-filled quarry. In order to achieve line-of-sight between the two and avoid a repeater, the antenna at the classifying plant was placed on top of its 20-meter height.

Riverstone Group, a sand and gravel mining company, recently decided to switch their operation over to wireless. Mike Gottwald, the chief engineer for the project, started his research into wireless with consumer-grade radios.

"We had several industrial radio companies look at this application," said Gottwald. "The consumer (non-industrial) radios were a disaster. They shut off when a plane flew by. Some told us it couldn't be done. Others told us we would need expensive repeaters."

Now the fully automated dredge runs not only the dredging operation, but also the booster pumps as well as the entire classifying plant via the radios. Annual savings with this wireless Ethernet solution were US$100k.

For indoor applications, a blueprint of the building can help map required coverage areas and indicate challenges posed by structural elements such as metal walls. The initial wireless network design is solidified by a site survey (simulating actual installation, such as antenna type and placement, as closely as possible) to verify actual coverage area by measuring signal strength indication (RSSI) and a spectrum analyzer may be used to check for in-band interference. Wireless Ethernet network performance

measurements including packet error rate (PER) and throughput are tested to adjust placement and determine if additional wireless devices are necessary to meet the application requirements. The wireless vendor should have easy to use tools for wireless network configuration and diagnostics. For WLAN, commercial and open source (Ethereal) 802.11 network analyzers are available to aid 802.11 network planning, monitoring and troubleshooting.

Material Handling, Luxembourg

Wireless Ethernet switches were used to provide connectivity between a fixed PLC and two PLCs on moving parts (150m travel) of a material handling system. In addition to designing the wireless network to provide a coverage area encompassing the moving PLCs, a unique challenge was presented by a metal wall separating the moving PLCs. Fortunately, the wireless Ethernet switch selected has active antenna diversity allowing antennas to be placed on either side of the metal wall and transmit/receive information from each moving PLC.

It's a Factory, Not a Spa

The factory environment in a number of industries can be very demanding. Wireless Ethernet products originally designed for pleasant small office/home environments (SOHO) may have difficulty acclimating to temperature extremes, vibration, shock, electromagnetic interference, and hazardous locations common in harsh industrial settings. If it does not attach to a DIN rail, how industrial can it be? Some general guidelines for wireless industrial Ethernet:

- Operating temperature of at least 0 to 50°C (-40 to +75°C better)
- Vibration and shock resistant to IEC 60068-2-6 and IEC 60068-2-27
- Rugged, DIN rail attachable enclosure
- 12 VDC (for solar power) to 24 VDC power
- ATEX (Europe), UL or FM rating for hazardous locations
- Active antenna diversity to reduce multipath fading and allow physical separation of antennas
- Appropriate frequency, modulation and design to resist electromagnetic interference
- A multi-year warranty to reflect quality of design

Coke Making, South Africa

Wireless industrial Ethernet switches replaced legacy, licensed radios to provide wireless Ethernet connectivity between seven pusher cars (used to level coal that has been charged into a battery of ovens and to push coked coal out of the oven battery into quench cars) and the central control room when the customer upgraded to Ethernet PLCs. The push cars move between the ovens within a battery, so omni-directional antennas were used to provide coverage over the 800m long site.

"This is the second system we have installed in the Iron & Steel industry here," remarked Bob Petrie of Throughput Technologies in South Africa. "We have installations in other industries but the iron and steel industry is significant due to the extreme harsh environments present in such locations such as heat, air borne particles, electro interference etc. The bandwidth is fine with regard to data traffic. What is significant is that the system went in and has been operating perfectly ever since (now 8 months). The fact that the transmission mode is Frequency Hopping Spread Spectrum is important as there are many other radio based systems in these plants and it is reassuring to know that interference from other applications will not affect the performance of the system that we supplied."