BELDEN
SENDING ALL THE RIGHT SIGNALS®

Achieving Next-Generation Connectivity

Industrial-strength Ethernet, bolstered by its wireless component, is giving facilities the tools they need to operate lean and mean and succeed in an uncertain economy

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Introduction

Few would argue that today's economy is uncertain and unstable. Manufacturers face unprecedented challenges. To compete globally and achieve profitability, most must strive for unprecedented efficiency. And that means implementing superior systems and practices throughout the enterprise and operating lean and mean at every turn. As companies seek to identify and eliminate waste, continually improve processes, and respond to the increasing product demands of its customers, they are learning to do more with less, whether it is resources, staff, or money. They are also learning that one tool perhaps more than any other goes a long way toward helping achieve those goals—industrial Ethernet.

Industrial Ethernet impacts every aspect of the operation. Building a strong industrial Ethernet system and harnessing the power of its wireless component can reap unanticipated benefits for the entire facility. Once the sole purview of the IT department and the office environment, Ethernet has forged forward, becoming commonplace throughout industry as it has grown robust enough for plant floor applications. Cost effective now down to the device level, it is a key technology that has shown adaptability far beyond other existing industrial protocols and legacy infrastructures.

The Ethernet infrastructure is developing rapidly in industrial manufacturing environments. Thanks to advancements in the technology—most recently in the wireless arena—it is becoming what many would term all-pervasive. Virtually every company has some level of Ethernet on the plant floor today. And it is fast becoming the principal infrastructure for industrial automation and control applications for a number of reasons. In this whitepaper, we examine some of those reasons, the factors that have influenced the success of the Ethernet infrastructure, and look in detail at the accelerating presence of its wireless component.

Developing a Universal Network Solution

Not long ago, a facility planning to deploy a SCADA system would implement whatever path was easiest and most cost effective. A common choice might have been a fiber optic ring installed around the plant floor with a box containing a switch inserted every few hundred feet for the hardwired connections. Today, nearly every device on every machine is plugged into an Ethernet port and connected to an I/O system. And now a wireless network can be added—many times for about half the cost of its wired counterpart.

The performance improvements that made it robust and reliable enough for just about any industrial application are largely responsible for driving Ethernet technology to its present role as a universal network solution. It is the way to go for countless industries, from oil, gas, and petrochemical to water and wastewater and beyond. It provides seamless interoperability and system integration from the board room to the shop floor. It finds application for pulling together legacy equipment and buildings for central management. It is an obvious choice for pipelines where high-maintenance buried cable subject to environmental hazards can be eliminated by wireless connections.

Any company investing in an industrial Ethernet infrastructure must take care to apply ruggedized components. Whether wired or wireless, industrial Ethernet must use environmentally hardened components that achieve long-term performance, and materials and methods of construction durable enough to withstand the extreme environments typically encountered in industrial applications—humidity, moisture, dust, chemical exposure, and temperature extremes, to name a few.

Typically, application dictates the wired/wireless decision. Until recently, wired Ethernet applications dominated. Indeed, many machines are hard-wired for a reason. Wired systems are more easily isolated from the balance of a network, making it is easier to keep other applications from spuriously accessing part of network bandwidth needed by the machine for reliable operation. In most cases, wireless components are best suited for meeting the needs of supervisory tasks that are able to tolerate variable access times.

Safety and cost are factors as well. Although often lower in cost overall, wireless can only be driven down to the device so far before the cost of equipping the device with wireless capability becomes more expensive than the cost of the device itself. Solenoid valves or proximity sensors on packaging equipment are one example. In those situations, components should be wired to Ethernet-ready I/O blocks and plugged into a controller that supports an Ethernet I/O infrastructure. Since wired and wireless components can coexist on any system, devices can also support a wireless component for SCADA functions because at that level additional access to the bandwidth will not adversely affect machine operation or endanger an operator.

Applying the Wireless Component

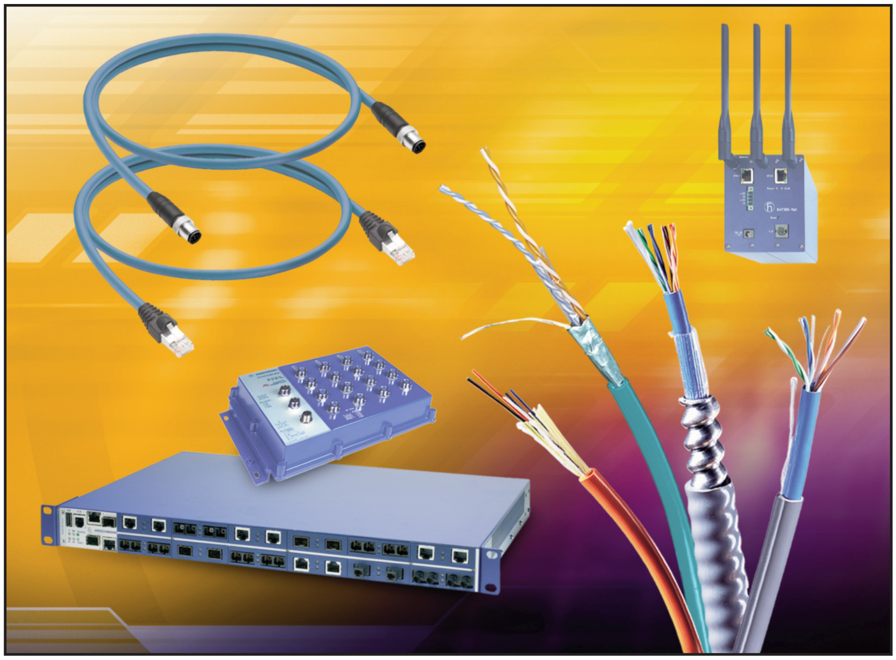
Wireless technologies are thriving on the plant floor for a number of reasons, but two key criteria include improved safety and security and lower costs. Security concerns initially associated with wireless have been dispelled or at least diminished. Standards development for wireless systems has caught up with conventional Ethernet with the development and expansion of IEEE 802.11 (www.ieee.org). The standard governs wireless LAN (local area network) communications and has helped advance the security of Ethernet wireless systems, some say even beyond that of hard-wired systems.

Specifically, IEEE 802.11b and g are directed at equipment in the 2.4 GHz frequency and 802.11a at devices operating in the 5 GHz range. A recent amendment ratified in 2009—802.11n: *WLAN Enhancements for Higher Throughput*—is intended to improve data throughput and range for WLANs as well promote the coexistence of higher data rate components with legacy systems and security implementations.

Wireless products supporting 802.11n are just now beginning to roll out. Among them is Hirschmann's new BAT300-Rail series of radios. This flexible line of 802.11n-compliant products operates in all the frequency ranges and offers data rates of up to 300 Mbps using MIMO (multiple input, multiple output) technology. Features such as multipath transmission with reflection coupled with 3 transmission/reception antennas for more stable network coverage and 20-MHz or 40-MHz wide channels provide improved bandwidth and ruggedness for industrial environments.

With multipath reflection, the RF waves propagate through the air and reflect off their surroundings, all reaching the receiver—or access points—at different times. Three antennas make the device better able to receive those signals, improving performance in areas that in the past would have been considered trouble spots. Now, multiple signals actually help increase reliability and extend communication distances, effectively reducing the number of radios needed for any given application. And n-compliant equipment is backwards compatible. Even legacy a, b, or g components that support only 54 Mbps and single-stream data, when paired with an n-equipped access point, can still take advantage of the reflections to achieve better reception. In addition, wireless application antennas enable transmission over long distances, with relays extending those distances even farther, as long as power is available, with no loss in bandwidth.

Another significant benefit of wireless applications is their lower cost. In many cases, a wireless system is more economical because it eliminates the hard wired costs of cabling and connections and the associated installation effort. In addition, it heightens safety and adds convenience to maintenance tasks. For example, if a technician can perform repairs, update firmware, or even do minor programming without opening the cabinet door to access a controller, tasks can be completed quickly, easily, and with less risk.



Belden's wired, end-to-end Complete Industrial Solutions include ruggedized Hirschmann™ - branded Ethernet switches, active network devices and patch cords and Belden Ethernet cables and connectivity. Wireless communications are the province of the Hirschmann BAT family of wireless access points/clients and related antennas.

Creating the Wireless Design

Integrating wireless technology into an overall system requires a bit of effort, careful planning, and attention to a number of details. Wireless is inherently a shared medium, meaning every device connected to a single access point must share the bandwidth. This characteristic can cause some latency and data collision issues; however, awareness up front can help ensure a properly designed wireless network. Although called a shortcoming for wireless by some, it is important to realize most fieldbus networks used in industry—even those considered the most deterministic—also are based on a shared-medium concept.

In most cases, simply increasing application time-outs will account for the latency. Slowing request or transmission rates can help as well, although not always needed. The more devices that are connected to the network, the greater the effect on latency. In applications such as video, a few devices can communicate a lot of data; in others, for example in a supervisory or maintenance network, a large number of devices communicate small amounts of data.

In any network that communicates critical or semi-critical data, testing the application before deploying it in a production environment is always recommended. Wireless is no different. With a little preplanning and some small adjustments to the process programming, wireless can be a very reliable solution.

Wireless is being deployed with ever-increasing frequency in such applications as conveyor systems. Recently introduced leaky coax or leaky feeder antennas—essentially coax cable with perforations in the shielding to allow small amounts of the RF signals to be sent and received along the cable length—can be designed into the length of the conveyor, providing seamless connectivity to the trolley and eliminating the need for data communication through a festooned cable or slip-ring assembly.

Focusing on Bandwidth, Determinism

By its nature, wireless technology calls into question two critical issues—bandwidth and determinism. In all probability, industrial environments will never need less *bandwidth* than they do now. Bandwidth requirements are typically determined by the application. Let's look at a couple of examples: Security applications such as those found in airports or used in the gaming industry employ streaming video from security cameras and need high resolution, which require large amounts of bandwidth to maintain performance and image quality. Industrial Ethernet, with its near-unlimited bandwidth capacity, is making grainy images of the past obsolete.

Rarely does manufacturing have a need for the high-resolution equipment found in security applications. A controls environment in most cases uses much less bandwidth; data packets are usually small, most containing only input/output data. But cameras *are* used in industrial wireless systems to monitor obstructed or inaccessible areas of a process or production line. In addition, they help enhance safety in and around robotics, warning operators or technicians of impending danger and keeping them from getting close enough to the work envelope to stop production; and streaming video plays a role in many inspection applications. In a high-speed machine producing at a rate of 2,000 to 3,000 parts per minute, enough bandwidth must be available to ensure reliable operation without compromising safety. Because of industrial Ethernet technology, it is.

In an automation application, *determinism*—the ability to measure how long it takes a device to react upon a command—means a system will respond in the same way at the same rate every time. In some control systems, however, the speed of the measurements is not sufficient to achieve the needed throughput and determinism becomes less important. Historically, Ethernet has been implemented in a automation and controls environment in one of two ways. In some cases, the master/slave communications methodology common to most legacy networks was used, with the controller managing all communications. Determinism could be achieved as long as the system was isolated from the network and no other application took away any bandwidth. A more common approach today is to use ODVA-specified (odva.org) multitask messaging that allows end devices to poll themselves and report their status at predetermined intervals, which is effective, but not deterministic because there is no way to confirm that a message reached its destination.

Industrial Ethernet with its inherent speed and abundant bandwidth again offers a solution. Legacy networks operate at single digit Megabaud rates, modern Ethernet systems in the 100 Megabaud range. The amount of available bandwidth negates any possible determinism or repeatability problems inherent in most applications. Most machine applications use less than 1% of available bandwidth making determinism no longer the critical factor it was in the past; data is delivered in a timely and reliable fashion. As bandwidth availability continues to grow, wireless applications are even making their way into some control situations. Overhead cranes, for example, can now be controlled from a wireless handheld pendant. To ensure safety, components operate in relatively close proximity in a contained environment. AGVs, once connected by communication rails in the floor, can now be controlled wirelessly using carefully placed access points. Wireless access point switching rates as fast as 20 ms ensure AGVs are never out of touch for any perceptible amount of time.

Connecting to a Promising Future

Unequivocally, a majority of manufacturing facilities that have established an Ethernet automation strategy have a wireless component today. It offers a strong solution set. As with any technology, it is suited for some applications more than others. Despite their obvious benefits, wireless applications face a plethora of environmental issues—the need for clean power, appropriate and effective EMI/EMR shielding, and the like—that can interfere with the operation the system and must be considered when developing any installation. In planning a wireless system, a survey of all existing infrastructures and surrounding devices is an imperative first step. Assess the manufacturing environment and determine what might interrupt the operation of wireless access points: machinery, cranes, moving equipment. Even a forklift in a warehouse aisle can affect signal access. Outdoor applications have special needs. To prevent connectivity losses, antenna installations will need protection from lightning strikes and/or wind loading.

Challenges remain. Security issues continue to present major stumbling blocks, and questions about IT involvement in the automation world remain. The ability—or inability—of production management and engineering to sit down with IT to plan a system or solve a problem still poses a challenge. Only a few large progressive corporations have issued top-down edicts requiring IT and production to work together. Without a facility security policy that provides an effective solution for both production and office domains, security is at risk. IT cannot implement policies in a vacuum. Everyone must be on board and aware of each others' problems.

When all is said and done, however, the days of walking around the plant with a clipboard are long gone. All-pervasive Ethernet connectivity and its wireless component *have* arrived. They are the future—and more. To maintain profitability, manufacturers everywhere need to pause and take a close look at their facilities today, and then take steps to bring their connectivity into the 21st century. No plant can operate effectively with yesterday's information in a world that operates in the "now." Whether the application is wired or wireless, the only way to succeed in that realm is with industrial Ethernet.