PlantWeb University – Wireless 101

What is Wireless?

15 minutes

In this course:

Overview

Most of us take advantage of wireless technology every day – whether we're listening to the radio, talking on a cell phone, or changing channels with a television remote control. People around the globe can even wirelessly access the Internet while visiting "hot spots" with Wi-Fi service.

Wireless technology is also nothing new for parts of the process industry. Oil and gas companies, for example, often use it to monitor remote fields and pipelines.

However, wireless technology has not been widely adopted for in-plant applications. Concerns about reliability, security, and battery life of wireless devices have slowed adoption of wireless options even where traditional wired solutions were cost-prohibitive or operationally difficult.

That's changing as improvements in wireless technology address these concerns. Users are now looking to wireless technology as a valuable tool for solving automation challenges in many areas of their operations.

This series of PlantWeb University courses is designed to help you understand what wireless technology can do for you, and what you need to know to choose and implement a wireless solution.

This first course introduces wireless technology and its use in process-related applications.

Hint

As you go through the topics in this course, watch for answers to these questions:

- How is information communicated in a wireless solution?

- Which wireless technologies are most appropriate for industrial applications?
- Will wireless technology replace HART and fieldbus?
- Why are process-industry users now more interested in wireless technology than in the past?

Wireless architecture

Any communication architecture, whether wired or wireless, has three basic components:

- a transmission **source** to send a signal
- a **medium** to carry the signal
- a **receiver** to accept the signal and do something with the information.

In the traditional "wired" world of process automation, for example, a measurement transmitter (the source) sends data through twisted-pair wiring (the medium) to a distributed control system or other host (the receiver).

Process-automation communications have traditionally used wired connections between the source and the receiver.

A wireless solution uses radio waves instead of physical wires as the communication medium. A radio and antenna convert electronic signals from the measurement transmitter into radio waves, and another antenna and radio at the host convert the waves back into usable information.

A wireless connection uses radio waves as the communication medium.

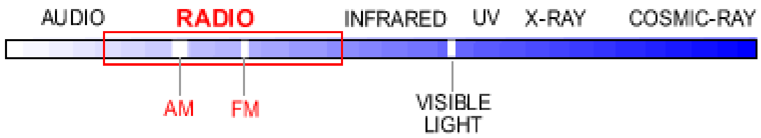
Although transmitters and other devices in a wireless network can use hard-wired electrical connections to power their electronics and radios, a device is said to be **"truly wireless"** when it doesn't use wires for communications ***or*** power. In these cases, power is typically provided by a battery; by energy-scavenging technologies that take advantage of available solar, thermal, or vibration energy; or both.

All wireless applications follow this basic model, but different industries or applications use different wireless technologies that are best suited for their particular needs.

Within a plant, for example, it's likely you would use one technology for a **wireless field network** that carries data to and from sensors and other field devices, a different technology for a **wireless process control network** that can be used to give mobile workers easy access to control and maintenance information systems, and other technologies for wireless access to the plant LAN to enable asset tracking and security applications.

Frequencies

Some wireless applications – for example, television remote controls – use infrared light waves to transmit data. However, these light-based wireless communications have limited range and always require a clear line of sight between sender and receiver. That's why most wireless applications instead use the **radio-frequency** (RF) portion of the electromagnetic spectrum.



Radio waves used in wireless communications are part of the electromagnetic frequency spectrum.

Most radio frequencies are already allocated for use. Many are in licensed frequency bands reserved for such applications as military, police, or other specialized uses. Companies in such industries as cellular phones and satellite TV also pay substantial fees to license certain frequencies. These licenses are often specific to a particular country or region.

However, a few frequency bands have been made freely available as unlicensed **Industrial, Scientific, and Medical (ISM)** frequency bands. Users are required to comply with certain regulatory requirements, such as limiting transmission power.

Three commonly used ISM frequency bands relevant to the process industries are 900 MHz, 868 MHz, and 2.4 GHz.

- **900 MHz** is most widely used in the Americas. Because it actually includes the range from 902 to 928 MHz, signals can be spread across multiple specific frequencies. This allows communications to tolerate many types of interference. If one channel is blocked, the next one will likely provide a clear link – greatly increasing network reliability.
- **868 MHz** is allowed for ISM communications throughout most of Europe. Because it is a single fixed frequency, however, it doesn't offer the same anti-interference capabilities as 900MHz. This greatly limits its robustness in industrial environments.
- **2.4 GHz** is accepted around the globe as part of the Wi-Fi standard, and can be used for wireless Ethernet communications. Other non-Ethernet devices can also communicate in this frequency band. Because it is a band rather than a single fixed frequency, it also allows the use of spread-spectrum techniques to increase network reliability.

Dealing with interference

A crowded environment of radio-wave transmissions can interfere with wireless signals. So can other sources of radio-frequency "noise," such as from electrical or electronic equipment.

One way to overcome this interference is to increase the signal strength by increasing transmission power. However, doing so could also risk interfering with other desired transmissions in the area. In battery-powered devices, increasing the transmitted signal strength will also significantly reduce expected battery life.

Physical obstructions can also interfere with radio signals by absorbing RF energy, which reduces the effective signal strength.

Certain materials will reflect RF signals. While this can actually help signals "bounce around" some obstructions, it also causes some loss of signal strength and can introduce time delays that can result in an "echo" effect.

Most receivers are designed to lock onto the strongest signal and ignore the echoes. However, since even the strongest signal is only part of the original signal emitted from the source, it may be significantly weaker. Thus the more obstructions a wireless signal must contend with, the weaker the signal and the shorter the effective range of that wireless communication.

Fortunately, advances in wireless technologies make it possible to overcome many interference problems in process-related applications.

For example, **frequency-hopping** technology transmits messages across alternative frequencies in the allotted band. If interference causes problems on one frequency, the message can get through on another.

Self-organizing networks also offer a solution to interference. If something disrupts communication between two devices in a self-organizing network, the network automatically uses other devices in the network to provide an alternative path to the message's destination.

Some wireless solutions use both techniques – and others – to ensure reliable communications.

Wireless technologies

There's no shortage of wireless technologies: Bluetooth. CDMA. GSM/GPRS. 900 MHz. Zigbee. Wi-Fi. Wi-Max. Satellite. And that's only a few of the names you're likely to hear.

Why so many? Because no one technology is ideal for every application in every industry.

For example, different technologies are better suited for different transmission distances.

- Cellular technology, which takes advantage of existing telecommunications networks, can be the right choice for communications that span countries or continents.
- Bluetooth, on the other hand, provides an effective, low-cost connection between your keyboard and computer, or from a headset to a phone – but its very short range means it's not the right choice for communicating with an offshore oil platform.

While there's no single wireless solution for all process-industry needs, certain technologies are well suited for some common applications.

- **GSM/GPRS**, which is widely used in cellular networks, works well for remote data-collection applications like inventory-tank monitoring.
- **900-MHz and 2.4-GHz radios** have also proven useful for monitoring and SCADA applications in oil and gas fields.
- **Self-organizing networks** offer high network reliability for in-plant applications – and can be especially cost-effective when they take advantage of advanced power-management techniques.
- **Wi-Fi** is well established, robust, inexpensive, and based on open standards. Used in conjunction with self-organizing wireless field networks, it can provide an excellent backbone for data concentration and networking. Wi-Fi access points can also give mobile workers access to information on a wireless process control network.
- **Satellite** communications can connect very remote operations to a central control room. For example, some offshore oil-production platforms use this technology to provide a data link to a land-based facility.

You'll learn more about these technologies – and others – in later courses.

Industrial applications

No matter how exciting a technology may be, you're not going to invest in it unless there's a practical application in your own operation – one that solves a problem or brings new benefits.

With the broad range of wireless technologies and solutions available today, however, most process-industry operations can easily find applications where wireless offers a strong return on investment.

Remote applications. When the data you need is kilometers from where you'll use it, hard-wired connections are usually impractical. Examples include monitoring inventory in remote storage tanks, gathering data from paper-chart recorders in remote areas, and accessing diagnostic information from equipment in remote oil and gas fields.

Wireless technology offers a practical solution. Using cellular technology, for example, data from such remote locations can be affordably transmitted through existing communication networks. You'll no longer have to wait until the next time someone visits a remote operation to know what's happening there.

Near-plant applications. Even when the information you want isn't coming from far away, barriers like highways, railroads, or rivers can make wired connections impractical. That's often the case for unstaffed or hard-to reach areas on the periphery of plants, such as tank farms or water-treatment operations.

Wireless technologies like Wi-Fi, however, can easily connect those areas with your control room or other in-plant location – so you can see what's going on in time to take appropriate action.

In-plant applications. Although communication distances inside a plant are relatively short, the high cost of installing traditional wired connections can sometimes outweigh the benefits of bringing in additional information.

Wireless technologies like self-organizing networks can shift the balance in your favor. These easily installed, easily expanded wireless field networks dramatically lower the cost of adding new measurement points, or of accessing diagnostic data that's not available through some legacy control networks and systems.

Wireless technology can also improve operator and maintenance productivity in most process applications by giving mobile workers wireless access to control and maintenance data – wherever they are.

Fieldbus, HART, or wireless?

How do wireless technologies fit with other communication technologies for process automation, such as HART and FOUNDATION fieldbus? Can they coexist? Is one better than the other?

The answer is that each has its own advantages, and operations seeking to maximize productivity and profitability will use a combination of these technologies.

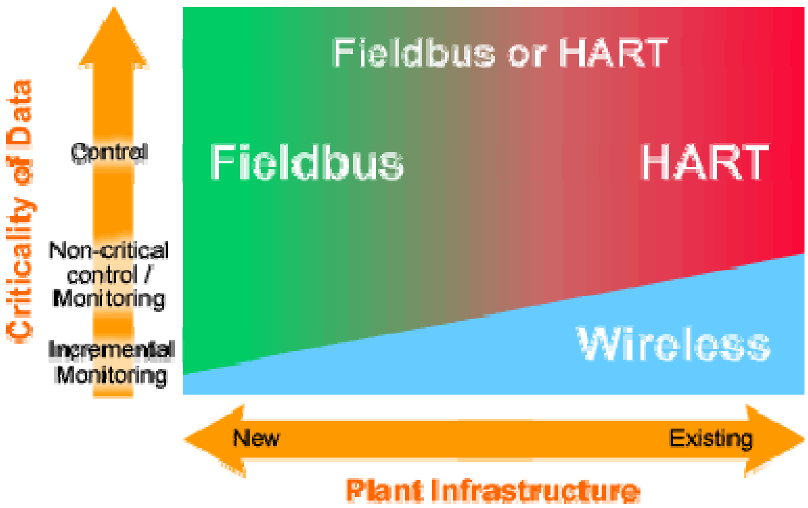
HART and FOUNDATION fieldbus communications are ideal for traditional control and monitoring applications.

- Control applications are essential to plant production and safety and often require update rates of one second or less.
- Traditional monitoring applications are also important to the production or safety of the plant, but don't typically require updates as often as control applications.

While today's wireless technologies are suitable for many control applications, they are ideal for monitoring assets that were previously out of economic and physical reach – for example, where the cost of installing physical cabling outweighed the benefits.

The additional data provided by these incremental monitoring applications is typically more important to the business optimization of the plant than to critical safety applications or basic production. They typically require update rates from every few seconds to several times per day, and are just as often integrated with data historians or asset management software as with control systems.

Robust wireless technology can also be used for certain types of control – specifically, where the chosen solution can meet latency and update requirements of the application. These typically include open-loop control applications and latency-tolerant non-critical control.



Wireless technology works well for incremental monitoring applications and for non-critical control applications.

As the graphic shows, wireless technology is particularly cost-effective for incremental monitoring in **existing facilities**, where adding new wiring runs can be a complex, expensive task.

The advantage is less dramatic in new facilities, where extra wired communication capacity can be included from the start – before infrastructure and other obstacles make incremental additions difficult. The difference narrows even more when extensive use of fieldbus further reduces wiring cost and complexity.

In some cases, you may find a combination of fieldbus, HART, and wireless technologies works best. You might use the control-in-the-field capabilities of FOUNDATION fieldbus in an unstaffed near-plant operation, with a wireless connection back to a central control room.

Why wireless now?

Wireless isn't new. Why all the recent interest about it in process industries?

Consider what happened with cell phones. Cellular technology was available for at least a decade before it was widely adopted, but the large size and short battery life of early phones made them impractical for most people. Once those problems were solved, adoption increased exponentially.

Something similar has happened with wireless technology for process automation. It wasn't hard to see the potential benefits, but users were reluctant to put wireless to work in their plants until concerns about security, battery life, standards, and communication reliability were addressed.

In recent years, several automation and wireless-technology suppliers have focused on addressing these and other concerns. As a result, "process-industry ready" wireless solutions are increasingly available.

- Built-in encryption, authentication, verification, key management, anti-jamming, and other security measures can make properly-implemented wireless networks as secure as many traditional wired ones – or more so.
- Advanced power-management techniques, low-power electronics, and energy scavenging technologies help minimize power consumption so wireless devices can operate for years without battery replacement.
- Self-organizing networks offer unprecedented reliability for wireless field networks, even when changes in the plant environment interfere with existing transmission paths.
- Emerging industrial standards -- such as those under development by ISA and the HART Communications Foundation -- are addressing concerns about integration and long-term compatibility in wireless field networks..

At the same time, users are looking for ways to wring even more productivity (and costs) out of their operations. Wireless technology offers a cost-effective way to get the information – from additional process measurements to equipment diagnostics to inventory levels – needed to achieve those goals.

Summary

This course provided a very basic introduction to wireless technology for the process industries. Key points included:

- Most wireless technologies replace physical communication cables with radio waves, often from the ISM (Industry, Scientific, and Medical) frequency bands.
- Different technologies have been developed to address the requirements of different applications – such as remote, near-plant, and in-plant applications in the process industries.
- Technologies used in these types of applications include cellular, Wi-Fi, and self-organizing networks.
- Wireless technology doesn't replace wired HART or FOUNDATION fieldbus; it complements them.
- Advances in wireless technology have addressed the concerns that previously slowed its adoption – and opened the door for users to gain the benefits of putting it to work in their operations.

The other courses in PlantWeb University's wireless series cover these concepts – and more – in greater detail.