PlantWeb University – Wireless 202

Technology selection

20 minutes

In this course:

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Overview

Wireless technology continues to evolve at a rapid pace. Today, there is a broad array of wireless technologies from which to choose – from Bluetooth and Wi-Fi to self- organizing networks, satellite, and cellular, just to name a few.

However, only a few wireless technologies are suitable for communicating process-automation information. Security and reliability are always high on the list of requirements, and the "steel canyons" of most plants can present challenges not common in office or residential applications. Network scalability and cost are also important considerations.

Even within the process industry, different applications have different requirements – such as for range, throughput, and energy efficiency – that call for different wireless technologies. In other words, the right technology depends in part on the application.

In this course you'll learn about several popular wireless technologies and why some are better suited to process-industry applications than others. Understanding the strengths and weaknesses of each will help you decide which technology is best for your specific application.

Hint

- What is typical dividing line between **short-range** and **long-range** wireless technologies?
- Which wireless technology **doesn't** use radio waves?
- Which technologies developed for business and consumer use are also good candidates for process automation applications?
- Which wireless technologies can be combined to extend transmission distance?

Range and throughput

To help us understand which wireless technologies are best for different applications, it's useful to begin by considering the relative **range** and **throughput** capabilities of each.

Range. Each wireless communication link in the short-range technologies is typically 100 meters or less. Some of these short-range technologies can cover longer distances using multiple links. Total transmission distance can also be extended by combining short-range wireless technology with other wired or wireless technologies.

Throughput. Throughput is similar to data rate, but generally excludes "overhead" bits used by the communications protocols. It's a good tool for judging the true performance and efficiency of a wireless network – the more throughput it delivers, the better.

Whether you're looking for short distance coverage and high data rates, long distance coverage and low data rates, or something in between, there's probably a wireless solution that meets your needs.

Let's look at several of the most common technologies.

Infrared

Infrared (IR) technology is nothing new. In fact, you may use it daily – it's the technology behind most remote control devices for televisions, VCRs, and DVDs players, to name a few.

Unlike other wireless technologies covered in this course, IR technology transmits data using light rays. The one-way signal spans very short distances – typically less than 25 feet – and requires a direct line of sight between sender and receiver. It cannot penetrate walls or other solid obstructions.

It's also relatively slow. For example, even though many PCs and printers have infrared links to allow printing without cables, few people use this capability because it's slower than a typical wired connection.

This slow data transmission, along with line-of-sight requirements and limited range, are clear disadvantages for most process automation communications.

Bluetooth

Bluetooth technology uses tiny, inexpensive, short-range radio transceivers in devices like phones, headsets, PCs, and personal digital assistants (PDAs). When Bluetooth devices come within range of one another, they automatically communicate electronically to share data in a Personal Area Network (PAN) or **piconet**.

Each Bluetooth piconet can have up to eight devices, and each device can belong to several piconets at the same time. Piconets are created dynamically and automatically as Bluetooth-capable devices enter and leave the coverage area.

Bluetooth communicates on a radio frequency of 2.4 GHz on the industrial, scientific and medical (ISM) devices band and supports data speeds of up to 721 Kbps. Although the Bluetooth specification allows ranges up to 100 meters if sufficient power is available, 1- to 10-meter ranges are more common.

The main attractions of Bluetooth are that it’s wireless, automatic, and inexpensive. It's a good fit for office applications. But its limited range and low reliability mean it's not a good candidate for industrial automation.

ZigBee

ZigBee is a communication protocol designed to use small, inexpensive, low-power digital radios for low-data-rate applications like building automation, medical devices, and embedded sensors. Like self-organizing networks (covered later in this course), it uses the IEEE 802.15.4 standard for wireless networks.

While building and office automation applications are ideal markets for ZigBee technology, there are drawbacks for process automation applications.

Frequency. ZigBee uses just one frequency channel per network. A site evaluation is required to locate a clear channel, which is then programmed into each device prior to installation.

This single frequency means that jamming or other interference on that channel can shut down the network. The only way to avoid the interference is to re-survey the site and then re-program the devices to use a different available channel.

Power. Although some Zigbee devices can run for a year or two on a single alkaline battery, actual network power requirements are more complicated.

That's because Zigbee networks use two types of devices: **reduced-function devices** and **full-function devices**.

- A **reduced-function** device is a low-power send-and-receive node, but it can "talk" only to full-function devices.

- **Full-function** devices serve as traffic routers in the network, and are not low-power. They are typically line-powered, so placement is limited to locations with easy access to power. Although ZigBee allows battery-powered full-function devices, their expected battery life has not been proven and may be only a few months.

In an industrial environment, adding new devices to expand a Zigbee network is also more difficult, because the location of full-function devices (and available power) must be carefully planned to support additional reduced-function devices.

Self-organizing networks

Also based on IEEE 802.15.4, self-organizing networks dynamically manage their own configuration and communications to ensure messages reach their destinations efficiently and reliably.

Each device in the network also acts as a router for other neighboring devices, so if one device can't communicate back to the gateway because of distance or obstructions, the message will be carried by one or more other wireless devices that have an open path to the host. This greatly increases network reliability.

Because messages can be passed from device to device to device (called "multi-hopping"), there's no requirement for direct line-of-site paths between source and destination. As a result, there's no need for costly site surveys or evaluations.

Multi-hopping can also overcome the otherwise limited range of low-power devices in a self-organizing network. Instead of having to "scream" all the way from the source device to the message destination, self-organizing network devices can "whisper" from device to device until the message is passed all the way to the gateway device.

Unlike Zigbee, all devices in a self-organizing network can serve as routers (or "full function" devices) for other devices, which makes expansion easy. New authorized devices are automatically recognized and added to the network.

Some suppliers also offer self-organizing network solutions with advance power-management and security features.

Together, these capabilities make self-organizing networks the most reliable choice for many in-plant process automation applications.

*For more on this topic, see the courses on **Self-organizing Networks**.*

Wi-Fi

Wi-Fi is widely used to provide wireless connections in offices, homes, and public Internet "hotspots."

It's based on the IEEE 802.11 family of standards for wireless local-area networks. In fact, the terms **Wi-Fi** and **802.11** are often used interchangeably. Different versions of Wi-Fi such as 802.11a, 802.11b, and 802.11g offer different combinations of range, speed, and cost.

Some Wi-Fi devices can transmit data at speeds approaching wired connections and at typical distances up to approximately 100 meters. Greater distances are possible, depending on equipment and conditions. As with other radio signals, Wi-Fi signals can pass through walls and other solid physical barriers, depending on material density and signal strength.

One reason for Wi-Fi's increasing popularity is that it's based on open standards, encouraging interoperability across devices and platforms. Competition among a large number of Wi-Fi developers and manufacturers has also led to wide availability of products that are robust, inexpensive, and easy to use.

Finally, enormous efforts have been made to provide security measures (such as encryption) to protect Wi-Fi transmissions.

In process-industry applications, Wi-Fi can be ideal for covering the distance between low-power, short-range devices in a wireless field network and a control room or other data-collection point. For example, you might use Wi-Fi to integrate data from the gateway of a self-organizing network into a host system such as a DCS, PLC, or data historian.

Wi-Fi can also be used to give mobile workers wireless access to a process control network – including critical process information, historical data, graphics and other key functions.

*For more about this technology, see the course on **Wi-Fi Networks**.*

RFID

One other short-range technology you're likely to hear about is radio-frequency identification or **RFID**.

RFID uses a small radio-frequency transponder (called an RF tag) that is electronically programmed with unique information. This data can then be read from a distance. One common use for this technology is in "toll tags" that allow drivers to use toll roads without stopping to pay each time. It's also used in inventory-tracking applications. Some tags can even be updated – for example, as the item progresses down an assembly line.

RFID may be useful for tracking plant equipment or barrels of product, but you can't tag something that's flowing through a pipe. And because RFID information is static and must be programmed into the tag you wouldn't use it for measurement or diagnostic data that's constantly subject to change.

RTLS

Real-time location services (RTLS) integrate location-tracking capabilities with existing 802.11 (Wi-Fi) wireless networks to allow real-time location of mobile workers, plant assets, and other valuable resources.

RTLS systems can graphically display the real-time location of wireless devices, laptops, PDAs, or any other item or person carrying an RTLS Wi-Fi tag.

The systems update a database with current tag locations as frequently as every several seconds or as infrequently as every few hours for items that seldom move.

How frequently updates occur can affect the number of tags that can be deployed and their battery life. In typical applications systems can track thousands of tags simultaneously, and the average tag battery life can be five or more years.

Potential benefits of RTLS are significant. For example, RTLS-tagged equipment can found more easily during installation or turnarounds. And mobile workers can be located quickly – whether for more efficient work scheduling, or as part of an emergency-response system.

Now let's take a look at some of the **long-range** wireless technologies.

WiMAX

WiMAX, an acronym for Worldwide Interoperabiity for Microwave Access, is designed for wireless networks within areas the size of cities. It can connect Wi-Fi hotspots with each other and with the Internet, and provides an alternative to hard-wired cable or DSL for the "last mile" connection between homes or businesses and Internet access points.

Based on the IEEE 802.16 specification for metropolitan area networks (MANs), it uses a frequency range between 2 and 11 GHz and provides high throughput (up to 75 Mbps). The low-frequency transmissions are not easily disrupted by physical obstructions and – with adequate power – can extend up to 50 kilometers (30 miles).

In the process industries, this emerging technology may be suitable for long-distance links and for providing a wireless backbone and access across an entire plant.

High-power 900 MHz radio

Wireless communications have been widely used in the oil and gas industry, where it can be impractical or cost-prohibitive to provide hard-wired communications to many remote locations.

High-power 900 MHz radios have a long and successful record of meeting the long range (10-20 miles), relatively low-bandwidth requirements of SCADA applications in this industry. That's not likely to change.

What will change, however, is the kind of data that's included in these communications. Especially as some fields begin to mature, companies can use equipment diagnostics and other device information to improve the productivity of their production assets. Because the I/O count in these applications is typically low, the additional data should not significantly challenge the bandwidth limitations of the 900 MHz frequency band.

Cellular

Cellular technology enables us to communicate on the move by automatically transferring our phone call from one tower to another as we travel between network "cells."

Cellular suppliers have supported the rapid increase in cell-phone users by expanding their networks of towers and other infrastructure. As a result, cellular coverage is available even in many remote areas, with good connections to other telecommunication networks.

This makes cellular a good option for collecting process-automation data from remote locations – one that's far more cost-effective than sending a person to collect the data manually.

However, there are several different cellular technologies, and some are better suited to process industry applications than others.

Global System for Mobile Communications (**GSM**), for example, is widely available, and its General Packet Radio Service (**GPRS**) is a good choice for wireless data transmission. GPRS works by layering "packets" of digital data on top of the digitized voice signal used for GSM cell-phone calls.

GSM/GPRS is the cellular technology standard for most of the world including Europe, Asia, and Africa. On a global basis, approximately 70% or more of the cellular phones in use today utilize GSM/GPRS. These networks utilize TMDA (***T***ime ***D***ivision ***M***ultiple ***A***ccess) technology to transmit digitized voice and data over alternating frequencies and scheduled time slots.

In the USA and a few other countries in the Americas, a competing cellular technology called CDMA (***C****ode*-***D****ivision* ***M****ultiple* ***A****ccess*) is available as an alternative. Conversely to TDMA, CDMA technology transmits encoded voice and data over the entire allotted frequency spectrum at the same time.

*For more about this technology, see the course on **Cellular Networks**.*

Satellite

Another option for monitoring geographically dispersed assets is satellite technology. For many applications, however, it has significant drawbacks compared to cellular technology.

For example, satellite data transmission is significantly more expensive than cellular transmission. Satellite radios are also slightly larger are require more power than competing technologies, such as cell phones, because their transmissions must reach satellites in earth orbit. And because satellite communication technology is not widely adopted, it doesn't offer the same economies of scale as cellular technology.

A lack of standards also increases the technology risk for integrating satellite communications with other systems – or with future versions of the same technology.

In general, satellite communications should be reserved for specialized low-bandwidth applications, such as offshore oil & gas platforms, maritime operations, and mobile asset tracking in isolated areas where cellular coverage may not be available.

Evaluation criteria

Although you've just seen that some wireless technologies are not a good fit for process-automation applications, several others are. Which should you choose?

The answer, of course, is "it depends." There is no single technology that's right for every application. Instead, you should define the criteria for success in your specific application, and evaluate the ability of each technology to meet those criteria.

Here are some examples of questions you might use in your evaluation:

- Which wireless technology will best integrate into my host systems or data management systems?

- What is the maximum distance between the wireless components?
- What level of security do I need?
- What throughput levels are required?
- How important is network reliability?
- Is line power available? Where it's not, how often can I afford to change batteries?
- What kind of obstructions and interferences exist in the plant?
- What other wireless technologies are being used and are supported in the plant?
- Does the wireless technology work well with existing instrumentation and installation practices, such as for existing HART instruments?
- How easy is it to expand the wireless network and maintain the technology?
- Is the technology supported by open standards and backed by knowledgeable vendors?
- Is it the most cost-effective technology for my application?

Promising technologies for process automation

While wireless solutions such as high-power 900-MHz radios have been used in the oil and gas industry for many years, some newer wireless technologies are likely to continue gaining ground in the process industry.

Self-organizing networks can be ideal for low-cost in-plant monitoring and control, and for accessing diagnostic data from smart devices. They're easy to plan, install, and expand; inherently reliable; and highly scalable.

Wi-Fi can transmit data from low power, short-range wireless devices in your plant to a central collection point, and can also give mobile workers wireless access to plant information. It’s a well established, standards-based technology that's both robust and affordable.

Cellular technology – specifically GSM/GPRS – is a good solution for applications that involve data sources far from your plant, such as monitoring inventory in remote tanks. The communications infrastructure for this technology is already in place.

Wi-Max may be suitable for long-distance links and for providing a wireless backbone and access across an entire plant.

RTLS offers the potential for more efficient maintenance and operations, as well as improved safety, by continuously tracking the location of workers and assets.

*You can learn more about some of these technologies in the courses on **Self-organizing Networks**, **Cellular Networks**, and **Wi-Fi Networks**.*

Summary

In this course you learned that, while there is an abundance of wireless technologies in the marketplace today, their capabilities vary widely.

Several are better-suited than others for process-automation applications, but no single solution works best in every case.

As a result, it's up to you to select the technology that's right for your application, based on the criteria for success in that situation.