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Wireless Connectivity for the Internet of Things

Learn how IoT methodologies can be used in conjunction with wireless technology to gather field data and to publish the information to those who need it most.

Author: Mark Lochhaas,
Product Manager, Advantech Corporation

The Internet of Things (IoT) and wireless connectivity technologies team together ideally, making it possible to improve how industrial data is collected, stored and distributed. Harnessing the information has never been easier or more economical, which leads to more effective data made available for analyzing and improving a variety of different industries.

The primary reason for monitoring as much data as possible is to more closely define a system and control it better, thereby improving profitability. In particular, for automated processes it is very desirable to capture enough information to perform an overall equipment effectiveness (OEE) analysis, as this and other similar studies form the basis of process improvement. For other more scientific situations the goal may simply be to capture extensive data for detailed analysis.

Of course, sensors and devices have been integrated into control and monitoring systems for many decades to perform these functions. Classic methods have depended upon carefully engineered designs, constructed into a wired infrastructure using mission-specific platforms. Whether the goal was to control an office building environment, automate a production plant or monitor a laboratory experiment—it has long been possible to develop extensive electronic integration strategies.

But in many instances, connecting those sensors back to a suitable monitoring platform represents most of the installed cost, particularly as costs drop for sensors and for control and monitoring systems. An expanding universe of field-located IoT sensors and smart devices (which are typically wireless-capable) means there are now more options for linking field devices back to control and monitoring systems. It makes sense to take advantage of such commercial off the shelf (COTS) offerings whenever possible.

In many cases, older devices (or simply more basic devices) with limited connection capability need to be integrated into control and monitoring systems. Examples are door switches and fan controls in a building, or flow and valve status in a process, or maybe analytical and temperature values in a laboratory. End users in these cases are looking for results, but may not have the time or budget to install new sensors and integrate comprehensive traditional hardwired solutions. Wireless I/O modules can handle these cases, often in a very cost-competitive manner.

Additionally, getting the data into the hands of those who need it has traditionally been no small challenge. It is true that the ability for users to visualize and manipulate data is a task that has been bolstered in recent years due to the proliferation of portable devices. The ultimate goal would be a system allowing end users to connect to whatever data is available in an easy and flexible manner.

Today there are solutions available that let any end user easily incorporate information from field devices into a powerful data gathering system using an IoT framework. Not only can existing input signals be harnessed, but they can be readily and wirelessly transmitted into the cloud and made available to users over common portable handheld

devices. This White Paper will examine how IoT methodologies can be used in conjunction with wireless technology to gather field data, and to publish the information to those who need it most.

Industrial IoT Offers Value

Before IoT implementation details are discussed, users must have reasons to consider the technology. These reasons are outlined below.

Reasons for Implementing the IoT

- Most economical way of gathering data
- Can be implemented in stages
- Can cost-effectively scale from very small to the largest installations
- Information from IoT devices can be supplied quickly to those who need it
- IoT devices can be continuous, scheduled or event-triggered data sources
- Suitable for commercial, industrial and academic applications

The most compelling IoT considerations revolve around economics, both for the devices themselves and for the connectivity technology in general. Traditional methods of monitoring signals involved the application of specialized sensor devices engineered into a master control system in a rigorous manner. A great initial effort was required to achieve functionality.

On the other hand, the IoT represents a much simpler and cost-effective approach. This is partly because of the proliferation of commercial grade IoT devices. Commercial scale production quantities are almost always far greater than industrial quantities, which leads to lower cost devices. Add to this the fact that IoT-enabling technologies allow even simple devices to be made IoT-capable, and it becomes clear that it is cheaper than ever to provide remote monitoring capabilities.

Keep in mind that it is still important to make some targeted decisions about what will be monitored. As *InformationWeek.com* (Reference 1) points out, “When purchases are made in the absence of a business purpose, companies struggle to realize the value of their investments.” What the IoT offers users is the ability to make cost-effective choices quickly and easily, with the confidence that if incorrect selections are made then they can “fail cheaply”, and implementation strategies can then be adjusted.

The more granular nature of IoT devices lend themselves to a staged implementation, which is in stark contrast to the way classic automation systems have been provided. Customary instrumentation methods must be initially designed and installed as part of a relatively large project, and future upgrades require similar but smaller projects.

IoT devices, particularly when they are wireless, require far less hard infrastructure. Additional sensors, production lines or equipment can be added with relatively minor impact once the basic wireless network is in place.

This granularity is a boon for staged installations, but is scalable from very small to very large installations. The native scalability of wireless IoT devices yields a far more cost-effective solution than the linearly increasing installation costs of traditional instrumentation and control platforms.

Wireless IoT devices offer their data in one of several fairly standardized protocols, some of which will be discussed in the next section. While there is not one comprehensive protocol that offers the best of all worlds, the fact is that higher-powered Wi-Fi IP devices are the norm for the most robust offerings. IoT devices over Wi-Fi are therefore natively poised to provide data to the most common consumer electronic devices such as phones, tablets and PCs. Connection speeds are fast, and options for direct open communications or cloud access are readily available.

Of course wireless communications are only half of the installation concern, since most devices also require power. Fortunately, IoT devices typically have frugal requirements. Where locally sourced power is expensive to install, solar cells and batteries can often be used, while other sensors can work for long periods on batteries alone. Energy harvesting devices are also being used in some applications to generate power from the heat or vibration often found in industrial processes.

All of these solutions are viable because data polling rates are often configurable and can be continuous, scheduled or event-triggered. There is no point to consuming power (and overloading databases) with signals any more often than necessary, and configuring for lower data update rates cuts power requirements significantly.

Flexibility is a defining feature of IoT devices, as they can be cost-effectively applied to any type of system whether commercial, industrial or academic. The capability to use common materials, means and methods across such a wide range of applications truly differentiates IoT devices from traditional control and monitoring systems.

Wireless Is the Way

Although options exist to implement IoT sensors with wired components, users will realize the most benefits by going wireless. Wireless solutions are often more cheaper, quicker to install and simpler to maintain. Below identifies the advantages that wireless offers, while the following paragraphs provide additional specifics.

<u>Wireless Complements IoT Devices</u>

- Wireless is a mainstream mature technology
- Handles many common protocols and formats
- Often more cost effective than hard wiring
- No maintenance of wiring infrastructure required
- Quicker to install
- Offers the ultimate in flexibility to add/change/remove devices
- IT-oriented format can leverage in-house knowledge
- Empowers a reliable data source

The fact that wireless technologies are quite mature is actually a leading reason why users are willing to adopt this installation method. Portable electronic devices are in reliable and common operation throughout the world by billions of users. It is no great leap to expect IoT sensors to provide equal or better performance.

Several protocols and formats have been developed specifically to support the wireless sensor network sector, offering a great amount of flexibility. While it is true that there is no single best protocol, there are certain formats tailored for handling sensors and I/O. Some devices may work over common commercial Wi-Fi or Bluetooth. WirelessHART and ISA100.11a are examples of two industrial-specific protocols, while Zigbee and Z-Wave cover certain industrial, commercial and residential applications.

Obviously, the main cost benefit of wireless is that there are no wires. Of course, that is not completely true. There is still some level of infrastructure wiring required, and all of those IoT devices need power. Often there will be a limited amount of field wiring which must be installed near the sensors, and even if a device is battery powered there is an ongoing maintenance cost to monitor and replace batteries. But overall, classic installation methods using conduit, wire, and lots of labor are very expensive and can be greatly reduced by installing wireless devices.

Conduit and cable systems also require a degree of ongoing maintenance and can be susceptible to the elements or other physical damage. Removing the physical connection from a project just makes sense from a sustaining cost standpoint.

Wireless installations require some level of design, but the effort is nowhere near as involved as with hardwired design. Overall, design effort is minimized and field installation labor and duration is greatly reduced.

Lighter installation requirements mean that wireless systems can be far more agile than wired systems. Users can add, change or remove devices at will. This flexibility allows users to scale up installations as they like, or try new configurations and monitoring strategies with fewer risks.

Many wireless IoT protocols are Wi-Fi based, or share enough similarities with commercial wireless systems that users can leverage in-house IT capabilities. Even though wireless IoT is a specialty technology to a degree, IT professionals will be quite comfortable integrating these devices. This means end users may already have personnel in place that can work on new IoT components.

The bottom line is that IoT devices over wireless empower users to quickly and cost-effectively integrate data from field sensors into their operations. This technology is a game changer for all types of business sectors. Now that reasons for implementing the IoT via wireless connectivity have been discussed, we can look at implementation details.

Tapping Into the Plant Floor

IoT devices and wireless sensor networks are completely applicable for new projects, but there are many more retrofit opportunities due to the sheer number of installed monitoring systems. Many existing machines and systems are installed as standalone data “islands”, and sometimes this equipment is configured in a proprietary manner.

In these cases, a few new sensors can be strategically installed to harvest the most important operating parameters.

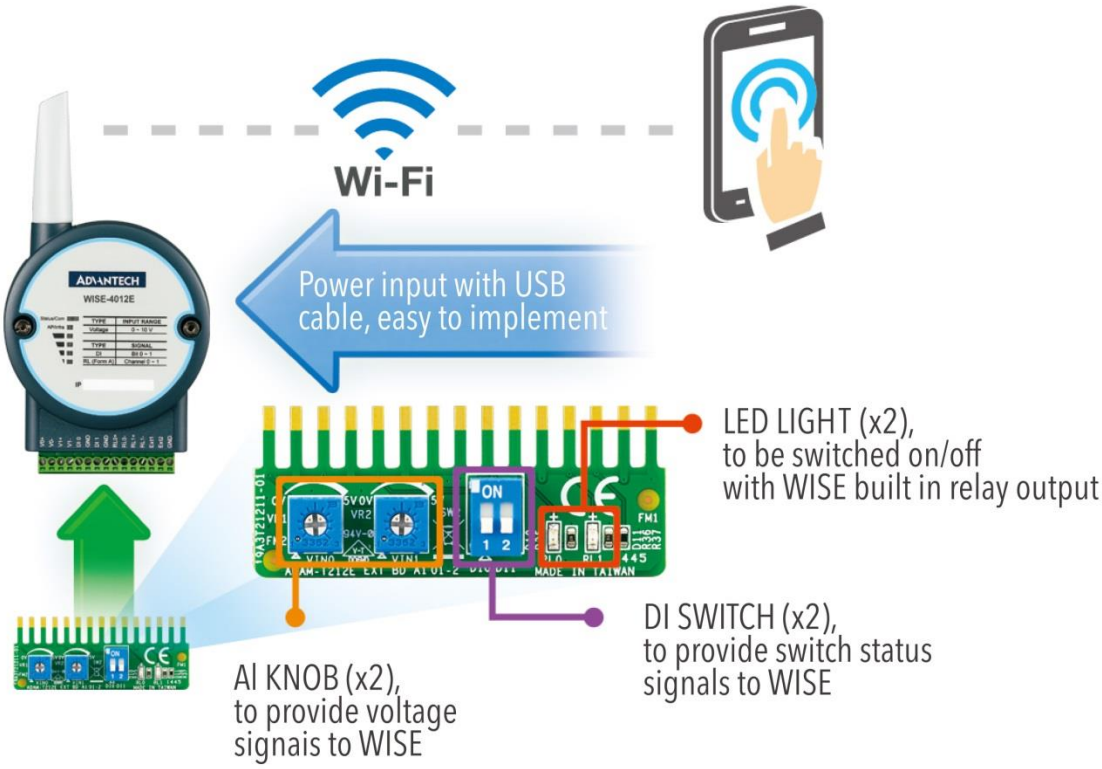

Figure 1 - Many different types of switches and sensors can be connected to wireless I/O modules, which then transmit data via Wi-Fi or other wireless protocols.

To avoid interfering with existing operations, the expedient answer may be to piggyback data monitoring systems on top of the existing underlying automation systems. For example, a relay can be tapped onto an existing photoeye or solenoid circuit to provide a throughput count signal, or a simple current transmitter can be added on the power feed to monitor power usage.

When there are existing analog signals from embedded devices, such as temperature transmitters or analyzers, simply installing a signal isolator in the existing loop can enable an IoT input device to monitor the very same signals without impacting the equipment.

In this way, classic analog and discrete I/O signals can be connected into a local IoT wireless input/output (I/O) device.

Figure 2 - Wireless I/O modules can accept a variety of different input signals and transform these signals as wireless output.

These devices are economical and can be arranged to suit the needs of the field installation and minimize wiring.

Monitoring With or Without Control
Many types of data are possible, some of which are identified by *ReadWrite.com* (Reference 2) with various "data value" to users include:

- Status Data (is it running? How much power?)
- Location Data (tracking equipment and products)
- Automation Data (immediately initiating control based on rules and feedback)
- Actionable Data (stored offline for later analysis to determine optimum actions)

From a practical standpoint, the focus of IoT devices is typically more about gathering data, and less about controlling other devices. Even though control is certainly possible, there is a valid concern that wireless links are more likely to be disrupted than wired connections. If this type of communication failure occurs, it is generally more acceptable to lose status information than it is to lose command and control capability.

Focusing on the data harvesting potential and the flexibility in choosing new data sources is where users can find great value. Readily available streams of new data can be actively viewed by users, or archived into a database for later offline analysis. Once raw data is processed into information, users can take action to make control system improvements to improve throughput, or can modify process strategies to improve quality and reduce energy use.

When Speed Is the Key
Speedy implementation is a characteristic of wireless IoT devices, as they change the way business is done by significantly reducing the time from concept to reality. Users can quickly and easily attach to field signals, and transmit the data up to higher level systems. The extreme speed and flexibility of this approach gives designers new freedom to select what they will monitor, and reduces the penalty for making a wrong choice. In the event that a different signal is needed, the cost to make alterations is far less than it would be for a hardwired system.

Academic and research groups in particular may have a need to instrument a completely new application without established methods. The wireless IoT approach complements the nature of experimental applications, providing the users with much needed agility.

Another important form of speed is the “velocity” of the sensor information flowing in for analysis. The data connections must be sufficiently fast to deliver enough useful data in a timely and robust manner. Four “V’s” of big data are indicated by *ZDNet.com* (Reference 3) as: volume, variety, velocity and veracity. Fortunately, the IoT over wireless is more than up to the task and is capable of satisfying each of these criteria.

Taking It to the Next Level

Another key difference between classic automation methods and wireless IoT designs is that centralized control systems are no longer mandatory in all instances. Traditional automation systems such as programmable logic controllers (PLCs) concentrated the hardwired field data into a controller, which typically required programming to organize the data and make it available to higher level human machine interface (HMI) systems and databases. HMIs and databases in turn required programming to process and display the data in a useful manner.

With a wireless IoT approach, much of the interposing hardware, software and configuration can be avoided or minimized. IoT devices are available to handle multiple I/O points of various types, and are easily powered via micro-USB connections. These devices can be directly accessed over a Wi-Fi network with nothing more than a PC-based, or with a mobile browser running on a smartphone or tablet. For more involved displays, software such as WebAccess HMI can be used to rapidly develop graphics and combine information from multiple sources.

Other options include the ability to log data on local storage, in an on-site private cloud or even in an Internet-based public cloud such as Dropbox. Once the data is in the cloud, users can readily access it via fixed or mobile devices, and perform more detailed offline analysis.

While we have focused on the expediency of obtaining useful data quickly and easily via IoT devices, *Forbes.com* (Reference 4) cautions us to “not just view IoT as the means to an end for near-term decision making. Keep in mind that the data being generated may need to live for long periods of time …” Cloud connectivity facilitates retention of IoT data.

IoT in Action

Previous generations of automation demanded serious design and coordination of multiple disciplines, and still barely approached the capabilities of today’s wireless IoT I/O devices. Let’s look at how quickly and easily the new technology can be put into service.

Consider a production machine that runs 24/7, but isn’t producing at its full rated capacity.

Figure 3 - Machines like this one can be retrofitted with wireless I/O modules to bring them into the IoT world, allowing for quick and simple monitoring via any web-connected PC or mobile device.

Management isn't quite sure when the slowdowns occur and why, and the machinery is packaged OEM equipment that doesn't report results in that way.

Even though the machine does not natively offer an easy communications path, a quick look at the schematics shows that some useful I/O signals are already connected to the proprietary controller.

The maintenance staff therefore connects a few interposing relays into the existing control panel to duplicate the existing "running", "downstream clear photoeye", and "finished part photoeye" signals. In addition, a current transducer is installed to produce a 4 to 20 mA signal indicating an appropriate range of machine current draw. These new signals are wired into a single IoT I/O device located at the machine control panel.

As soon as this device is registered on the user's existing facility Wi-Fi network, portable devices are be used to monitor the signals directly. At a glance, the user sees if the machine is running, and ascertains key points regarding its operation.

Back in the office, users configure WebAccess software with a basic dashboard indicating the machine status, and the running signal and current signals are trended. All of the

signals are populated into a cloud-based database, allowing the company's IT expert to log in and run hourly production reports.

These reports indicate typical production rates, running and stopped times, hours when production dips, and whether those slower times correspond with downstream stoppages. Analysis helps the company identify and correct the root causes of slowdowns.

Within a day the team has been able to assemble a powerful diagnostic tool. And if a week later they discover that the part supply hoppers might be causing the problem, those signals can be quickly added in a similar manner.

Conclusion

It is clear that IoT and wireless technologies are revolutionary in many arenas. In particular, where automation and data monitoring systems previously were highly engineered endeavors, today's devices allow everyday users to quickly and easily integrate field information into readily accessible formats. This can be done very economically, with a nimbleness and speed of delivery previously unavailable.

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