Wireless Sensor Network Implementation in the Industrial Plant Setting

An Online Continuing Education Course for Engineers

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1.0 Introduction

Talk of wireless instrumentation and wireless applications is all around us. But, practically speaking, how do we, as engineering professionals, "break the ice" with our operating units on installing wireless devices in the plant? Once we have determined that wireless is a viable option for an application, how can we help our organizations take the first step into the "world of wireless" with the minimum risk?

This course will help the engineer to answer those questions by analyzing several case studies in applying wireless instrumentation and systems into the industrial plant setting. The ideas and concepts presented in this course should give the reader the basic principals of wireless instrumentation, when wireless is a viable option and when it isn't, a framework for installing a wireless system in their facility, and guidelines as to what works and what does not work.

The data presented in this paper will reflect wireless from the user's standpoint, applicable to all industries and installations, without mention of any specific vendor products.

2.0 Historical Background

Wireless communication is not a new concept. Marconi's experiments and eventual successes in broadcasting telegraph messages wirelessly at the turn of the 20th Century ushered in an age of communication without wires. Just prior to World War I, the first radio licenses were granted and in 1934, the Federal Communications Commission was formed to regulate the use of the radio spectrum.

In the 1960's, NASA was able to communicate with satellites and manned spacecraft orbiting the Earth via radio transmission, and in the 1970's, engineers could converse with people on the surface of the moon as easily as they could with their peers in the next office using wireless technologies. So why couldn't a temperature transmitter on a reactor talk to the control system in the next building without running conduit and cables?

The delay in employing radio frequency transmissions in industrial instrumentation can be attributed to not being able to package the radio, power source, communication protocol, and security layers into a compact package until fairly recently. Now that the technical hurdles to wireless instrumentation systems have, in large part, been solved, no one believes that

wireless instrumentation networks will not be one of the largest growth segments in industrial automation over the next 5 -10 years.

3.0 Considerations for Any Wireless Network

This course is not intended to be a tutorial on wireless communications or radio fundamentals. Other resources, such as ISA's Technical Report 100.00.01 – 2006, provide an in-depth look at the science behind wireless devices and radio technology. This course, by contrast, will focus on the application of wireless in the industrial setting, with a specific look at what is required, what needs to be considered, and how to proceed for a successful implementation.

There are as many options in the wireless instrumentation world as there are in the "wired" world. Many vendors offer various wireless transmitters, wireless data concentration devices, and numerous other radio-based devices. Different vendors offer wireless communication using different radio sets and communication protocols. Therefore, in developing a wireless network, the engineer needs to determine the best way to "wire" the wireless devices. The main differentiation, then, between "wired" and "wireless" systems is that wireless systems share the same data transmission medium with other devices.

With wired systems, additional instruments can be added by adding more wires. The limitation is the available I/O terminations available at the control system. With wireless systems, the limitation is the available bandwidth available for all instrument connections. This bandwidth is not unlimited and will eventually be exhausted in any wireless network for a given frequency band. Unfortunately, determining where this limitation is reached in a wireless network is not easy, or even possible, to do, until that saturation point is reached.

Certain activities must be completed prior to implementing a wireless instrumentation network in order to select the proper hardware devices, to insure reliable and secure data transmission, and provide the required throughput and data handling. These required activities include:

- Determination of the features, data throughput, and update rates required
- Completion of a wireless site survey to develop the correct topology and architecture
- Construction of the proper suite of applications required to process the data collected from wireless devices
- Development of a security and failure recovery methodology in case of transmission errors, power failure, etc.

Physically, the essential requirements of any wireless instrument network are fairly simple:

- Instrument or control device with a transmitting radio (wireless instrument)
- Power source for the wireless instrument

- Receiver (access point or gateway) capable of receiving communication from the wireless instrument or device
- Power source for the access point or gateway.

In order for the wireless instrument and the access point/gateway to communicate, the additional following wireless characteristics must also be considered:

- Physical characteristics of the space in which your wireless network will operate, including fixed tanks, pipes, etc., building materials, competing electromagnetic transmitting devices, and other interferences.
- Communication protocol following published and emerging wireless standards and radios [WiFi (IEEE 802.11g), Zigbee (IEEE 802.15.4), Bluethooth (IEEE 802.15.1), ISA100.11a (IEEE 802.15.4), etc.)
- Security features which limit access to the devices and networks to authorized users
- Applications capable of concentrating the data received from wireless devices and storing the results.

In the balance of this course, it is assumed that the discussion of wireless networks implies "wireless instrument networks". While many of the methods discussed are also applicable to WiFi networks of computers and telephony equipment, the scope of this paper is limited to instrument systems. So, with these items in mind, let's develop a method for getting started with wireless instrument networks in your plant.

4.0 Getting Started with Wireless Instrument Networks

As with any "new" technology to be introduced into an industrial setting, such as a wireless instrument network, the engineer will undoubtedly encounter many questions resistance from peers and from management. This is normal and to be expected, but the informed engineer will have an arsenal of data and technically-sound responses to these inquiries.

For those born prior to 1970, you can probably remember the introduction of electronic controls to industry. Why would a plant want to invest in new technology when the current technology (pneumatic controls) worked well? The engineer of the 1980's made the arguments for lower cost, more reliable operation, and less required maintenance. As we introduce wireless networks to modern industrial plants, we can use similar arguments in defending a choice to dive into wireless networks. As with the 1980's arguments, we must have knowledge of the technology, know how to apply it correctly, know the limitations of the technology, and know how to minimize or eliminate the risks in its implementation.

The author believes the best way to introduce wireless technology to an industrial plant is to do it slowly, using one process area, one specific piece of equipment, or one specific control loop as a starting point. Once successfully implementing wireless for this limited area, the wireless network can be expanded more easily into other areas. Using this "building on

success" method, the engineer can introduce the technology without opening the organization to unnecessarily high risks. Cost is also limited in this scenario, and valuable experience can be gained from this initial implementation.

So what process, equipment, or control loop best qualifies as the initial candidate for wireless implementation? The answer to that question obviously depends upon the plant and process, but the methodology for successful wireless network implementation is the same whether one loop or 1000 loops are being deployed using wireless technology. The balance of this course will focus on that methodology for success implementation.

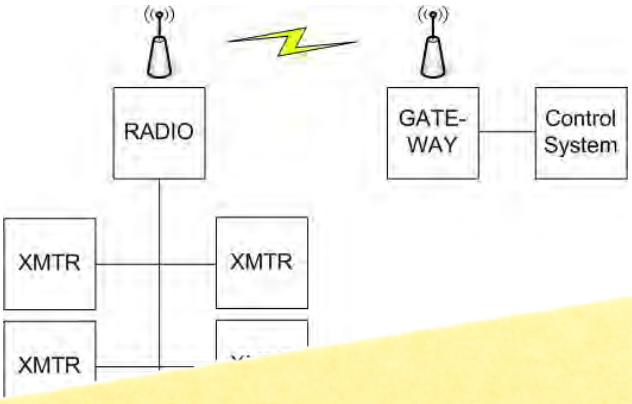
4.1 Determining the Scope of Wireless

The first step toward a successful wireless implementation is to decide which instruments should be on the wireless network. Whether the initial implementation is a single loop or an entire plant process area, the following steps are required and important to a successful implementation.

The decision of which instruments to include on the wireless network can be aided by understanding the major topologies used in wireless instrument networks.

POINT-TO-POINT CONFIGURATION

The simplest form of wireless instrument network is the point-to-point configuration. In this configuration, one radio at the wireless process transmitter is paired with the access point radio. This is usually the lowest cost option and one which works well for isolated process transmitters, such as the pressure at a remote location along a gas transmission line or a tank level at a loading dock.



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In a multi-poi devices are controlled from a central point in the c e preferred method for communicating with room temperature m points back to a building management system or for interfacing tank levels in a tank farm to the control system. This is also typically how multiple computers in a home or office wireless network communicate with a host or server computer. This configuration can typically handle large numbers of wireless devices, and is limited only by the gateway and the type of radio and wireless communication protocol.