ISA100.11a Completely Obviates the Need for WirelessHART

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Executive Summary

As wireless networks and applications become more pervasive in the industrial market, users are faced with the decision of choosing a network based on one of two emerging technologies, ISA100.11a or WirelessHART. This paper addresses the users' dilemma for selecting an appropriate infrastructure technology and demonstrates that the choice is easy: ISA100.11a offers a more powerful and comprehensive architecture which provides all the benefits of WirelessHART and more, therefore obviating the need for WirelessHART.

Industrial Wireless Networks

Wireless technologies provide many benefits to industrial and process automation. The obvious advantage is in wiring installation and maintenance savings. However, the value proposition for wireless communications extends beyond just wire replacement. For example, sensors and actuators can now be installed on rotating equipment. They can be installed on a temporary basis for troubleshooting or data gathering to gain process knowledge. Wireless networks also enable mobile applications like wireless workers and asset management.

It is no surprise that wireless networks have generated a lot of interest in the industry. Many users are experimenting with wireless communications using niche point solutions. Technology advances have made possible the development of solutions that meet the key requirements for the success of a wireless network - reliability, security and battery life.

A major complication is that the industry is currently littered with a huge collection of wired communication protocols like Modbus, FOUNDATION Fieldbus, HART, Profibus, DeviceNet, ControlNet and other similar standard and proprietary protocols. Industrial installations typically have a combination of several wired protocols. Each protocol runs over an infrastructure (copper wires) dedicated to it, so multiple protocols can easily coexist without interfering with each other or even being aware of each other's existence.

Unlike wired installations where each protocol has its own instance of the wired medium, wireless versions of these protocols need to share a common medium (air) and coexist without mutual interference in the same physical space. Thus, industrial wireless installations need an architecture that can accommodate all wired protocols. Uncoordinated point solutions cannot coexist without stomping on each other while transmitting at the same time, in the same space, at the same frequency.

HART Communication Protocol

The HART protocol was invented as a means to configure and get extended diagnostic data out of standard 4-20 mA field instruments using the same physical wiring as the control connection.

HART is an overlay application level protocol based on an extensible set of simple commands and responses which are transmitted digitally (encoded using Frequency Shift Keying – FSK) on top of the 2-wire physical layer as shown in the following figure:

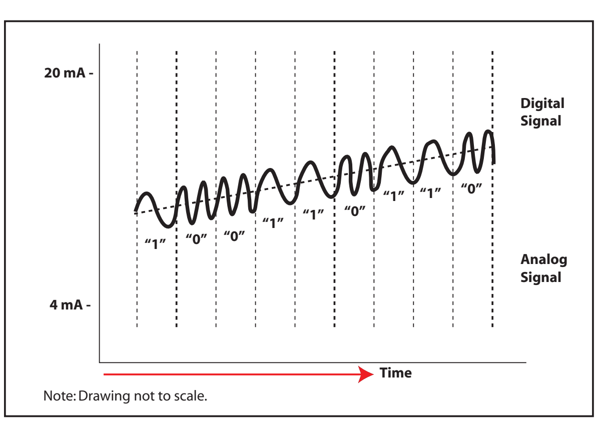

Figure 1. HART signal (courtesy of HCF)

The HART communication protocol is based on a simplified OSI layer model consisting of (i) an application layer on top of (ii) a basic data link layer on top of (iii) an actual physical layer – copper wire in the most basic case.

A typical system using HART to bring device diagnostics into a control system consists of HART-capable I/O modules that connect HART-capable devices into the control or maintenance system.

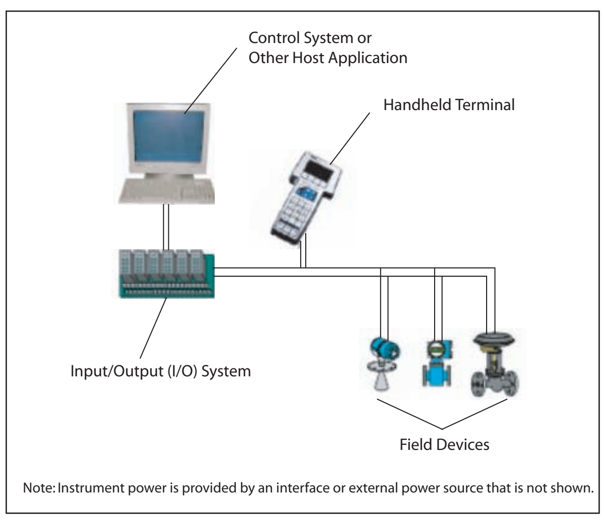

Figure 2. Typical HART system (courtesy of HCF)

Later HART implementations extended the model to run the HART application layer on top of serial buses such as RS-484 allowing some multi-drop capability; this capability was popularized by several HART MUX or multiplexer devices. The HART application protocol was carried over intact from the two-wire copper medium to the RS-484 serial link: the HART application command to read a primary value measured by the device looks identical whether it is transmitted over a copper wire as an FSK overlay or over a serial multi-drop bus.

This migration from one physical medium to another is very indicative of the industry trend – keep the application layer intact and adopt the lower communication protocol layers to make the best use of the new underlying physical communication medium.

Today, wireless is a new medium that is steadily growing in popularity through the pervasive use of cellular, WiFi and other technologies. Thus, the time is ripe for HART applications to migrate to this new medium. However, this migration needs to happen in a way that obeys the constraints of the new medium; for example, the power required for wireless transmission needs to be taken into account for battery operated devices, the new medium needs to be shared by all communicating devices (including those running other protocols), etc.

WirelessHART

WirelessHART is a wireless communication protocol developed by the HART Communication Foundation (HCF) for the transmission of HART messages over a wireless medium instead of a 4-20mA or RS484 medium. A WirelessHART device uses the same command structure used in 4-20 mA based HART devices. Thus, a WirelessHART deployment enables only HART applications.

Industrial sensor and actuator networks need to allow all types of field devices to transmit their protocols/data wirelessly, not just HART. If one follows the WirelessHART approach, one must define individual wireless versions for every other field protocol (WirelessFoundationFieldbus, WirelessModBUS, WirelessProfinet, WirelessCAN, etc.).

However, unlike wired deployments, where the communications medium (e.g., copper wire) is dedicated to a particular protocol, in wireless deployments the communications medium (2.4 GHz frequency band over the air) would be shared by all these protocols. These uncoordinated transmissions would interfere with each other leading to chaos: transmissions from different devices at the same time, in the same space (plant), at the same frequency would create interference and cause loss of the transmitted data. This data loss would reduce network reliability and availability and increase cost. Furthermore, managing several separate networks would be an operational nightmare.

The situation described above is analogous to building a variety of separate car washes, one for every car model and tailoring the dimensions of each car wash to the corresponding model.

Even worse, imagine that several different car washes were laid out in proximity so that the paths of cars through these car washes would cross and cause collisions.

Fortunately, engineers have figured a way to make adjustable car washes that can accommodate any car model. Similarly, there is a need for a universal wireless protocol that manages all transmissions irrespective of the protocol. This is what ISA100.11a accomplishes.

ISA100.11a

The ISA100.11a standard is a multi-functional standard for industrial sensor and actuator networks. It enables reliable and secure operation of a plethora of applications ranging from monitoring to closed loop control. It was built from the ground up on the requirements of simultaneously transporting application data from different application protocols to existing wired or new control systems.

ISA100.11a defines the OSI stack, system management, gateway, and security specifications for low data rate wireless connectivity with fixed, portable, and moving field devices. It needs very limited power consumption. The ISA100.11a wireless communication stack is developed specifically for harsh industrial environments and their unique demands on robustness, interference rejection and security.

ISA100.11a provides the infrastructure (capabilities and services) to enable an open interoperable application environment. The ISA100.11a application model can be "molded" to emulate legacy application layers for any wired fieldbus and integrates with existing systems. (This is analogous to a car wash that can adjust its brushes to trace the contours of any vehicle.) This application model permits the reuse of existing and proven tools and interfaces, and also reduces overall development and testing time, resulting in faster deployment of robust implementations.

Thus, the proper way for HART to migrate to the wireless medium is to interface its application layer on top of the ISA100.11a communication stack (built to accommodate all protocols) rather than invent its own dedicated stack.

Superiority of ISA100.11a

ISA100.11a has several features that make it superior and completely obviate the need for a dedicated wireless network of HART messages only (WirelessHART). These features include:

Tunneling & Mapping

Conveniently, the ISA100.11a protocol stack makes transporting various application protocols over a wireless medium very simple. Basic tunneling, smart tunneling and attribute mapping are three power tools that the ISA100.11a application sub-layer provides to facilitate wireless enablement of legacy protocols developed in the pre-wireless days.

Basic tunneling is the simplest tool available to transport pre-wireless application packets. It is a simple envelope in which you place your application payload (HART command or response in this case) and it gets delivered over the ISA100.11a wireless medium to the end device that does not even need to know that the data came in wirelessly. This is depicted in *Figure 3* below. It is like sending a letter in the mail: your document is packaged in an envelope and "mailed" or sent wirelessly to the receiver who opens the envelope to get your letter.

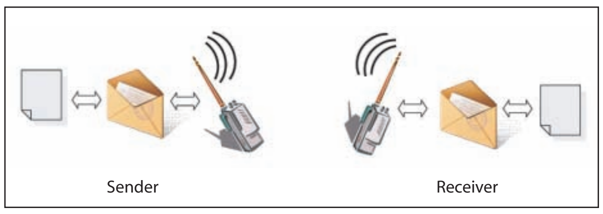

Figure 3. Basic tunneling concept

The main advantage of basic tunneling is that the end device does not need to change in order to make use of the wireless medium. Wireless capabilities can be implemented as an add-on board or even an external device. The disadvantage is that basic tunneling is practical only for instruments powered by the electric network that do not need to be concerned with battery life issues. The complete system for a HART application is then constructed as follows:

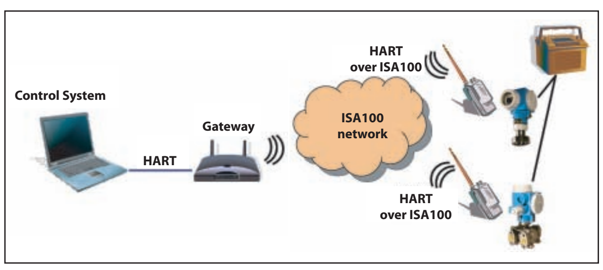

Figure 4. Radio add-on tunneling option

Smart or extended tunneling provides additional capabilities in the gateway devices that interconnect the wireless medium with the control system wired networks. Now instead of blindly forwarding every message to the field device, smart gateways may cache some of the data internally and respond with that cached data. The associated decrease in messaging over the air allows for new battery operated field instruments to be created. The resulting system is very similar to the basic tunneling case but, with a smarter gateway, external radios and external power can be eliminated as shown here:

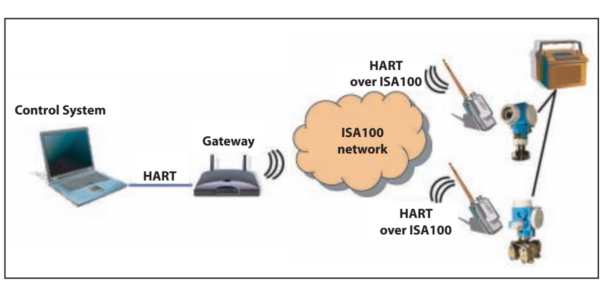

Figure 5. Smart tunneling system

A further elaboration of the ISA100.11a application theme defines a way to map any legacy application layer into a wireless-optimized ISA100.11a application layer and take full advantage of advanced wireless communication capabilities. When this approach is taken, HART messages are exchanged between the host system and a HART gateway device as before. The communication between the HART gateway and the field instrument can be based on a pure ISA100.11a application layer. The main advantage of this approach is that the ISA100.11a device can be incorporated easily into a system that speaks HART, Foundation Fieldbus, Profibus, DeviceNet or any other established industrial communication protocol:

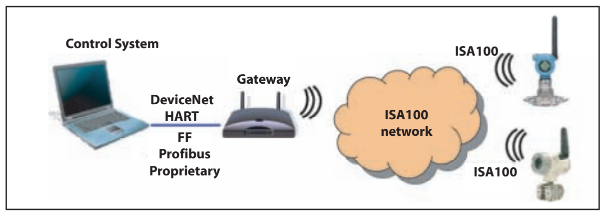

Figure 6. Attribute mapping concept

What is the user benefit then of selecting the less flexible approach of WirelessHART that can accommodate only HART devices when ISA100.11a can support all protocols, including HART? Nobody has been able to demonstrate any such user benefit.

Furthermore, nobody has been able to justify the rationale for maintaining a wireless stack dedicated to HART. Wireless technologies are still maturing. New radios, communication topologies and routing algorithms are constantly being developed. How will WirelessHART keep up with all this?

Fortunately, with ISA100.11a you do not have to worry about all this: you can rely on ISA100 to follow these technology trends, adopt best practices and develop communication standards that are flexible and perfectly suitable for every imaginable use in a range of different industries. All your applications (including HART) will automatically benefit from the latest in wireless technologies.

Backbone routing

Multi-hop networks tend to repeat the same message multiple times as the topology scales, thus draining the battery capacity of routing devices. One fundamental goal of the ISA100.11a architecture is to get the message to a high quality backbone as directly as possible, thus typically reducing the use of the ISA100.11a radio channel to one or two ISA100.11a wireless messages per report. WirelessHART has no such backbone.

Moreover, the backbone provides a way to increase the bandwidth available to messages as they move closer to the gateway. In typical industrial sensor and actuator networks, more and more routes (and thus data) converge towards the gateway to the legacy control system. The backbone provides the means to increase the bandwidth and maintain efficient communications near the gateway. This is analogous to a highway model, where for optimal transportation capacity, the number of lanes on a highway increases as the highway approaches the downtown area. It would lead to large traffic jams if all streets in a city were fixed to a single lane. WirelessHART is designed this way, where all wireless communications are 250 Kbps. For added flexibility, ISA100.11a does not specify what the backbone network is – it could be any high data rate network including wireless or wired Ethernet.

Conclusion: if you want your wireless network to scale to large numbers of devices and if you want the battery life of those devices to be long and predictable, then go with ISA100.11a.

Flexible time slots

The time slots in ISA100.11a are flexible and configurable, whereas time slots in WirelessHART are always 10ms. Three general modes of operation are supported by the ISA100.11a DLL: slotted channel hopping, slow channel hopping, and a hybrid. Through this flexibility, ISA100.11a can accommodate different sets of devices, ranging from those that transmit periodically and require time synchronization to those that transmit sporadically and sleep most of the time with no need for time synchronization.

Conclusion: if you want long battery life for your devices and if you want the ability to transmit urgent application messages without delays, go with ISA100.

Power saving redundant connectivity

The flexible time slot lengths in ISA100.11a mean that the network can be arranged so that a field device can transmit a message and this single transmission can be received and acknowledged within the same time slot by 2 or more routers. This provides redundant connectivity at low battery expense. The fixed slot length in WirelessHART does not allow this feature. Note that smart tunneling essentially means that this power saving redundant connectivity could be realized even with HART messages over ISA100.11a. Thus you are better off running your HART applications over ISA100.11a rather than WirelessHART.

Conclusion: if you want high reliability without wasting battery power, go with ISA100.

Conclusions

The industry needs a universal solution like ISA100. In fact, there is no real-world use case or application that a WirelessHART network can handle and SP100.11a cannot. In contrast, there are lots of applications (i.e., all non-HART protocols) that can run on ISA100.11a but cannot be accommodated on WirelessHART. Even HART applications can gain more benefits from an ISA100 network than a WirelessHART network. From an operational standpoint, ISA100 allows you to manage a single wireless network for all applications rather than deal with the difficulties of multiple networks. Based on the arguments above, it is clear that the ISA100.11a wireless system completely obviates the need for WirelessHART.

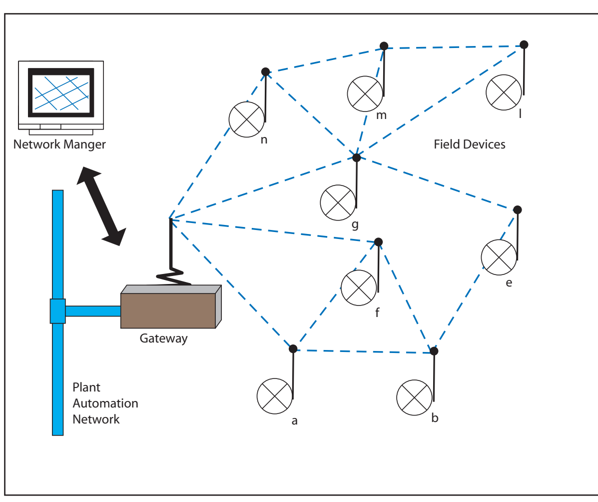

Figure 7. Wireless HART has no backbone (courtesy of HCF and ISA)

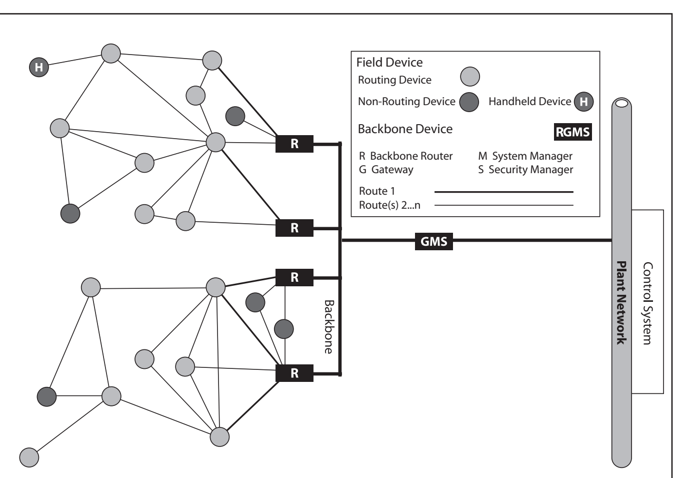

Figure 8. ISA100.11a defines a high speed backbone (courtesy of ISA)

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