Wireless Process Control- An Overview

V.A. Joshi

Head, Department of Instrumentation
VPM's Polytechnic, Thane , Maharashtra-400601
Email:vjoshi_vpmp@yahoo.com

Abstract-**Though wireless for process control has evolved for last couple of years, the industrial enterprises are not without doubt regarding the feasibility and success of this technology. In this review paper, I will discuss the need, advantages, limitations and challenges of the same. Also, the standards applicable and communication technologies are discussed.**

Key words- Wireless HART, ISA 100.11a

I. EVOLUTION OF PROCESS CONTROL SYSTEMS

Industrial processes control have undergone sea change from manual control to fully automatic in last 50 yrs. The signal transmission from the field devices to controllers have also evolved from **Pneumatic** (3 to 15 psi) to **electrical** (4 to 20 mA or 1-5 volts) to **Digital** to **wireless**. The basis of all these developments was to overcome limitations of previous technologies and yield a fast, reliable, safe and consistent output; yet cost effective and robust. To summarize;-

Pneumatics had a limited signal transmission distance and were incompatible with computers but were safe to be use in hazardous areas.

Electrical signal wires were difficult to manage as the process I/O s increased (min 2 wires from every device travelled from field to central control room) and data carrying capacity was limited.

Arrival of ***digital*** signals enabled multiple data items to be transmitted over the same co axial cable as well as enabled two way communications – evolution of field bus.

II. NEED FOR WIRELESS TECHNOLOGY

Where the process plant modules are geographically distributed and spread over difficult terrain, it is a herculean task to lay the cables through tunnels or trenches to connect the field devices to controllers to gather plant data. This is not only time consuming; but it also limits data acquisition rate and compromise on safety of the plant and thus directly translate into increased cost.

Furthermore, global competition is driving the industry to continuously improve process operations, product quality, productivity, reliability and compliance with regulations (IWC, 2002). The newer projects often demands cost competitiveness and faster execution time. Today's fast changing economic environment demands flexibility and ease of scalability of the plants and newer wireless technology promises the same. The refineries and petrochemicals plants employ hazardous process and require fast recovery/rebuild time after a fire/explosion incidence. The cabling and wiring of the classical wired control system often are the hindrance.

III. ADVANTAGES OF WIRELESS CONTROL

The wireless technology scores on following points over the conventional wired systems.

- Ease Of Installation: Wired Installation takes weeks whereas wireless can be installed in days wherein installation of End points only is required.
- Scalablity/Modularity: Several slaves (nodes) can be controlled by a single Master.
- Fail Safe: Harsh Industrial environment can damage the wires leaving the operator blind to the process. Wireless systems are capable of informing the operator if the communication link is broken. The slave will continue to control the process with its preprogrammed fail safe values.
- Flexibility: wireless can seamlessly integrate with the existing wired system.
- Reliability: Three factors determine the signal reliability-signal strength, signal loss and RF interference.
- Self - diagnostics: The system continuously monitors additional signals like signal strength, bit error rates, battery life etc.along

with the intended signal and issue a warning to notify the operator of any impending abnormalities.

- Low power consumption: Is particularly useful for remote places where small batteries/ Solar Panels will serve the purpose
- Data integrity: All the data contains error checking bits to ensure error free transmission. If there is any discrepancy, the messages are sent again at different frequency.

IV. WIRELESS PROCESS CONTROL ARCHITECTURE

Automation in process control is achieved by collecting data from sensors or field devices which are distributed in the plant. These wireless sensors are equipped with transmitters to convert signals from process control instruments into radio transmission. The receiver then converts this wireless signal into desired output

There are three levels of process control system as shown in figure 1[1]

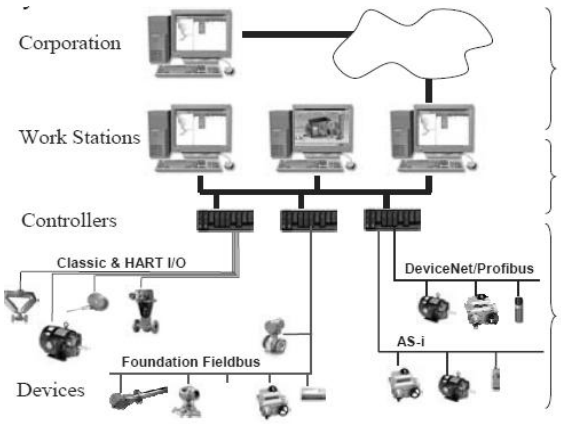

Figure 1. A Process Control System

Lowermost level connects the process to controller through Field devices. It has tight real-time requirement . The network protocols used are HART, FF, devicenet etc. Level 2 has less timing requirement but still requires good reliability. It employs s proprietary protocols or Ethernet. Level three links the process with management systems.

The wireless level is primarily used at level one as shown in in figure 2 which requires reliable short range data transmission.

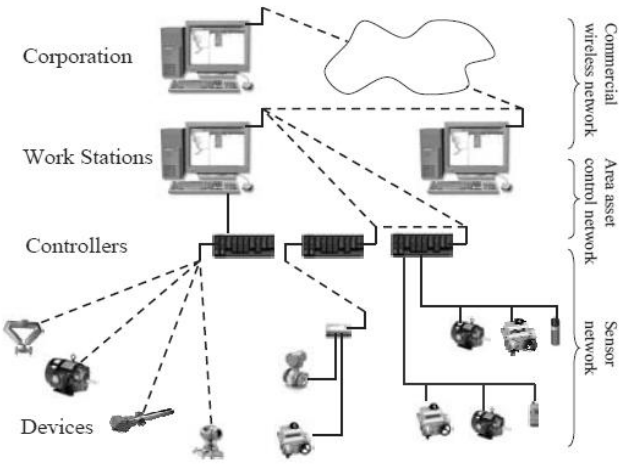

Figure 2 Wireless Process control system

V. INDUSTRIAL COMMUNICATION STANDARDS

Several technologies have evolved to address the needs of wirelss control. The two major ones are

WirelessHART is an extension to the well-established and well-supported HART Communication Protocol Standard

ISA100.11a developed by ISA SP-100 standards committee aims at a completely new communication standards including management and security design. ISA100.11a is defined as a universal wireless communication.

WIRELESS HART

It is a wireless communication protocol for process automation applications.[2] It utilizes a time synchronized , self healing, self-organised and redundant path mesh network which operates on 2.4 GHz ISM band. As shown in figure 3, it consists of

a. Wireless field devices connected to process field devices
b. Gateway for communication between field devices and plant wide communication network.
c. A network manager responsible for overall control and supervision It is based on IEEE 802.15.4 radio standard operating at 2.4 GHz. For safety and reliability, it employs DSSS technology and frequency hopping and TDMA.

Each device serves as a router for messages from other devices

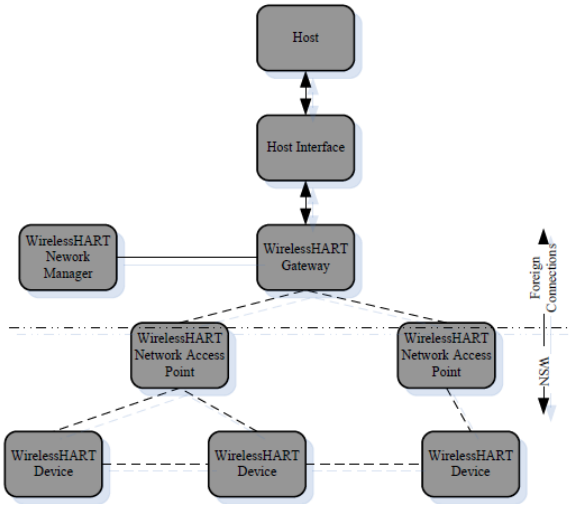

Figure 3. Wireless HART management Architecture[5]

ISA100.11A STANDARD

In September 2009, the ISA has published the ISA100.11a wireless communication standard for industrial automation.[4] Figure 4 shows a typical field wireless system configuration based on the ISA100.11a. The wireless field device is a field device with wireless communication capability, and the gateway is an interface between the wireless network and applications, and has a gateway function for upper control systems such as a distributed control system (DCS). The backbone router has a function to interconnect between the wireless field devices and between a wireless field device and gateway. The system manager and security manager have functions to control and manage the behavior and security of the wireless network. As shown, it is possible to provide redundant paths between the controller and wireless field devices via multiple backbone routers, and also possible to provide multiple communication paths from the wireless field devices to the backbone router. The ISA100.11a defines the many basic functions to improve data arrival reliability in communication

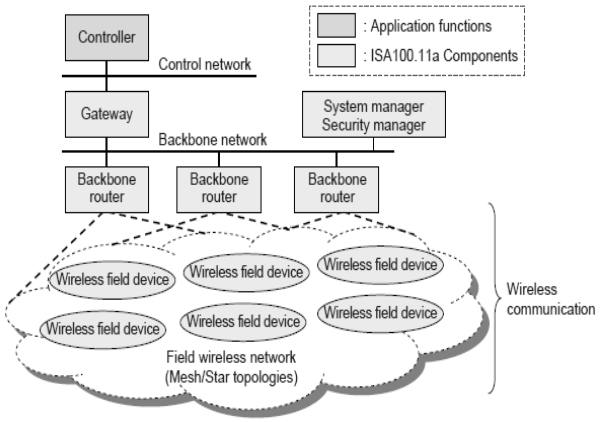

Figure 4 ISA 100.11a system Architecture

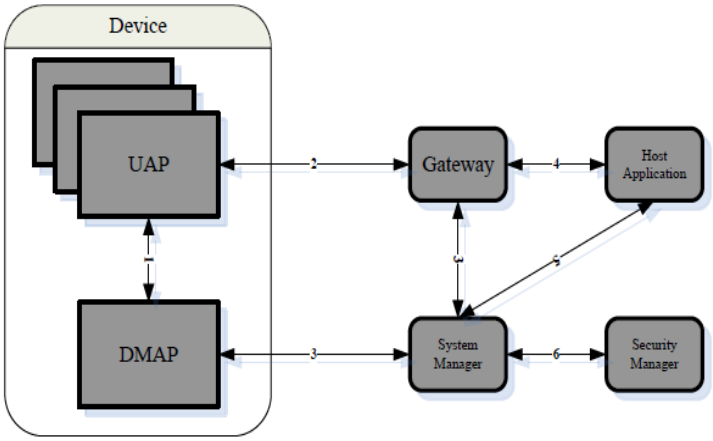

Figure 5. System Management architecture in ISA 100.11a[4]

VI. WIRELESS HART VS. ISA 100.11A[6]

Criteria	ISA 100.11a	Wireless HART
Architecture	Backbone device, provisioning, security manager, subnet definition	Network access points. Peer to Peer Communication risky.
Digital Link Layer	Three Channel hopping scheme Programmable time slot(10-14 ms)	One Channel hopping scheme Fixed time slot(10 ms)
Neighbour discovery	Active and Passive	Passive
Network Layer	3 header specifications	1 header specification
Addressing	Based on IP v6	Based on HART addressing
Tranport Layer	Connectionless service; end to end session security	TCP like reliable communication service.
Application Layer	Object orientation Support legacy protocol tunneling	Command orientation Support HART protocol

VII. CHALLENGES OF WIRELESS PROCESS CONTROL

Any problem with the equipment or plant translates into economical loss, hence if the equipment is operated wirelessly, the reliability of the network is of utmost importance. Therefore, parameters like robustness, guaranteed message delivery, security and integrity are important for industrial use.

Amongst the various challenges which are associated with the use of wireless communication, the two important ones are related to security and interference.

Data and Network Security: Data could be tampered while it is air borne. The use of wireless for transportation of vital process information hence requires incorporation of data encryption and advanced security measures.

Interference: The use of licence free radio channel for communication is susceptible to interference from other nearby sources operating in the same band. If the ISM **(**Industrial, Scientific and Medical) band is to be used for communication, then it requires network coordinator to continuously assess the channel status to ensure reliable communications.

Authentication: To prevent unauthorized devices from entering the network, all the devices need to authenticate themselves to each other using unique and time sensitive keys.

Denial of service: This can jam the network disabling the author from receiving the alarms which can result into safety issue besides deteriorating performance.

Data Confidentiality; RF network is prone to eavesdropping and spoofing, careshould be taken to ensure the security. End to end encryption is a necessity.

Radio-waves in Hazardous Environments: Electromagnetic waves can cause currents to flow in metallic structures and if that flow is interrupted momentarily, sparks can occur resulting in ignitions in flammable atmosphere if induced voltage and current is large [3]

Other challenges include: guaranteed real-time delivery in unprotected radio spectrum, robustness, power management and effective utilization of limited bandwidth etc.

VIII. CONCLUSION

Over the years, wireless technology has been primarily used and proven for data acquisition of process parameters for the assets, spread over wide area or difficult terrain, for facilities such as oil wells, cross- country pipelines and remote tank farms. However, it had been a challenging task to implement this technology on a full scale for automation purpose in a complex and challenging environment like ECC (Ethylene Cracking Complex) or refineries. With the successful implementation of this technology by Shell, Belden and Yokogawa together at the Shell Eastern Petroleum Limited (SEPL), Singapore, a new benchmark has been set [8]. This would encourage more facilities worldwide now to consider wireless process control option for the automation and thus would result in faster maturation of the technology.

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