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Application of Wireless Technology for Control: A WirelessHART Perspective

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Abstract

Process monitoring and automation in the industrial sector are hitherto done over wired connection between devices. It is evident that the amount of wires required increased proportionally to the complexity of the industry and their installation is time consuming. The wires used in the industry must withstand the harsh environmental conditions, hence expensive to install and maintain. In the event of loss of connection due to accident or any other reason, the cost incurred as a result of the downtime is high. The highlighted problems necessitated the need for an open, interoperable wireless standard like WirelessHART that can overcome these problems. Three categories of applications running in any process plant with increment of criticality are for monitoring, control and safety. The current application of wireless technology including WirelessHART in the industry so far is limited to monitoring and some attempts are being made to apply it for control. This paper examines the extent to which WirelessHART technology is applied especially for the purpose of control.

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Keywords: WirelessHART; Gateway; Wireless Control

1. Introduction

Evolution of communication between field devices and control systems in the process and automation industry began with the 4-20mA analogue communication. Then, there comes the hybrid systems using protocols such as highway addressable remote transducer (HART) which combines both the analog and digital signals. This was followed by digital communication technologies such as Foundation Fieldbus and PROFIBUS and finally the wireless technologies such as WirelessHART and ISA100 Wireless standards [1,2].

The importance of wireless technology is becoming more glaring in both the public and industrial sectors [3]. Wireless technology employed in the wireless sensor networks (WSNs) is one of the most demanded technologies in the industry and is guaranteed to provide the same control services or even better than its wired counterpart [4–7]. In ad-

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dition, the WSNs have several advantages over their wired network counterparts[4]. Firstly, the technology eliminates the limitation associated with costly and cumbersome cabling[5]. This in turn will eliminate cable maintenance and greatly reduce the deployment, redeployment, installation and commissioning times of sensor nodes in the network. Secondly, the capability of wired networks can be extended to such areas where cables cannot reach (i.e., environments considered dangerous to run cables)[6]. Another advantage of WSNs is that they are self-organizing[7] with the ability to support large number of battery-powered nodes[8].

However, concerns about security, reliability, safety, device interoperability and integrity have caused great delay in the acceptance, adoption and deployment of the WSNs in the industry[9,10]. The reason being that, none of the available wireless technologies is matured enough to provide for real time performance[11]. Another reason for the slow acceptance and lack of widely adoption of the existing wireless technologies is the absence of an open standard that will ensure customers are not tied to a single supplier and also meets the stringent requirements of the industry[12]. With the coming on board of such open standards, the benefit of wireless technology will dominate the risks posed by uncertainties in deploying the technology in the industry[13].

Several industrial organizations such as HART Communication Foundation, ISA, WINA and ZigBee have been actively working on improving the application of wireless technologies in industrial automation. As a milestone of such efforts, the HART Communication Foundation released the version 7 of the HART protocol and ratified the WirelessHART in 2007[14,15]. WirelessHART is the first complete interoperable and open WSN standard, specifically designed for process measurement and control applications[16]. WirelessHART assured to maintain the tradition of simplicity and robustness known to users of the earlier versions of the HART protocol. The mesh topology structure of network allows for possibility of each device in the network to be used as a router to neighboring devices, thereby creating redundant routes and extending the range of the network. In case of any incidence of obstruction, interference or interruption in a given route, the self-organizing network simply reroutes the communication to another possible route in the mesh network. This feature of the WirelessHART network ensures increased reliability, up to 99.999%. In addition, the new standard is based on the HART protocol which has about 30 million devices already in operation and it is the most widely used communication protocol in the industry[14,17]. Hence, there will be need for very little training for the plant operators to start using the WirelessHART.

The application of modulation methods of both frequency-hopping spread-spectrum (FHSS) and direct-sequence spread-spectrum (DSSS) and the use of spatial path diversity and retransmission capability of the mesh network ensure high expectation of robust communication in the system. The standard has also taken care of the issue of data security; it has also ensured that the users have the choice of selecting the level of security required for their plant. This was made possible through the adoption of a multi-layered technique for data authentication and the use of well-tested encryption algorithms for encryption[14]. The typical structure of the WirelessHART network is shown in Fig. 1. The WirelessHART network consist of primarily five basic elements which include: (1) Field Devices that are attached to the plant process, (2) Wireless Handheld used for device configuration, diagnostics and calibration, (3) a gateway that connects host applications with field devices, (4) a network manager responsible for network configuration, scheduling and communication management between WirelessHART devices, and (5) a security manager that manages and allocates security encryption keys, and also keep track of devices approved to join the network[12].

The following parts of this paper is organized as follows. In Section 2, a classification and review of some wireless technologies in comparison to WirelessHART is presented. The application of WirelessHART to control both in the simulation and practical environment is discussed in Section 3. Section 4 highlights the challenges and research issues associated with applying the technology in the practical environment. Lastly, in Section 5 a concluding aspect of the paper is presented.

2. Classification of Wireless Technologies

WirelessHART is an improvement to the (wired) HART standard that offers a relatively low speed (e.g., compared to IEEE 802.11g) and cheaper wireless connection. Just like most of the communication standards devised for industrial application, the WirelessHART is based on the Open Systems Interconnection model (OSI) and it adopts the IEEE 802.15.4-2006 as the physical layer as shown in Fig. 2. Moreover, it operates in the near globally available unrestricted 2.4 GHz Industrial Scientific and Medical (ISM) radio frequency band using 15 different channels (11-26). A key difference between WirelessHART and other similar standards like ZigBee is that it specifies its MAC layer