Chapter 17
Emerging Technologies for Industrial Wireless Sensor Networks

Ivanovitch Silva
Federal University of Rio Grande do Norte, Brazil

Luiz Affonso Guedes
Federal University of Rio Grande do Norte, Brazil

Paulo Portugal
University of Porto, Portugal

ABSTRACT

The evolution of industrial networks can be summarized as a constant battle to define the universal technology that integrates field devices and applications. Since the Fieldbus wars in the 1980s, diverse wired solutions have been proposed. However, this scenario has been changing due to the introduction of industrial wireless sensor networks. In the last 10 years, the development of deterministic scheduling techniques, redundant routing algorithms, and energy saving issues has brought wireless sensor networks into the industrial domain. This new communication paradigm is governed by a de facto standard, the IEEE 802.15.4, and more recently also by the IEEE 802.15.5. However, there are signs of a new battle on the horizon with the new publicly available specifications of WirelessHART, ISA100.11a, and IEC 62601. In this chapter, to the authors analyze the advantages and drawbacks of these emerging technologies for industrial wireless sensor networks.

INTRODUCTION

In an automated system, the activities related to process control can be structured using a hierarchical model characterized by vertical and horizontal information flows. The former flows occur between entities in adjacent levels, while the latter occur between entities on the same level. These activities are closely related with the communications infrastructure that supports them, and therefore it seems natural to adopt a similar model for factory communications too.

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Although the number of levels used to characterize the control structure can range from four to six, being usually dependent on the type of industry (e.g. manufacturing, process), it is usual to employ only three levels to characterize the communication architecture: factory, cell, and field. Each level employs different types of networks, whose characteristics result from the application requirements that operate at each level.

Factory networks cover the needs of higher levels. The main activities found at this level are related to production, process and materials planning, engineering, finance, and commercial applications. Descending flows are related to manufacturing orders and also to their scheduling. Upwards flows concern the status of manufacturing orders, production quality, and requests for acquisition of materials/resources. Information flows within this level are characterized by high volumes of data, but without critical time requirements.

Cell networks cover the needs of intermediate levels. A cell comprises a set of equipments which cooperate for the execution of a given task. The main activities found at this level are scheduling, sequencing, and execution of tasks. Other activities are related to data collection concerning the performance or status of product quality equipment. Information flows for the lower levels include execution orders or control programs. Information flows from these levels concerns the status and results of executed operations and are characterized by medium or low volumes of data with demanding timing requirements, which in many cases may be critical.

Field networks meet the needs of the lowest levels. The main activities found at this level are linked with the direct control of the process, particularly with the execution of control algorithms. The interface with the process is performed by means of sensors and actuators, many of them already fitted with complex processing capabilities (smart sensors). Information flows within this level are characterized by small volumes of data with time critical requirements. Field level networks have specific requirements that result from the nature of the applications that operate at this level. These requirements include the support of periodic and sporadic data with real-time constrains, fault tolerance regarding equipments and data transmission, high reliability, and safety aspects.

The main differences between cell/field networks and office networks result from the limitations of the technologies and the application requirements. However, technological progress has led networks that were originally designed to be used in offices (e.g. Ethernet, WiFi) to industrial domains. To better understand this context it is necessary to consider the evolution of industrial networks, from the earlier technologies to the most recent ones.

WIRELESS COMMUNICATIONS IN INDUSTRIAL ENVIRONMENTS

The emergence of technologies for industrial wireless networks was a natural evolution of the legacy industrial communication technologies. The proposal to eliminate field wiring and use a new paradigm for data transmission in industrial environments is not recent. Lessard *et al.*(1988) developed one of the first works in this area in an attempt communicating industrial devices for infrared. According to colpo and mols (2011), the use of wireless equipment can reduce installation costs by 50–90% compared to scenarios where wired devices are used. Despite eliminating costs, industrial wireless networks still face many challenges. Some open issues are related to addressing, routing, managing devices with limited physical capabilities (energy, processing, memory, etc.), security and privacy, dealing with heterogeneous technologies, safety, and standardization. Other relevant issues to be analyzed are dependability requirements (reliability and availability), as faults

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