Invention Journal of Research Technology in Engineering & Management (IJRTEM)
ISSN: 2455-3689
www.ijrtem.com Volume 1 Issue 12-Version-3 ǁ November. 2017 ǁ PP 30-32

Wireless Sensor Networks in Chemical Industry

Matthew N. O. Sadiku[1], Sarhan M. Musa[1], and Osama M. Musa[2]
[1]*Roy G. Perry College of Engineering Prairie View A&M University*
Prairie View, TX 77446
[2]*Ashland Inc. Bridgewater, NJ 08807*

ABSTRACT: *When it comes to implementing new technologies such as wireless sensor networks (WSNs), the chemical industrial community has been cautious for reasons ranging from safety to the high cost of production. WSNs promise significant advantages in terms of flexibility, cost, autonomy, and robustness compared with wired networks. They are poised to become a major enabling technology in many sectors, particularly the chemical industry. This paper briefly describes how the chemical industry can benefit from wireless sensor networks.*

KEY WORDS: *wireless sensor networks, chemical industry, industrial wireless sensing*

I. INTRODUCTION

Wireless sensor networks (WSNs) are collections of compact-size, inexpensive, heterogeneous computational nodes that can sense the environment, communicate with neighboring nodes, and perform basic computations on the data being collected. WSNs are everywhere. They are gaining ground in all sectors of life; from homes to factories, from military to health applications. They can reduce costs, increase productivity, and ease maintenance. They are deployed in unpleasant, inaccessible or hazardous environments which are impractical with normal wired systems. The increased adoption of wireless sensors across industry is due to practical reasons. These reasons include ease of implementation (no cable runs), ability to operate in harsh environments, easy troubleshooting and repair, and high levels of performance [1]. Industrial wireless sensing has now become more economical, efficient and secure compared to traditional wired sensing [2]. The adoption of wireless sensor networks is prevalent in the oil and gas, mining, and water/waste water industries. They are particularly used where wireline systems cannot be deployed. A typical example of an industrial WSN is shown in Figure 1 [3].

II. BASICS OF WSN

A wireless sensor network usually consists of a large number (hundreds or thousands) of sensor nodes deployed over a geographical region. The geographic region could span a single manufacturing facility to a network of remotely coupled sites. Typically, sensors are deployed in a high-density manner and in large quantities. The wireless sensor nodes are compact, light-weight, battery-powered devices that can be used in virtually any environment. The sensor nodes monitor physical or environmental conditions such as temperature/heat, humidity, sound, vibration, pressure, light, object motion, pollutants, the presence of certain objects, noise level or characteristics of an object such as weight, size, speed, direction, and its latest position. Each sensor node is made up of four components: a power unit, a transceiver unit, a sensing unit, and a processing unit. The node may also have some application-dependent components such as a power generator, a location finding system, and a mobilizer if sensor transport is required. Communication among the nodes is done in a wireless fashion, thus the name wireless sensor networks.

Wireless sensor networks belong to the general family of sensor networks that employ distributed sensors to collect information on entities of interest. In general, there may be both sensing and non-sensing nodes in a wireless sensor network; i.e. all sensors are nodes but not all nodes are sensors. A sensor has four operating modes: transmission, reception, idle listening, and sleep. As with any network of independent communicating devices, network collisions occur when there are two or more nodes transmitting at the same time and these situations need to be readily handled. Wireless sensor networks typically operate at 900 MHz (868- and 915-MHz bands). A sensor node is designed to use an operating system (OS). TinyOS (developed at UC Berkeley) is perhaps the first operating system specifically designed for WSNs. It is a general-purpose OS. Both the TinyOS and programs written for it are written in a special programming language called nesC, which is essentially an extension of the C programming language [4].

III. APPLICATIONS

Wireless sensor network applications are extremely broad: military, environmental, medical, health, home, smart electrical and other grids, and commercial applications. In the chemical industry, WSN applications can be classified into two broad categories: monitoring and tracking [5].

- **Monitoring:** Wireless sensor networks facilitate the monitoring and controlling of factories, offices, homes, vehicles, cities, and plants. The monitoring may involve physical parameters such as temperature, humidity and light. In the chemical industries, manufacturing wastes are stored and processed in a particular location at a manufacturing or processing site. By implementing efficient monitoring sensors in and around the chemical industrial environment, the hazards of chemical wastes can be minimized [6]. A major pharmaceutical manufacturer may decide to instrument all of its R&D equipment and connect them to the company's control systems for 24/7/365 monitoring. Monitoring may also include water/petroleum pipeline monitoring, security monitoring, environmental monitoring, and pollution monitoring.

- **Tracking:** The sensors nodes were deployed in such a way that more than one node would be triggered if an intruder enters the area covered by the WSN. This makes them suitable for tracking applications. These include tracking objects, animals, humans, and vehicles. For example, one can track the development of an acidic chemical plume applied to the monitoring environment through a point source [7].

Other applications include manufacturing automation, sensing, and control, security, surveillance, and warehouse inventory. The safety and security of oil pipelines is largely handled by wireless sensor networks.

IV. CHALLENGES

For WSNs to become widely adopted in the chemical industry, a number of challenges must be overcome. Sensor nodes are usually designed with minimal complexity for large-scale deployment. They cope with resource constraints such as limited supply of operating energy, limited bandwidth, exposure to interference, and limited computing power and memory resources [8]. Power consumption is an important issue that needs to be taken into account during design. For example, in a distributed chemo-/biosensing application, the energy demands and reliability of the sensor are major limiting factors [9]. Sensor networks have a wide range of diverse applications, but the design of sensor networks is application specific. They are exposed to many security threats that can endanger the success of applications. They need a high level of security, but their security is technically challenging due its exceptional design characteristics. The security requirements in wireless sensor networks are availability, authorization, authentication, confidentiality, integrity, and non-repudiation [10]. Open standards are needed at the network and management protocols. It is important to specify relevant standards so that sensor products from different manufacturers can interoperate. The Wireless Industrial Networking Alliance (WINA) and IEEE develop standards for wireless communication.

V. CONCLUSION

A wireless sensor network typically consists of a large number of sensor nodes working together to monitor and obtain data about the environment. Industrial chemical wireless sensor networks offer several advantages over traditional wired industrial monitoring and control systems. They have been regarded as one of the most important technologies for the twenty first century. They have attracted great interest in both academia and industry. Development of such networks requires the integration of sensor technology, information processing technology, and network communication technology. Wireless sensor network technology will have a significant impact on the chemical industry in the 21st century. More information on industrial chemical wireless sensor networks can be found in several books on them available at Amazon.com.

REFERENCES

[1] David Greenfield, "Why wireless sensor networks are everywhere (almost)," November 2012, https://www.automationworld.com/article/food-and-beverage/why-wireless-sensor-networks-are-everywhere-almost

[2] A. A. Minhas and S. Jawad, "Wireless sensor networks in chemical industry," Proceedings of the 3rd Symposium on Engineering Sciences, Lahore, Pakistan, March 2010.

[3] K. S. Low, W. N. N. Win, and M. J. Er," Wireless sensor networks for industrial environments," Proceedings of the 2005 International Conference on Computational Intelligence for Modelling, Control and Automation, and International Conference on Intelligent Agents, Web Technologies and Internet Commerce, 2005.

[4] M. N. O. Sadiku, S. M. Musa, and O. D. Momoh, "Wireless sensor networks: opportunities and challenges," Journal of Engineering Research and Applications, vol. 4, no. 1, Jan. 2014, pp. 41-43.
[5] J. Yick, B. Mukherjee, and D. Ghosal, "Wireless sensor network survey," Computer Networks, no. 52, 2008, pp. 2292–2330.
[6] K. N. Kumar et al., "Future sensors and utilization of sensors in chemical industries with control of environmental hazards," Proceedings of 2nd International Conference on Environmental Science and Development, Singapore, 2011, pp. 224-228.
[7] S. Beirne et al., "Chemical event tracking using a low-cost wireless chemical sensing network," Proceeding of the EEE Sensors 2008 Conference, 2008, pp. 1615-1618.
[8] K. Sohraby, D. Minoli, and T. Znati, Wireless Sensor Networks: Technology, Protocols, and Applications. Hoboken, NJ: John Wiley & Sons, 2007.
[9] D. Diamond et al., "Wireless sensor networks and chemo-/biosensing," Chemical Reviews, vol. 108, no. 2, 2008, pp. 652-679.
[10] S. O. Amara, R. Beghdad, and M. Oussalah, "Securing wireless sensor networks: A survey," EDPACS, vol. 47, no. 2, 2013, pp. 6-29.

AUTHORS

Matthew N.O. Sadiku is a professor in the Department of Electrical and Computer Engineering at Prairie View A&M University, Prairie View, Texas. He is the author of several books and papers. His areas of research interest include computational electromagnetics and computer networks. He is a fellow of IEEE.

Sarhan M. Musa is a professor in the Department of Engineering Technology at Prairie View A&M University, Texas. He has been the director of Prairie View Networking Academy, Texas, since 2004. He is an LTD Sprint and Boeing Welliver Fellow.

Osama M. Musa is currently Vice President and Chief Technology Officer for Ashland Inc. Dr. Musa also serves as a member of the Advisory Board at Manhattan College's Department of Electrical and Computer Engineering as well as a member of the Board of Trustees at Chemists' Club of NYC. Additionally, he sits on the Advisory Board of the International Journal of Humanitarian Technology (IJHT).

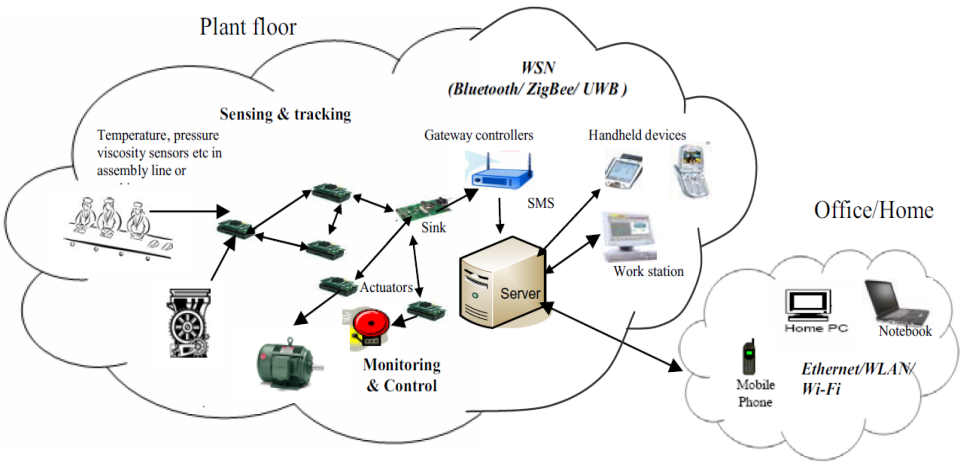

Figure 1. A typical industrial wireless sensor network [3].