Chapter 7

Wireless Sensor Network: Challenges in Underground Coal Mines

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ABSTRACT

Wireless Sensor Network (WSN) has an enormous prospective in hazardous areas such as underground coal mines. However, there is a need to ensure safety while installing WSN in underground coal mine as it is hazardous in nature and WSN radiates Radio Frequency (RF) signals which can be an eminent source of ignition. Henceforth when the underground coal mines are equipped with WSN there is a need to set the threshold limits of different physical parameters in order to eradicate such hazards for enabling safety. Therefore, in the present chapter, attempts have been made to assess the required safety for WSN while installing in underground coal mines. In addition, various types of hazards associated with underground coal mines and their consequences are elaborated in details with a glimpse to mitigate them with the use of WSN.

INTRODUCTION

Communication is derived from the Greek word communicare which means to impart or to make some information common. However, in case of electronics; it is related to the transmission of signals (data) for the sake of information swapping. It goes without saying that in the present scenario, communication is the need of today’s competitive world in terms of not only the day to day human life but also for the industries. However, underground coal mines being hazardous in nature are lagging behind in terms of underground communication in compared to other industries. However, underground communication is the need of the hour in terms of both safety and productivity. Proper and reliable communication
Wireless Sensor Network systems not only save the machine breakdown time but also help in the real-time monitoring of the underground condition and detecting/identifying any untoward incident prior to its occurrence. It can also help for speedy rescue operation in case of any disaster, if occurred. Keeping in view of the importance of underground communication technologies, researchers have been trying to improve it from the last few decades in which underground wireless sensor network (UWSN) (Trinchero, Fiorelli, Galardini, & Stefanelli, 2009) is one of them. Wireless sensor networks (WSNs) have emerged as a reliable technology for wireless data transmission from underground to a safer place or surface (Wang, Zhao, Liang, & Tan, 2007; Bandyopadhyay, Chaulya, & Mishra, 2010; Akyildiz & Stuntebeck, 2006; Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002; Aniss, Tardiff, Ouedraogo, & Fortier, 2004; Li & Liu, 2009; Chen, Hou, & Sha, 2004). WSNs are the cluster of sensor nodes which are arranged spatially in space to monitor different underground corporeal or environmental conditions, such as stress, strain, pressure, temperature, humidity, concentration of toxic and inflammable gases at different locations. The sensor nodes are equipped with a radio transceiver along with a microcontroller unit, digital signal processor and an energy source (Yick, Mukherjee, & Ghosal, 2008). Each sensor node is responsible for sensing an event and that event is remotely relayed to an end user which is being sensed with the aid of other sensor nodes. The whole system is incorporated with a power supply unit which is depicted in Figure 1.

WSNs should be designed by choosing the proper protocol in such a way that it should be energy efficient so that the lifetime of sensors can be longer. Energy efficiency is the most important performance index for WSNs due to the limited energy resource of the sensor nodes and their operations in hostile and unapproachable environments such as underground coal mines where replacement of energy resource might be impossible. The different protocols followed in WSNs focus mainly on energy awareness to prolong the functional lifetime of each sensor node and in turn the entire WSNs (Kaur & Garg, 2012; Sohraby, Minoli, & Znati, 2007).

The topology for data transmission is chosen on the basis of complexity, stability, optimality, redundancy, fairness, power efficiency etc. (Salhieh, Weinmann, Kochhal, & Schwiebert, 2001; Mumun, 2012; Leonard, Mellia, & Marsan, 1999). There are two types of topology which can be used for data transmission through WSNs, namely physical topology (Lewis, 2004) and logical topology (Mumun, 2012). Logical topology is defined as the path of the network on which the data travel, as opposed to the physical topology which refers to the appearance of the shape or layout of the network. Each network has a logical topology that may or may not be the same as its physical topology. For example, on a linear bus network, physical and logical topologies are the same; however the Token Ring topology (Dixon, Strole, & Markov, 1983) sometimes called star-wired ring topology is the most common example of a network with different logical and physical topologies. The comparison between logical and physical topology is depicted in Figures 2 and 3. Physical topology can be classified as bus, ring,
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