Chapter 14
Application of Wireless Sensor Networks in Industrial Settings

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ABSTRACT

Recent advances in computing and communication have caused a significant shift in wireless sensor network (WSN) research and brought it close to achieving its original vision. WSNs have gained much attention in both public and research committees, because they are expected to bring the interaction between humans, environment, and machines to a new paradigm. The development of WSN requires technology from three different research areas: sensing, communication, and computing (including hardware, software, and algorithms). Combined and separate advancements in each of these areas have driven research in WSN. Small and inexpensive sensors based on Micro-electro mechanical system (MEMS) technology, wireless networks, and inexpensive low power processors allow the deployment of wireless ad-hoc networks for various applications. This chapter discusses about WSN, industrial WSN, and technical challenges. One of the major challenges is reduction in power consumption. The chapter also discusses some of the major industrial applications and two case-studies of fire-fighting and home healthcare.

INTRODUCTION

Research on sensor networks started around 1980 with distributed sensor networks program at Defense Advanced Research project Agency (DARPA). By this time the Arpanet (predecessor of Internet) had been operational for a number of years with about 200 hosts at Universities and Research institutes. Current sensor networks can exploit technologies not available 20 years ago and perform functions that were not even dreamed of at that time. Sensors, processors, and communication devices are all getting much smaller and cheaper. In addition to sensor nodes,

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commercial off-the-shelf PDAs using palm or pocket PC operating systems contain significant computing power in a small package. These can easily be ruggedized to become gateway in a sensor network. Wireless Sensor and Actuator Network (WSAN) are networks of nodes that sense and potentially control their environment. They communicate the information through wireless links. The data gathered by the different sensor nodes is sent to a sink (base station) which either uses the data locally or connected to other networks such as Internet through a gateway, or control environment through the use of actuators (J.W. Gardner et. al, 2001). Increase in chip capacity and processor production capabilities has reduced the energy per bit requirement for both computing and communication. WSN can now be performed on a single chip, further reducing the cost and allowing deployment in large numbers. Advances in the development and integration of small battery-powered sensors have enabled the design of applications where a group of sensors cooperate in monitoring their environment. Wireless sensor networks are today used in a wide variety of areas like habitat monitoring, disaster management, health monitoring, and industrial control. Their applicability is often reduced by the limitations in the sensor nodes power supply, communication, bandwidth, processing capability, and buffer size. Many researchers have put effort in overcoming these shortcomings with a special focus on maximizing the battery life of a single node as well as the life time of the network as a whole. As applications become more and more mission-critical, it is crucial that the collected sensor data arrive at the sink within a specialized time limit. Guaranteeing a certain Quality-of-Service (QoS) to a user or an application is difficult because of the unpredictable nature of the wireless link and the often unstable topology of the sensor network (due to node failure or mobility).

In industrial environments, sensors are typically used to monitor the operation of a piece of equipment, an asset, or environmental conditions. Sensors are often used in locations that are inaccessible or hazardous to workers. The sensor data are then wirelessly transmitted to a sink node that analyzes the data from each sensor. Any potential problems are notified to the plant personnel as an advanced warning system. This enables plant personnel to repair or replace equipment before their efficiency drops or they fail entirely. In this way, catastrophic equipment failure and the associated repair and replacement costs can be prevented.

Intelligent Industrial Sensor Network

A wireless sensor network consists of a sink that can communicate with a number of wireless sensor nodes via a radio link. Data is collected at the WSN nodes, processed, and transmitted to the sink directly (single hop) or if required uses other WSN nodes (multi-hop) on the way to forward data to the sink as shown in Figure 1. The transmitted data is then presented to the system by the gateway connection. Individual sensors become smarter by adding micro-controller and become wireless by including transceiver in the sensor node. A micro-controller manages data collection from the sensors, performs power management functions, interface sensor data to the physical radio link, and manages the radio network protocol. Generally the radio subsystem requires the largest amount of power. Therefore, it is advantageous to send data over the radio only when required. The event driven data collection model of sensor requires an algorithm to be loaded into the node to determine when to send data, based on the sensed event. It is important to minimize the power consumed by the sensor itself. Therefore, the hardware should be designed to allow micro-controller to judiciously control power to the radio, sensor, and sensor signal coordinator. Due to small size and low power, multiple sensors can be deployed to perform an entire function such as monitoring atmospheric conditions at the position of a node. The size of a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust.