Chapter 17

Wireless Nanosensor Networks: Prospects and Challenges

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ABSTRACT

Nanotechnology is enabling the development of devices in a scale ranging from one to a few hundred nanometers, which can perform tasks such as sensing, data storing, computing, and actuation. These nano devices will be able to cover larger areas and perform more complex tasks through communication. Wireless nanosensor networks (WNSNs) are collections of nanosensor devices with communication capability. The key components of a WNSN include nano-nodes, nano-router, nano-micro interface, and gateway. WNSNs have numerous potential biomedical, environmental, industrial, and military applications. This chapter provides an overview of the architecture, applications, and issues associated with the development of WNSNs.

INTRODUCTION

Wireless nanosensor networks (WNSNs) are collections of nanosensors with communication capability. They can be used for sensing and data gathering with very high resolution and low power consumption. There are numerous potential applications for WNSNs. In the biomedical field, the WNSNs can be used in the health monitoring systems. They can also be used in the drug delivery systems. In industry, the WNSNs can be used to develop ultra high sensitivity touch surfaces and haptic technology interfaces. The network architecture of WNSNs is based on the following components:

- Nano-nodes,
- Nano-routers,
- Nano-micro interface devices,
- Gateway.

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Communication among nanosensors is of paramount importance in expanding the capabilities and applications of individual nanosensors. However, the development of effective communication among nanosensors currently faces several research challenges. This chapter provides an overview of the architecture, applications, and the research issues associated with wireless nanosensor networks (WNSNs). The chapter begins with a presentation of background information regarding nanosensors and WNSN. Next, the current developments pertaining to the architecture of WNSN and the communication among nanosensors are described. Following this description, an overview of WNSN applications is presented. Finally, the research issues associated with the development of WNSN are highlighted.

BACKGROUND

Nanosensors constitute one of the most promising applications of nanotechnology. A nanosensor is a device that is able to sense a physical or environmental property at the nanoscale level. Nanosensors make use of the unique properties of nanomaterials to detect and measure events in the nanoscale. However, due to its extremely small size, the sensing range of a single nanosensor is limited to its close nano-environment. A nanosensor network is needed to cover larger areas. A Wireless Nanosensor Network (WNSN), which consists of a collection of nanosensors, can be used to cover larger areas and to perform sensing and data collection with extremely high resolution and low power consumption (Kocaoglu & Akan, 2013).

Development of novel communication techniques is essential for WNSN design. Communication among nanosensors will expand the capabilities and applications of individual nano-devices. Two key approaches used for communication at the nanoscale level are nano-electromagnetic communication and molecular communication (Usibe, Menkiti, Onuu, & Ogbulezie, 2013). Nano-electromagnetic communication uses electromagnetic carriers for transmission and reception of information among components based on nanomaterials. The unique properties of nanomaterials will determine the specific bandwidths for electromagnetic radiation emission, the time log of the emission, or the emitter power strength for a given amount of input energy (Akyildiz & Jornet, 2010).

Molecular communication involves the transmission and reception of information encoded in molecules (Akyildiz, Brunetti & Blazquez, 2008). Molecular communication of nanoscale elements is an existing natural phenomenon and provides opportunities for developing solutions through modeling nanonetworks (Malak and Akan, 2012).

The WNSN applications are categorized into environmental, medical, industrial, and military. The WNSNs can be used in plant monitoring and plagues defeating systems. Biological nanosensor networks have potential applications in remote monitoring of physiological data. Distributed networks of nanosensors and nanoactuators can be used to release a specific drug in unreachable locations within a human body (Anwar, 2015). In the context of military applications, WNSNs can be used for armor damage detection and for the battlefield surveillance. In the arena of industrial applications, networks of physical nanosensors and nanoactuators can be used to enhance the remote control of machines of complex machines and devices. Moreover, the physical sensors can be used in a distributed arrangement to develop touch surfaces with high sensitivity and precision.

The development of WNSNs will need to overcome many challenges. The key WNSN research challenges are as follows: