Chapter 12
An Overview of Wireless Sensor Networks: Towards the Realization of Cooperative Healthcare and Environmental Monitoring

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ABSTRACT

Wireless Sensor Networks constitute one of the highest developing and most promising fields in modern data communication networks. The benefits of such networks are expected to be of great importance, since applicability is possible in multiple significant areas. The research community’s interest is mainly attracted by the usability of sensor networks in healthcare services and environmental monitoring. This overview presents the latest developments in the field of sensor-based systems, focusing on systems designed for healthcare and environmental monitoring. The technical aspects and the structure of sensor networks are discussed, while representative examples of implemented systems are also provided. This chapter sets the starting point for the development of an integrated cooperative architecture capable of widely providing distributed services based on sensed data.

INTRODUCTION

Lately, the focus of the research community is directed towards the development of flexible and extensive networks, which consist of small devices capable of collecting information regarding the surrounding environment. This procedure is commonly called “sensing” and the corresponding devices “sensors.” The realization of sensors has become recently possible and cost efficient, due to the significant advances in the field of wireless communications, hardware design, and computer networking.
A Wireless Sensor Network (WSN) involves multiple sensors that are capable of collecting data, perform some processing, and relay them. Sensors are expected to be able to interact with one another and act as intermediate nodes, when information needs to be routed over multiple hops in order to reach the destination. The latter is considered a central entity inside the WSN, often called “sink,” where all data are gathered, stored, and processed. The results can then be presented in a comprehensive and useful form, based on the specific case.

Thus, the sensing devices should incorporate components capable of gathering information from the surroundings, convert the measurements into digital form, and forward data using appropriate wireless transmission techniques, medium access control, and routing methodology. The required flexibility in topology is directly related with the need for self-organizing features among different sensors. In specific, the nodes are expected to cooperate and adapt to dynamic conditions, increasing the availability and reliability of the whole system. Taking into account that some popular WSN applications involve deployment in harsh environments, the necessity for self-management becomes even more critical.

The special area that has probably attracted most of the research community’s attention regarding WSNs is energy efficiency. Sensors are small wireless devices that usually need to operate on their own energy source for extended periods of time. Hence, power consumption is an issue of great importance that greatly affects the success and usefulness of multiple WSN applications. For this reason, different technologies make significant steps in optimizing energy conservation and ensuring efficient battery charging schemes. According to the specific application, sensors are allowed to transit to low power modes, increase the periodic transmission intervals or even switch on only upon request.

Since the decentralized approach in the operation of WSNs is becoming very popular among the researchers, the ad hoc wireless networks are thought as a promising solution for realizing a WSN. However, ad hoc computer networks are considered to constitute a networking paradigm that is significantly different from the sensor networking concept. Some key differences are listed below (Akyildiz, Su, Sankarasubramaniam, and Cayirci, 2002a, 2002b):

- A WSN may involve far more nodes than a typical ad hoc network.
- The sensing devices are typically placed close to each other to compensate for limited transmission range.
- Each sensor is more likely to fail.
- WSN topology is considered highly dynamic.
- Sensors commonly rely on broadcast transmissions instead of point-to-point links.
- Each node has limited energy, processing power, and memory.
- The involved devices may not carry globally set unique addresses.

Regarding sensors’ special characteristics, these are straightly related to their inherent resource constrains (Culler, Estrin, & Srivastava, 2004): The processing speed, the storage capacity, and the communication bandwidth are all limited. From the perspective of a system, WSNs exhibit substantial capabilities, but each device as an independent entity is significantly constrained in resources. Thus, sensors’ cooperation and self-organization are fundamental in fulfilling the network requirements.

The demands regarding the operation of WSNs may be significantly challenging; in most cases the sensors are expected to be functional for large time periods using just the energy produced by small size batteries. Since most power saving schemes involve long inactive periods, connectivity typically varies at a great degree, significantly affecting the overall system reliability. For this reason, the deployment pattern, the node density, and the...