Chapter 9
Implementation of a Smart Sensor Node for Wireless Sensor Network Applications Using FPGAs

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ABSTRACT
Applications that involve monitoring of environmental parameters require measuring devices to be placed at different geographical locations but are controlled centrally at a remote site. The measuring devices in such applications need to be physically small, consume low power, and must be capable of local processing tasks facilitating the mobility to span the measuring area in a vast geographic area. This chapter presents the design of a generalized, re-configurable, re-programmable smart sensor node using a Zigbee with a Field-Programmable Gate Array (FPGA) that embeds all processing and communication functionalities based on the IEEE 1451 family of standards. Design of the sensor nodes includes communication, processing and transducer control functionalities in a single core increasing the speedup of processing power due to inter-process communication taking place within the chip itself.

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1. INTRODUCTION

With rapid developments in modern science and technology, most of manually operated systems are transforming to automated systems because of easy controlling, faster performance and low operation cost. In this scenario, the sensor network concept plays a vital role in a variety of fields, especially in control and systems science. Wireless sensor network applications can be categorized under selected general headings such as “military”, “environmental monitoring”, “commercial” “human centric”, “robotics” etc. (Arampatzis et al., 2005; Xia, 2009; Gilbert et al., 2012; Akyildiz et al., 2002).

Military applications make use of wireless sensor network technology for enemy tracking, battlefield surveillance and target classification. One such example is a network of sensor nodes which are capable of detecting metallic objects that track vehicles and armed soldiers with significant metallic content, specifically by ignoring other human beings (civilians) (Lamont et al., 2011; Arampatzis et al., 2005; Gilbert et al., 2012; Akyildiz et al., 2002).

Another major application category is environmental monitoring where it is further divided into three sub categories namely “Indoor environmental monitoring and emergency services” and other two outdoor monitoring application to “ecology” and to “agriculture”. In indoor environmental monitoring applications use optimally controls of the indoor environment, smoke and fire detection and inspect structural stability of a building after an earthquake etc. Those wireless sensor network applications mainly focus on the safety of the lives of people who live in indoor environments (Porter et al., 2005; Arampatzis et al., 2005; WTEC, 2004).

Under the category of “ecology”, wireless sensor network technology is the ideal one for remote monitoring and event detection in large regions or inhospitable areas such as natural environment monitoring parameters (temperature, humidity, wind speed etc.) and record information about animals’ behavior according to the climatic changes. In the animals’ behavior monitoring applications, researchers have used mobile and static nodes to setup a wireless sensor network. Mobile nodes were installed inside the animals and static nodes were collected stored information from mobile nodes, when animal runs across static nodes (Arampatzis et al., 2005; Akyildiz et al., 2002; Mainwaring et al., 2002).

In agriculture sector, wireless sensor technologies are used to enhance the efficiency and monitor the growth of cultivations. By acquiring details of soil conditions and micro-climate with wireless sensor network would benefit to farmers to improve their productivity and efficiency (Arampatzis et al., 2005).

In commercial applications, RF ID tags are used for inventory control systems and GPS embedded nodes which are installed in vehicles to track the transportation network. It is feasible to track the vehicles and detect faulty parts of a vehicle...
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