Chapter 6
Wireless Sensor Networks (WSN) Applied in Agriculture

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ABSTRACT

This chapter presents an overview of recent developments, challenges and opportunities related to the application of wireless sensor networks (WSN) in agriculture. The material presented here is introductory in nature and has been designed to be useful for students starting to work in the field of WSN and for researchers looking for state-of-the-art information in general or specific details related to their practical application in agriculture.

INTRODUCTION

In the 1950's, computers were so bulky that a person could literally walk inside of them. These days, some computers are still large enough to fill an entire building, but the big difference is that the modern ones are actually clusters composed by millions of processors interconnected to work collaboratively, achieving a processing power unimaginable for most people. Microprocessors have become so small and powerful that, in contrast to the old days, computers are beginning to "walk" inside of us. For instance, one application that is being explored for medical purposes is to insert a complex electronic device into a plastic bubble that can be swallowed by a person; this device will travel through the digestive system gathering images that can be analyzed by a physician in real time. This futuristic technology is not the only one of its kind. Combining in a single device a microprocessor, a link to the real world in the form of a sensor (e.g. to detect temperature, humidity or light, or to capture images) and a wireless com-

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munication interface, has been a common practice during the last decade or so. Other applications include automatic control of sunlight, temperature and humidity in greenhouses, automation of lighting, climate control, intrusion detection and security at home, in hotels or in office buildings, wildlife tracking, automatic inventory of containers on transoceanic carriers, etc. Usually, many such devices are deployed in the geographic area of interest and they are interconnected using the integrated wireless interface, thus creating what is referred to as a wireless sensor network (WSN).

WSN are becoming so commonplace that a standardization effort is underway. The IEEE 802.15.4 standard has been adopted as the best candidate for these types of networks. The Zigbee alliance, which is a group of companies that have joined efforts to promote the rapid development of this type of technologies, in addition to adopting the protocols described in the IEEE 802.15.4 standard for the signals to be used over the wireless medium (physical layer) and the mechanism to achieve an orderly access to the transmission capacity (medium access control), have taken on the task of creating a de-facto standard for the way the information will flow from the sensing nodes to the central repository of such data (routing), as well as for the techniques that the different types of application software will use to interact with the rest of the protocols (middleware, security, etc.). Other competing standards are IEEE 802.11 (Wi-Fi) and IEEE 802.15.1 (Bluetooth), but their use is far less widespread.

As mentioned above, researchers in companies and universities all over the world are working on applying the sensor network concept in many different areas, including agriculture, home automation and medicine. However, the true success of WSN will happen when commercial products are widely available and consumed. Its success will bring about the growth of other compatible technologies. For instance, when keeping track of a person's health signs (e.g. weight, blood pressure, temperature) and home status (e.g. energy consumed by appliances and lighting fixtures, available food in fridge and pantry, home temperature and humidity) becomes an everyday necessity, smart appliances will be needed as well as servers to concentrate and process all that information and to take the necessary actions. Stores will also need devices able to communicate with the smart appliances in the customers' homes to take orders and deliver goods. A fast and reliable network will have to be available to allow communication among such numerous and diverse devices. To give an idea of the potential growth, it has been predicted that just as billions of clients need millions of servers in the current Internet, the expected trillion wireless sensing devices to be deployed in the near future will have to be coupled to a billion other computers (Bell, 2007).

The February 2003 issue of *Technology Review* (MIT's magazine of innovation) listed 10 emerging areas of technology that will have a profound impact on the world's economy and on how we live and work (Van der Werff, 2003). The corresponding leading researchers and projects in each area are also highlighted. The first one on the list was *Brain-Wireless Sensor Networks*, which is nothing but the WSN concept we have described above. That was just the beginning of what has continued to be a sequence of successes and improvements for this technology.

Wireless technologies, in general, have been under rapid development during recent years. The types of wireless technologies being developed range from simple point-to-point two-node networks, to local-area networks covering short, medium or long distances. Examples are IrDA (Infrared Data Association), which uses infrared light for short-range, point-to-point, low-speed communications; body-area networks (WBAN), aimed at monitoring health signs or for gaming purposes; wireless personal area networks (WPAN) for short range, point-to-multi-point communications, such as Bluetooth and ZigBee; mid-range, multi-hop wireless local area network (WLAN), such as Wi-Fi; long-distance cellular

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