Chapter 18

Unattended Sensors in Marine Environments: Oxybuoy for Hypoxia Study

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ABSTRACT
This chapter discusses the use of unattended sensors and its use in marine environment. The authors present challenges of designing a marine sensor in harsh environments and a case study in implementing a marine sensor to study hypoxia. Hypoxia is a world-wide anthropogenic phenomenon related to pollution. The authors describe the construction of an inexpensive sensor buoy system, Oxybuoy, designed for long-term unattended oxygen sensor measurements. The technology is available to construct such sensor buoys. The authors showed a prototype based on commercial off-the shelf components: an embedded PC, an optical dissolved oxygen sensor, a temperature sensor, a Wi-Fi transmitter and a satellite transmitter. Its total cost is around $5,000 to construct, program and test a proof of concept of such sensor. The authors describe the buoy’s architectural design and three experiments that the authors carried out to demonstrate its viability.

INTRODUCTION

Unattended sensors can be divided into several classes based on their size and capabilities. Microsensors are small scale devices with low power requirements, processing, communication and storage capacity. Midsize sensor nodes have a higher power requirement but they have greater communication, storage and processing capabilities. There are a large number of diverse applications, where both microsensors and midsize sensors can be used successfully. In this chapter, the authors describe the most common architecture and applications for microsensors and for midsize sensors. The authors then focus on marine based applications of these sensors.

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Microsensors

The advances of processor manufacturing and sensing technology have enabled the construction of microsensors for the use in sensor networks. Researchers today are able to deploy these microsensors devices equipped with sensors and radio transmitters to measure the physical phenomena in the environment, gather data, relay to human operators as well as use actuators to influence this environment (Culler, Estrin, & Srivastava, 2004; Estrin, Govindan, Heidemann, & Kumar, 1999; Culler & Hong, 2004). Microsensors can be used in a wide range of applications from military surveillance (Arora, et al., 2004; Chhabra, Kushalnagar, Metzler, & Sampson, 2004; Maroti, Simon, Ledeczi, & Sztpanovits, 2004) to environmental monitoring (Oliver, Smettem, Kranz, & MAyer, 2005; Mainwaring, Culler, Polastre, Szewczyk, & Anderson, 2002; Brennan, Mielke, Torney, & Maccabe, 2004).

A single microsensor is limited in terms of processing speed, storage capacity and communication bandwidth. However, this makes their manufacturing cost very low. Due to their low cost, microsensors can be deployed in large numbers: hundreds, thousands or even hundreds of thousands of units. In such large numbers, the intended sensor nodes tend to be located closer to the observed phenomenon. The collected sensor data provides a far greater resolution than a few large scale sensors are able to provide. These allow the microsensor technology to provide solutions to problems that were previously impossible to solve. The most common application of sensor networks is monitoring (Oliver, Smettem, Kranz, & MAyer, 2005; Mainwaring, Culler, Polastre, Szewczyk, & Anderson, 2002; Brennan, Mielke, Torney, & Maccabe, 2004; He, et al., 2004; Tolle, et al., 2005). Among the most frequently used devices are Berkeley prototype sensor nodes called motes (Crossbow Technology Inc.). Motes are a convenient research and development platform because they are flexible and easy to operate. There are several families of motes: Mica, Mica2, Mica2Dot and MicaZ. All of them share a common Atmel AT-Mega128L microprocessor with a 32 kHz crystal and 4 Mhz crystal except for Mica2 which has a higher crystal clock of 7.37 MHz. The motes have a 10-bit ADC, two UART channels, an SPI bus and an I2C bus. All of them have an external serial flash memory of 512 KBytes. The motes have 3 programmable LEDs, except Mica2Dot, which has only one LED, to help in debugging. All motes have I/O connectors to interface with sensors and a programming board. Mica has an RFM TR1000 radio transceiver and is capable of radio communication in the frequency range from 902--928 MHz and 433.1 434.8 MHz. Mica2 and Mica2Dot provide better communication capabilities with the Chipcon CC1000 radio transceiver. They could operate on frequencies ranges which was from 868--870 MHz, 902--928 MHz, 433.1 434.8 MHz and 313.9 316.1 MHz. MicaZ provided a better range with a higher frequency in the range of 2400—2483.5 MHz using the Chipcon CC2420 transceiver. MicaZ is also the first in Mica family to support the IEEE 802.15.4 protocol.

All of the motes models run the TinyOS operating system (Hill, et al., 2000) which was specifically designed for such resource constrained devices. TinyOS is designed to be power efficient, modular, has a small memory footprint and is capable of supporting concurrency-intensive operations. Although TinyOS does not provide any hard real-time guarantees, it does support real-time query and feedback control of physical world. An application in TinyOS is a combination of the scheduler and a graph of components compiled into one executable. The architecture is event-driven with a single shared stack. TinyOS does not have kernel and user space differentiation.

Motes have frequently been used on land for monitoring purposes. One of the first successful deployments of motes is the habitat monitoring application developed by Mainwaring et al. (2002). This application recorded the temperature and humidity in a nature preserve. Mica motes were deployed