Chapter 43
Medium Access Control Protocols for Wireless Sensor Networks:
Design Space, Challenges, and Future Directions

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ABSTRACT

This chapter provides an overall understanding of the design aspects of Medium Access Control (MAC) protocols for Wireless Sensor Networks (WSNs). A WSN MAC protocol shares the wireless broadcast medium among sensor nodes and creates a basic network infrastructure for them to communicate with each other. The MAC protocol also has a direct influence on the network lifetime of WSNs as it controls the activities of the radio, which is the most power-consuming component of resource-scarce sensor nodes. In this chapter, the authors first discuss the basics of MAC design for WSNs and present a set of important MAC attributes. Subsequently, authors discuss the main categories of MAC protocols proposed for WSNs and highlight their strong and weak points. After briefly outlining different MAC protocols falling in each category, the authors provide a substantial comparison of these protocols for several parameters. Lastly, the chapter discusses future research directions on open issues in this field that have mostly been overlooked.

INTRODUCTION

The pervasiveness, self-autonomy, and self-organization of low-cost, low-power, and long-lived WSNs (Karl & Willig, 2006; Ilyas & Mahgoub, 2006; Li X. Y., 2008; Misra, Woungang, & Misra, 2009; Sohraby, Minoli, & Znati, 2007; Tubaishat & Madria, 2003; Akyildiz & Varun, 2010) have brought a new perspective to the world of wireless communication. This domain is destined to play a vital role to our future ubiquitous world as it extends the reach of cyberspace into physical and biological systems. Coupled with sensing, computation, and communication into a single tiny device, WSNs are

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emerging as an ideal candidate for several daily-life applications, particularly in monitoring and controlling domains. Demands placed on these networks are expending exponentially with the increase in their dimensions. The development of new hardware, software, and communication technology, and continuous refinements of current approaches is also pushing this domain even further. Besides the development of new algorithms and protocols, many commercial hardware vendors are also engaged designing novel and efficient architectures for sensor nodes[1]. Figure 1 shows some of the sensor nodes used for deployment, experiment, and evaluation of different WSN related applications, whereas Table 1 gives hardware details in terms of microcontroller, radio chip, and memory available to these platforms.

However, unique characteristics along with limited resources available to sensor nodes pose several challenges in the design of sensor networks. Integrating sensing, processing, and communication functionalities into a tiny sensor node has added a lot of complexities. Moving from sensors with only few hours of life time to one with many years of life time demands several iterations of energy efficient techniques. Shrinking size of nodes requires small size transceivers. Mapping overall system requirements down to individual device capabilities is not an easy task. Moreover, the direct interaction with the real world and the application-specific nature of WSNs require them to respond accordingly. As a result, a detailed understanding of capabilities, requirements, constraints, and limitations of WSNs is required.

Figure 1. Some of the common sensor platforms used by industrial and research organizations for several WSN related applications and testbed implementations. They differ from each other in processing, storage, and communication capabilities and are suitable for an application or the other.

(a) Tmote Sky (b) MSB-A2 (c) Imote-2

Table 1. Detailed hardware specifications of the WSN platforms shown in Figure 1

	Tmote Sky	MSB-A2	Imote-2
CPU - Speed	TI MSP430 8 MHz	NXP LPC2387 Upto 72 MHz	PXA271 XScale 13 – 416 MHz
Radio - Frequency - Data Rate - RX Current - TX Current - Modulation - Output Power	Chipcon CC2420 2.4 GHz 250 kbps 18.8 mA 17.4 mA DSSS +0 dBm	Chipcon CC1100 315/433/868/915 MHz upto 500 kbps 15.6 mA 28.8 mA 2-FSK/GFSK/MSK/ OOK/ASK +10 dBm	Chipcon CC2420 2.4 GHz 250 kbps 18.8 mA 17.4 mA DSSS +0 dBm
Memory - RAM - Flash	 10 KB 48 KB	 98 KB 512 KB	 32 MB 32 MB