Chapter 16
Hybrid MAC Layer Design for MPEG-4 Video Transmission in WSN

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ABSTRACT

Wireless Sensor Networks (WSNs) have been attracting increasing interest lately from the research community and industry. The main reason for such interest is the fact that WSNs are considered a promising means of low power and low cost communication that can be easily deployed. Nowadays, the advanced protocol design in WSNs has enhanced their capability to transfer video in the wireless medium. In this chapter, a comprehensive study of Medium Access Control (MAC) and MPEG-4 video transmission is presented. Various classifications of MAC protocols are explained such as random access, schedule access, and hybrid access. In addition, a hybrid MAC layer protocol design is proposed, which combines Carrier Sense Multiple Access (CSMA) and unsynchronized Time Division Multiple Access (TDMA) protocols using a token approach protocol. The main objective of this chapters is to present the design of a MAC layer that can support video transfer between nodes at low power consumption and achieve the level of quality of service (QoS) required by video applications.

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1. INTRODUCTION

The demand for connecting devices without cable with low power consumption especially at inaccessible areas and hazardous environments fosters the rapid advance in protocol design for Wireless sensor networks (WSNs). Moreover, WSN can be considered as a promising means to establish green telecommunication networks. It is a worldwide goal to minimise energy consumption of any design in the telecommunication sector and the importance of the energy efficiency in telecommunication industry are discussed in Koutitas and Demestichas (2010). To achieve this goal, both academia and industry should cooperate in order to design low energy consuming protocols and produce low power devices for the wireless sector.

Since 2003, the Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) released the new IEEE 802.15.4 standard for low rate wireless personal area network (LR-WPAN) (Man, 2006). The IEEE802.15.4 standard has been designed specifically for short-range communications with low-power sensor networks and can be considered with the resulting effect on low power consumption. This attribute makes the IEEE 802.15.4 wireless standard used widely in most WSN applications such as environmental monitoring, target detection, industrial process monitoring and emergency measures (Ismail, Yunus, & Ariffin, 2011). Recently, the availability of CMOS cameras that can be attached with wireless motes has enhanced the transmission capability in order to send the video applications in the wireless medium. Video applications based on WSN have significant importance due to their potential to collect visual information needed for security, military and scientific purposes.

In general, earlier wireless standards such as IEEE 802.11, IEEE 802.15.3 and Bluetooth are more suitable for video applications than IEEE 802.15.4 since they offer much higher data rates (Zainaldin, Lambadaris, & Nandy, 2008). However, this task can be achieved at lower cost and lower power consumption if IEEE 802.15.4-based devices were employed. The high energy overhead of IEEE 802.11-based networks makes this standard unsuitable for low power sensor networks (Dargie & Poellabauer, 2010). MPEG-4 video is one of the international standards for video encoding which offers high level of compression (Sikora, 1997). Therefore, it is more suitable for low-rate communications, specifically; it can be used in implementation of video transmission over IEEE 802.15.4.

This chapter focuses on MAC layer protocol design. MAC layer is responsible to control channel access that allows multiple nodes within a network to communicate. Moreover, the MAC layer has significant importance in wireless networks: it organizes how the channel is shared across the users, which directly impacts the system throughput, fairness, reliability and quality of service (QoS). The high QoS requirement for video transmission brings the necessity to design efficient MAC protocols. Recently, hybrid MAC protocols have appeared to be the most suitable for supporting real-time communication in WSNs. This is because they provide a mechanism to guarantee support for real-time traffic, while promoting energy efficiency and scalability (Misra, Reisslein, & Xue, 2008). To achieve reliable communication, the token passing mechanism is used in this hybrid MAC design to minimize collision and solve strict synchronization problem in schedule access method.

Most of the previous works on multimedia applications over IEEE 802.15.4 focus on image transmission, while the research on the video applications is still in earlier stages. The objective of this chapter is to provide the reader with an understanding of how the MPEG-4 video transmission can be applied in low rate IEEE 802.15.4 wireless standard medium, and how the token approach protocol is used in MAC layer design.

This chapter is organized as follows. In section 2, an overview of MAC layer protocol that covers three access methods areas, namely, random
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