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MAC Layer Issues and Throughput Analysis for the IEEE 802.15.3a UWB

Yang Xiao

Computer Science Division,
The University of Memphis,
373 Dunn Hall, Memphis, TN 38152 USA,
Email: yangxiao@ieee.org

Abstract. To provide faster transmission delivery with better quality, the IEEE 802.15.3a task group is pursuing a very high data rate physical layer, ultra-wideband (UWB) wireless communications for short range, in which raw data rate reaches 480Mbps and 110Mbps over distances of 1 meter and 10 meters, respectively. In this paper, we first introduce the standardization efforts of IEEE 802.15.3a and its current status at the physical layer. We introduce two proposals of the medium access control (MAC) layer for UWB communications. Then, we provide a throughput analysis for the MAC layer for UWB, and address several MAC issues such as suitability for higher data transmissions. We also derive several throughput limits such as N-limit, rate-limit, and throughput upper limit for the IEEE 802.15.3 MAC. Throughputs for combined contention period and contention-free period in both IEEE 802.15.3 MAC and IEEE 802.11 MAC are derived. Three acknowledgement policies are also considered: No-ACK, Immediate-ACK, and Delayed-ACK.

Keywords. CSMA/CA, IEEE 802.11, IEEE 802.15.3a, Ultra-wideband.

1 Introduction

Ultra Wideband (UWB) is a radio technology for high speed, short range, wireless personal area mobile devices. It promises to revolutionize home media networking, taking over such tasks as transmitting video, voice, images, data among HDTV (high-definition television) receivers, TV sets, computers, printers, digital cameras, etc., around a house/office. It can potentially replace any electronic signal cable (not power cable) on the premises.

On Feb. 14, 2002, Federal Communications Commission (FCC) approved a variety of UWB devices for usage within specific frequencies. UWB frequencies start at 3.1 GHz, above the bands assigned to GPS receivers and the IEEE 802.11b WiFi networks, and extend upward to 10.6 GHz.

Currently, the IEEE 802.15 working group begins working on a standard for a UWB-based physical (PHY) layer for high-speed Wireless Personal Area Network (WPAN). Different from the IEEE 802.11a/b/g wireless LANs, which provide up to 54Mbps data rate for a relative larger range, i.e., 100 meters approximately, UWB is suitable for short-range connectivity and provides raw data rate 480Mbps and 110Mbps over distances of 1 meter and 10 meters, respectively. Compared to existing wireless networking technologies, UWB offers greater data-carrying capacity, lower power use and potentially lower costs,

For UWB to reach its full potential, the industry must agree on the best way to implement the technology. There were total 31 UWB standard proposals submitted to the IEEE 802.15.3a task group. Many proposals are finally combined together into one proposal. The IEEE 802.15.3a task group is struggling to choose one among them as the draft standard for implementing UWB in short-range WPANs. The final two major proposals for IEEE 802.15.3a include the Multi-band orthogonal frequency-division multiplexing (OFDM) system and the direct-sequence CDMA. Xtreme Spectrum, partnering