Light Medium Access Control (MAC) Protocol for Wireless Universal Serial Bus (WUSB)

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Abstract

USB has arguably become the most successful PC peripheral interconnect ever defined. As appearing UWB, wireless USB (WUSB) emerges very popular technology. However, the distributed Medium Access Control (MAC) does not harmonize with the topology of WUSB. In this paper, we address a novel MAC protocol for conformity with WUSB. The protocol is to handle negotiation on Distributed Reservation Protocol (DRP) including the channel time slot of WUSB.

I. Introduction

The motivation of Universal Serial Bus (USB) came from both ease-of-use and port expansion. USB devices are widely spreading due to this motivation. USB has arguably become the most successful PC peripheral interconnect ever defined. In 2005, analysts predict there will be over 500 million USB products in use. Now, as technology innovation marches forward, wireless technologies are becoming more and more capable and cost effective. Ultra-Wide Band (UWB) radio technology, in particular, has characteristics that match traditional USB usage models very well. UWB supports high bandwidth (480Mb/s) but only at limited range (~3 meters). Applying this wireless technology to USB frees the user from worrying about cables; where to find them, where to plug them in, how to string them so they do not get tripped over, how to arrange them so they do not look like a mess disk and so on. It makes USB even easier to use. Because no physical ports are required, port expansion, or even finding a USB port, is no longer a problem.

However, UWB MAC that is defined at WiMedia Alliance does not conform to Wireless USB (WUSB). Basically, WiMedia MAC provides only distributed service and WUSB works on the centralized topology (Host to Device). Thus, WiMedia is defining the MAC convergence architecture between MAC and Applications (WUSB, Wireless 1394 or IP Networks). If the MAC includes and supports the conversions mechanism, it is easy to implement WUSB on UWB. In this paper, we propose a novel MAC for WUSB transmission.

The paper is organized as follows. In section II we provide the overall description of WUSB and WiMedia MAC and in section III we describe our mechanism. Implementation for MAC is shown in section IV. Finally, section V concludes our work.

II. Background

1. The Overview of Wireless USB

Logically, Wireless USB is a polled, TDMA based protocol, similar to wired USB. The Host Controller initiates all data transfers. Like wired USB, each transfer logically consists of three 'packets': token, data, and handshake. However, to increase the usage efficiency of the physical layer by eliminating costly transitions between sending and receiving, hosts combine multiple token information into a single packet. In that packet, the host indicates the specific time when the appropriate devices should either listen for an OUT data packet, or transmit an IN data packet or handshake. Figure 1 shows the conversion between USB and WUSB frames [2].

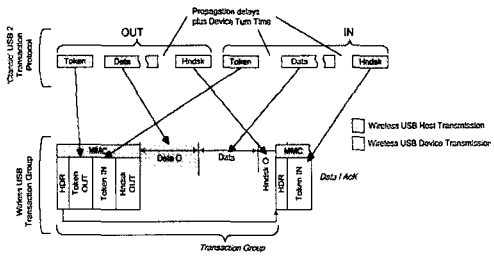

Figure 1. Wireless USB Transaction

Figure 2 shows the architecture of WUSB host and device.

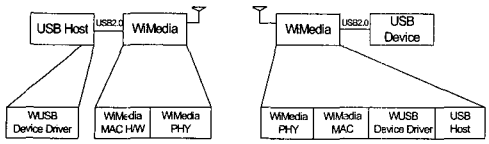

Figure 2. Wireless USB Architecture

Wireless USB maps the USB 2.0 transaction protocol onto the TDMA Micro-scheduling feature. The result is that the Wireless USB transaction protocol is essentially a split-transaction protocol that allows more than one 'bus transaction' to be active on the bus at the same time. The split-transaction protocol scales well (across multiple transactions to multiple function endpoints) with signaling bit-rates as it is not completely subject to propagation delays. The basic USB protocol is recognizable within the Wireless USB split transaction architecture, however there are modifications to certain aspects of the protocol in order to reduce or hide some protocol overheads [2].

2. The Overview of WiMedia MAC

When a WiMedia MAC is enabled, it scans one or more channels for beacons and selects a channel. If no beacons are detected in the selected channel, the device creates its Beacon Period (BP) by sending a beacon. If one or more beacons are detected in the selected channel, the device synchronizes its BP to existing beacons in the selected channel. The device communicates with members of its beacon group using the same channel the device selected for beacons. Each device operates in a dynamic environment and under unlicensed operation rules.

The MAC standard defines a MAC service and protocol. As shown in Figure 3, the MAC provides two transmission mechanisms [3].

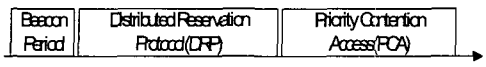

Figure3. The Superframe of WiMedia MAC

The PCA mechanism provides differentiated, distributed access to the medium for devices using 8 different user priorities. PCA is similar to Enhanced Distributed Control Access (EDCA) of IEEE 802.11e [1]. Before PCA, the DRP enables devices to reserve Medium Access Slots (MASs) outside the BP of the superframe. Reservations made by a device specify one or more MASs that the device can use to communicate with one or more devices in its beacon group. All devices using the DRP for transmission or reception, shall announce their reservations by including DRP Information Element (IE) in their beacons. This paper qualifies the transmission mechanism on DRP for WUSB. WiMedia MAC that is one of distributed MAC does not match WUSB.

III. Proposed MAC for Wireless USB

The basic idea of the proposed mechanism is that MAC sends negotiation reservation request to a destination. The destination allows MASs for transmission. During the negotiation, MAC recognizes several MAS information from several MMC frames. The MAC negotiates MASs in not the section of WUSB DRP but the section of negotiation after BP. The MMC consists of MAS information that devices passively follows. Figure 4 shows overall architecture of our proposed mechanism.

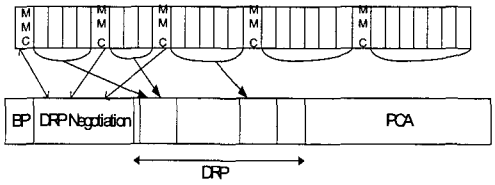

Figure 4. DRP Negotiation on MMC

MMC information is distributed on PCA protocol in the duration of MAS negotiation. The first transmission using PCA in DRP negotiation can be assigned to the first priority. On DRP section, the frames negotiated firstly have a change to transmit at first. It means that MMC negotiation in the section of DRP prevents delay caused by retransmissions on DRP. Even though the last transmissions on DRP were delayed, it would have not big deal due to be lowest priority. Figure 5 shows our proposed MAC mechanism.

Figure 5. Proposed MAC mechanism

IV. Implementation

The software is build as a single linkable library, which means that it runs in the context of an application task. The WUSB software are called directly from the including task. This approach provides the following benefits: The software contains only limited tasking knowledge, making it portable across operating systems. The use of a single library, as opposed to a library per layer, makes version control easier by eliminating

mix-and-match version discrepancies.

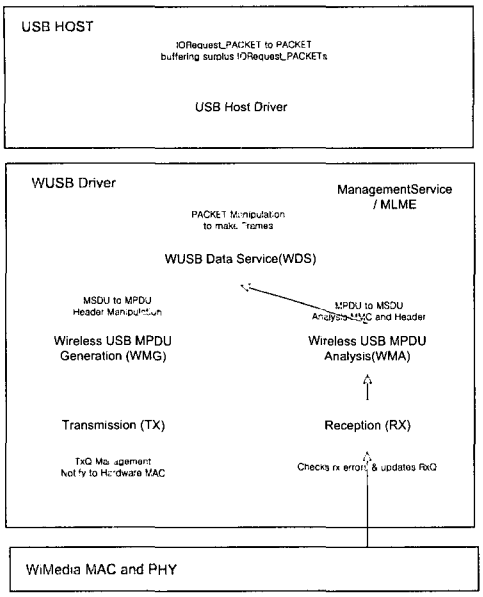

Figure 5.The Architecture of Device Wire Adaptor

USB host supplies a reserved time on Token. WUSB Driver assembles the time and arranges a time portion for MASs. WMG makes the negotiation request frame including the portion. After BP, the driver sends the negotiation request frame and receives a negotiation response frame. WMA analyzes the negotiation request including MMC so that the driver reserves MASs on DRP.

V. Conclusion

In wireless home networks, UWB is one of popular technologies and WUSB is a successful application on UWB. In this paper, the characteristics of the distributed MAC and the centralized WUSB have been shown and then we solve the bottle neck between the WUSB and the MAC. The proposed mechanism is MMC based negotiation on the WiMedia MAC.

References

[1] ISO/IEC 8802.11:1999 (ANSI/IEEE Std 802.11, 1999 Edition), Information Technology—Telecommunications and Information Exchange between Systems—Local and Metropolitan Area Networks—Specific Requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 1: High-speed Physical Layer in the 5 GHz band, May 1999

[2] USB Organization, "Wireless Universal Serial Bus Specification 1.0," May, 2005.

[3] WiMedia Alliance, "Distributed Medium Access Control (MAC) for Wireless Networks 0.95 Specification," Spring, 2005.

[4] A. Juha, M Jouni, R Jyri, "Wireless LAN Access Network Architecture for Mobile Operators," *IEEE Communications Magazine* , Volume: 39 Issue: 11 , November 2001

[5] S. Takahiro, T. Shuji, "Performance Evaluation of Priority-Based Multimedia Transmission with the PCF in an IEEE 802.11 Standard Wireless LAN," *Personal, Indoor and Mobile Radio Communications*, 2001 12th IEEE International Symposium on, Volume: 2 , Sep/Oct 2001.