A MAS Information Management Method for WiMedia MAC Protocol

Taewook Chung, Chulho Chung, and Jaeseok Kim

Abstract—**In this paper, a MAS information management method is proposed for the WiMedia MAC protocol. WiMedia MAC configures a fully distributed network based on Ad-hoc method. WiMedia devices communicate during Superframe which is a communication unit in WiMedia MAC. Each superframe which consist of 256 MASs is divided into two periods, beacon period and data period. In data period, devices communicate with each other using the received channel access information during the beacon period. Due to only 12 μs timing allowance between beacon period and data period, the process of the MAS information management cannot be completed in time if entire process handle by software. Therefore, we propose a novel MAS information management method using hardware module. With our proposed method, a WiMedia device is satisfied with the processing time that is required in WiMedia MAC protocol.**

Index Terms—**WiMedia, WPAN, MAC, MAS**

I. Introduction

Ultra wide band (UWB) is the communication system which uses more than 500 MHz bandwidth or 20% bandwidth of the center frequency [1]. It supports ultra high-speed of several hundreds of Mbps in wireless personal area networks (WPANs), and these system only consume 1/5 of power compared to wireless local area network (WLAN) devices.

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WiMedia alliance, special interest group which have been promoted global standardization of UWB, has proposed UWB system that is based on multi-band orthogonal frequency division multiplexing (MB-OFDM) scheme. After IEEE 802.15.3a PAR had been withdrawn, first UWB standard was released on Dec. 2005 and recently 3rd edition was announced on Dec. 2008.

WiMedia PHY layer supports up to 480 Mbps data rate, and MAC layer organizes a peer-to-peer, fully distributed network based on Ad-hoc method. It is difficult to manage the reservation status in fully distributed network, because each device that is a member of network should know neighbor's reservation requests and current reservation status. In order to get reservation information, a device analyzes every beacon frame in limited time.

In this paper, we propose an MAS information management method for WiMedia MAC protocol. With our proposed method, WiMedia device can handle the channel access information of other devices in the network. The proposed technique was verified by C language and Verilog HDL (hardware description language), and applied in WiMedia MAC-PHY integrated system.

The rest of this paper is organized as follows. In Section II, some essential features of WiMedia MAC protocol are introduced. A communication mechanism of WiMedia MAC focused on Reservation-based protocol known as a distributed reservation protocol (DRP) is

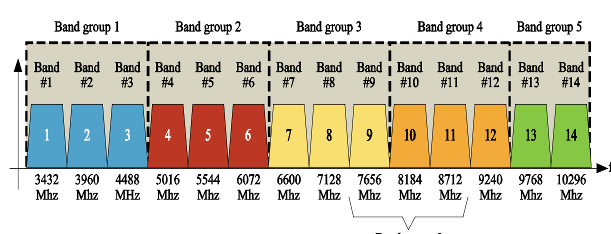

Fig. 1. WiMedia UWB PHY band.

studied in section III. In section IV, a novel methodology of MAS information management is presented. Implementation results are presented in section V and section VI concludes the paper.

II. Overview of WiMedia MAC

WiMedia MAC provides two medium access mechanisms: DRP and contention-based protocol called prioritized contention access (PCA). DRP is one of the mechanisms based on time division multiple access (TDMA). If a WiMedia device reserves one or more slots, it can access to the reserved time slot exclusively. PCA is for multiple prioritized classes using carrier sense multiple access with collision avoidance (CSMA/CA), which is similar to enhanced distributed channel access (EDCA) of IEEE 802.11e for quality of service (QoS) support [2].

WiMedia MAC composes fully distributed network based on Ad-hoc method which is main difference between IEEE802.15.3 and WiMedia. In IEEE802.15.3 network, a piconet coordinator (PNC) controls and managements the network. Fig. 3 shows the difference between IEEE802.15.3 and WiMedia network.

WiMedia MAC device communicates with other ones using superframe structure, which describes periodic intervals used to facilitate operation between devices. The duration of a superframe is 65,536 ms and is divided into 256 medium access slots (MASs) with duration of 256 us. Also, each superframe is composed of a beacon period and a data period, depicted in Fig. 4 In the beacon period, each device broadcasts its own channel access information using beacon frame. During the data period, all devices in the network communicate with each other using PCA or DRP depending on information about assigned channel access mechanism to the corresponding MAS acquired in the beacon period. After the data period, new beacon period of next superframe starts [3].

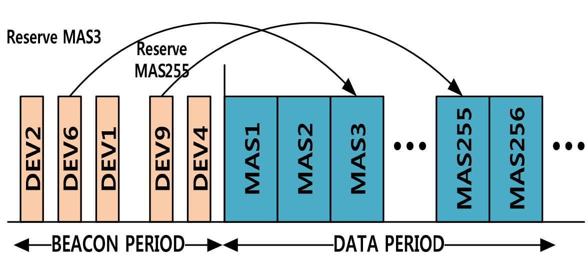

Fig. 2. Distributed Reservation Protocol.

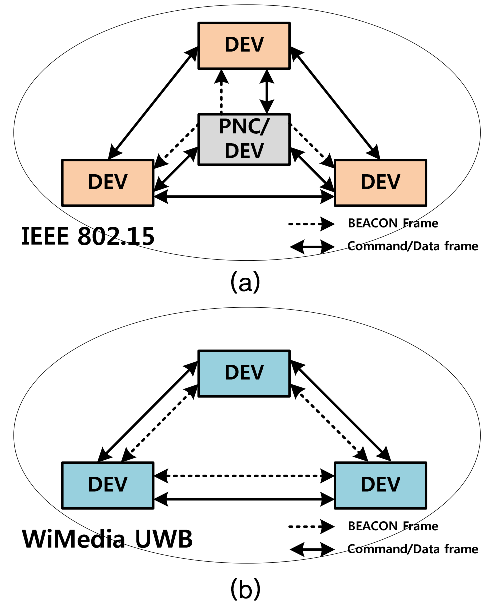

Fig. 3. Example of (a) IEEE802.15 network and (b) WiMedia network.

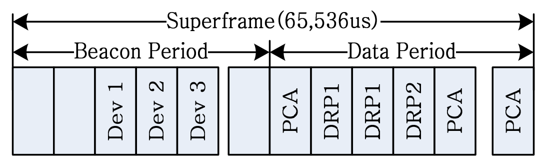

Fig. 4. Superframe structure.

III. Communication Mechanism of MAC Protocol

Each device should configure network with information that is collected in beacon period within the present superframe. The one of the most important thing is DRP reservation information in Beacon frame. DRP is used for QoS guarantee and limits the access of other devices that compose a network. Each device communicates using DRP mechanism within reserved DRP slots which are described in beacon frame. And they communicate PCA within MASs that are not reserved by beacon frames.

All WiMedia devices should reflect MAS information in data period themselves, because WiMedia system makes up fully distributed network without a coordinator. At this process, a WiMedia device should have MAS information from DRP information element (IE) in received beacon frame. DRP IE frame structure is same with Fig. 6, and necessary information is DRP Control field and Target/Owner DevAddr field.

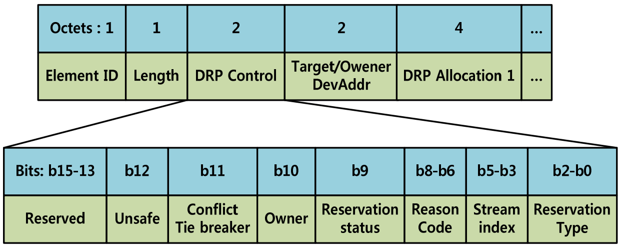

Fig. 5. DRP IE structure.

We have to consider how to process DRP IE information because a WiMedia device needs to know 32 bit information per each 256 MASs in every present superframe. There are two processing subjects, hardware and software. First, when we suppose that the hardware has 256x32 size memory, the software processing unit should analyze beacon frame and store it in hardware memory. At this process, a processing time is composed of read operation from hardware buffer and writing operation to buffer. The description of this processing time is as following [4]:

-Maximum beacon frame length: 320 bytes

-Maximum upload delay:

$$\frac{320bytes}{4bytes} \times 15.15ns \times \alpha \approx 1.7\mu s$$

-Download delay to 256x32 memories:

$$256 \times 15.15ns \times \alpha \approx 5.43\mu s$$

-Processing time for MAS information:

$$700 \times 15.15ns \times \alpha \approx 14.85\mu s$$

-Total delay: $14.85 + 5.43 + 1.7 \approx 21.98\mu s$

α is a bus overhead, and processing time for MAS information is expected to be about 700 instructions. After beacon period, WiMedia device has time margin, mGuardinterval (12 μs) depicted in Fig. 7, before data period. However if these processes are handled by software, it takes at least 21.98 μs, and it could not meet

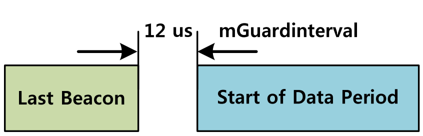

Fig. 6. mGuardinterval between beacon period and data period.

the restriction on time about 10 μs. To solve this problem, we propose efficient MAS information management method using hardware.

IV. Proposed MAS Information Management Method

MAS information should be updated and controlled by hardware because software needs more time to process this information than requirement of WiMedia MAC. Shown as Fig. 8, DRP IE is composed of 1 octet DRP allocation field, 2 octets zone bitmap and 2 octets MAS bitmap. One superframe has 256 MASs, and it could be divided in 16 zones which are composed of 16 MASs. Upper 2-octet zone bitmap and lower 2-octet MAS bitmap indicate MASs that a device wants to reserve.

To update MAS information in real-time, it has to process at least 4 clock cycles because DRP IE field is received 4 bytes at every clock cycle. For that reason, we divide 256x32 memory into 64 of 4x32 size memory, and then a device could store MAS information during 4 clock cycles. The read operation is same as the access to 256x32 memory.

A WiMedia device should confirm MAS information whenever it want to trasmit in data period. At that time, it needs additional 1-bit valid information that informs DRP reservation availability of present MAS. While a reservation valid bit, called as “DRP On/Off” is set to 1 during updating DRP IE, a WiMedia device could confirm valid bit and know DRP reservation availability. Fig. 8 shows a part of MAS information memory.

The proposed MAS information management method makes about 60 ns time delay, because all processes are handled real time by hardware. This result shows that it satisfies processing time that is required in WiMedia MAC protocol.

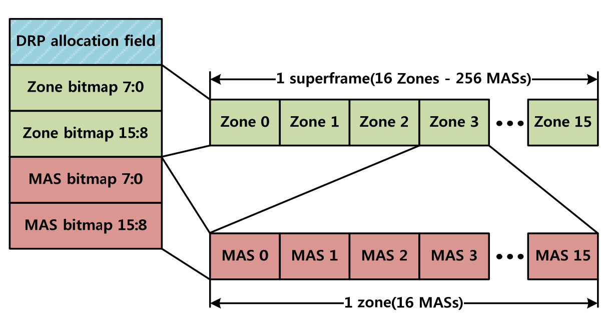

Fig. 7. zone based MAS bitmap.

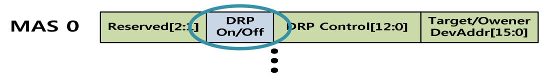

Fig. 8. Structure of DPRAM for MAS information.

V. SYNTHESIS AND VERIFICATION

The MAS information management module that is proposed in this paper was implemented by Verilog HDL and applied to WiMedia MAC-PHY integration system. This module was synthesized using Synopsys Design Compiler and **Table** 1 shows result of synthesis using CMOS 0.18 libraries.

Table 1. synthesis results of the proposed module

Combinational area	9k
Noncombinational area	15k
Total cell area	24k

VI. CONCLUSIONS

MAS information should be handled by hardware instead of software because of the timing constraints that is described in section III. In this paper, we have proposed a MAS information management method for WiMedia MAC protocol. With our proposed method, a WiMedia device satisfies the processing time that is required in WiMedia MAC protocol. Designed module was manufactured by chip and applied to WiMedia UWB MAC-PHY integration system.

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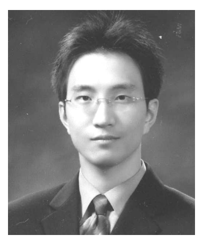

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