Beacon Signaling Framework of IEEE 802.15.6 WBAN for WUSB MMC Scheduling

Kyeong Hur [1], Won-Sung Sohn [1], YangSun Lee [2]

[1] Dept. of Computer Education, Gyeongin National University of Education, Gyesan-Dong San 59-12, 45 Gyodae-Gil, Gyeyang-Gu, Incheon, 407-753, Korea, sohnws@ginue.ac.kr
[2] Dept. of Computer Engineering, Seokyeong University Seoul, Korea

Abstract. In this paper, we integrate the IEEE 802.15.6 wireless body area networks (WBAN) with the wireless USB (WUSB) system to develop wireless communication technologies for wireless wearable computer systems. To successfully set up wireless communication links for wearable computer systems, the WUSB channel should be encapsulated privately within a WBAN superframe. However, in the current IEEE 802.15.6 WBAN standard there is no available period allocated for other heterogeneous networks. In this paper, we propose a beacon signaling framework (BSF) of IEEE 802.15.6 WBAN to set up WUSB channel efficiently.

Keywords: Hierarchical MAC, Wearable Computer, Wireless USB, Wireless Body Area Networks (WBAN).

1 Introduction

A recent major development in computer technology is the advent of the wearable computer system that is based on human-centric interface technology trends and ubiquitous computing environments [1]. Wearable computer systems use the wireless universal serial bus (WUSB) that refers to USB technology that is merged with WiMedia PHY/MAC technical specifications [2-6]. A wireless body area network (WBAN), which describes the application of wearable computing devices, allows the integration of intelligent, miniaturized, low-power, invasive/non-invasive sensor nodes that monitor body functions and the surrounding environment [7].

The WUSB channel is a continuous sequence of linked application-specific control packets, called micro-scheduled management commands (MMCs). WUSB maps the USB 2.0 transaction protocol onto the TDMA micro-scheduling feature. Within the WUSB protocol, the micro-scheduled sequence consists of an MMC and the subsequent time slots that are described in the MMC; this sequence is called a transaction group [4]. The WUSB host dynamically manages the size of transaction groups over time according to the demands of the endpoint data streams. Therefore, the number of transactions per transaction group can be variable. MMCs are used by a host to control WUSB channel. A WUSB network consists of a WUSB host and several WUSB devices, and this is referred to as a WUSB cluster [4]. In a similar manner, IEEE 802.15.6 WBAN hubs and sensor nodes form a star topology [7].

In the WUSB over WBAN Architecture, in order to set up a wireless communication link to wearable computer systems, secure WUSB channels should be encapsulated within a WBAN superframe. This enables the MMC scheduling between WUSB host and its several peripheral devices without contention. In a user scenario, the user carries a portable or wearable computing host device. This host device performs roles of the WUSB host and the WBAN hub simultaneously. Therefore, a “wearable” WUSB cluster and a WBAN cluster can be formed. The attached input-sensor nodes perform the functions of localization-based input interfaces for wearable computer systems and health-care monitoring. Furthermore, the attached wireless nodes comprise the peripherals of a wearable computer system, and the central WUSB host exchanges data with the outer peripherals of the WUSB slave devices.

2 Beacon Signalling Framework for WUSB over WBAN Architecture

WBAN slave devices which have received beacon from WBAN host schedule their receiving and transmitting operations according to information delivered by the beacon. IEEE 802.15.6 WBAN superframe begins with a beacon period (BP) in which the WBAN hub performing the WUSB host’s role sends the beacon. This beacon mode of the WBAN is operated in both non-medical and medical traffic environments. The data transmission period in each superframe is divided into the exclusive access phase 1 (EAP1), random access phase 1 (RAP1), Type-I/II access phase, EAP2, RAP2, Type-I/II cccess phase, and contention access phase (CAP) periods. The EAP1 and EAP-2 periods are assigned through contention to data traffic with higher priorities. Further, the RAP1, RAP2, and CAP periods are assigned through contention to data traffic with lower priorities.

The IEEE 802.15.6 WBAN MAC systems have several MAC Capability options. To successfully set up wireless communication links for wearable computer systems, secure WUSB channels should be encapsulated privately within a WBAN superframe. Furthermore, the WUSB channel allocated privately in the IEEE 802.15.6 WBAN MAC enables the MMC scheduling between WUSB host and its several peripheral devices. In the current IEEE 802.15.6 WBAN standard, there is no available period allocated for other heterogeneous networks. In this paper, we propose a beacon signaling framework (BSF) of IEEE 802.15.6 WBAN to set up WUSB channel efficiently. The Private Period Allocation field is set to one if the WBAN MAC supports private WUSB channel allocations, or set to 0 otherwise. If the Private Period Allocation field is set to 1, the RAP2 length field indicates the private WUSB channel length. Therefore, after receiving beacon from the WBAN host non-WUSB devices never use the RAP2 periods during the WBAN superframe.

The WUSB/WBAN host should transmit WUSB data without interference with WBAN data when a request for WUSB data transmissions occurs in the WUSB cluster. For this purpose, the WUSB/WBAN host has to allocate the WUSB private channels. Basically, the IEEE 802.15.6 superframe is composed of several data transmission periods such as EAP1, RAP1, Type-I access phase, EAP2, RAP2, Type-II access phase and CAP. However, Except the RAP1 period, length of the other periods can be set to zero. By using this feature, the WBAN host which also performs the function of WUSB host allocates the WUSB private channels at the RAP2 period.

When a request for WUSB data transmissions occurs at the WUSB host or WUSB slave-devices in the WUSB cluster, WBAN host which also performs the function of WUSB host sets the Private Period Allocation field to one in the MAC capability field. And the WUSB/WBAN host also sets the WBAN beacon's RAP2 length field to the length required for MMC scheduling in the WUSB private channel. Then, the WUSB/WBAN host transmits its beacon frame. After receiving beacons, non-WUSB WBAN slave devices enter into sleep mode during the RAP2 period. On the contrary, the WUSB/WBAN slave devices enter into active mode during the RAP2 period and they enter into sleep mode during the other periods. The RAP2 length is determined by the WUSB/WBAN host according to priorities between WUSB transactions and WBAN traffic.

Performance of the proposed scheme is evaluated through OMNet++ simulations [8]. The m_{In} parameter indicates the occupation ratio of non-WUSB WBAN traffic for the entire WBAN superframe length. Simulation results show that the larger m_{In} ratio of WBAN traffic reduces throughput of a WUSB device more. This result caused by the reason that the increase of m_{In} ratio reduces the length of RAP2 period. In the proposed BSF scheme, only the RAP 2 period can be allocated to the WUSB private channel. Therefore, the reduced RAP2 period leads to the decrease of throughput of a WUSB device or a WUSB transaction.

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References

1. Rosenberg, R., Slater, M. : The Chording Glove: A Glove-Based Text Input Device. IEEE Transaction on Systems, Man, and Cybernetics-Part C: Applications and Review. 29, 2, pp.342--353 (2009)
2. USB 2.0, USB-IF, http://www.usb.org/home
3. WiMedia Alliance, http://www.wimedia.org
4. Certified Wireless USB 1.1, USB-IF, http://www.usb.org/developers/wusb
5. WiMedia MAC Release Spec. 1.5, Distributed Medium Access Control (MAC) for Wireless Networks. WiMedia Alliance, http://www.wimedia.org
6. Kim, J.W., Hur, K., Park, J.S., Eom, D.S. : A distributed MAC design for data collision-free wireless USB home networks. IEEE Transaction on Consumer Electronics. 55, 3, pp.256-264 (2009)
7. IEEE 802.15 WPAN Task Group 6 Body Area Networks (BAN), IEEE, http://www.ieee802.org/15/pub/TG6.html
8. Varga, A. : The OMNeT++ Discrete Event Simulation System. In: European Simulation Multi-conference, pp.124--133 (2001)