인체영역 네트워크와 무선 USB의 결합을 위한 에너지 효율적인 MAC 프로토콜

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An Energy-Efficient MAC protocol for WUSB over WBAN Protocol

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ABSTRACT

In this paper, we propose a low-power hibernation technique (LHT) for WUSB over IEEE 802.15.6 hierarchical MAC to improve its energy efficiency. Simulation results show that the LHT also integrate WUSB transactions and WBAN traffic efficiently while it achieves high energy efficiency.

Ⅰ. 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, 2]. Wearable computer systems use the wireless universal serial bus (WUSB) that refers to USB technology that is merged with WiMedia PHY/MAC technical specifications. WUSB can be applied to wireless personal area networks (WPAN) applications as well as wired USB applications such as PAN. WUSB specifications have defined high-speed connections between a WUSB host and WUSB devices for compatibility with USB 2.0 specifications [3, 4].

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. Each intelligent node has sufficient capability to process and forward information to a base station for diagnosis and prescription [5].

In this paper, we focus on an integrated system of the wireless USB (WUSB) over the IEEE 802.15.6 wireless body area networks (WBAN) for wireless wearable computer systems. Due to portable and wearable nature of the wearable computer systems, the WUSB over IEEE 802.15.6 hierarchical medium access control (MAC) protocol has to support the power saving operation and integrate WUSB transactions with WBAN traffic efficiently. In this paper, we propose a low-power hibernation technique (LHT) for WUSB over IEEE 802.15.6 hierarchical MAC to improve its energy efficiency.

Ⅱ. Low-power Hibernation Technique 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 (WUSB/WBAN host) sends the beacon. 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 access phase, and contention access phase (CAP) periods. The EAP1 and EAP2 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 [5].

The IEEE 802.15.6 WBAN MAC systems have several MAC Capability options. We denote the WUSB slave device which also performs the WBAN slave device function as WUSB/WBAN slave device. The WUSB/WBAN slave devices keep its active mode during an entire superframe if the Always Active field is set to one in the received beacon in that superframe. Otherwise, if the Always Active field is set to zero, the WUSB/WBAN slave devices keep its active mode during the beacon period and other allocated periods [5]. This operation is called as the hibernation.

Figure 1 shows the WUSB private channel allocation procedure for the m-periodic hibernation. When a request for WUSB data transmissions occurs in a WUSB cluster, WUSB/WBAN host sets the WBAN beacon's RAP2 length field to the length of inactive periods required for MMC scheduling in the WUSB private channel. Then, the WUSB/WBAN host transmits its beacon frame. And the Wakeup Period field in the Connection Assignment control frame is set to m value. And its Wakeup Phase field is set to a sequence number of superframe increased by m. After receiving beacon and Connection Assignment control frames, non-WUSB WBAN slave devices enter into sleep mode during m-1 superframes. On the contrary, the WUSB/WBAN host and slave devices enter into active mode at every RAP2 period during consecutive m-1 superframes for WUSB transactions.

Ⅲ. Results and Discussion

Performance of the proposed scheme is evaluated through NS2 simulations and WBAN PHY/MAC simulation parameters used in this paper [6-8]. The network size is 5m*5m. Maximum 20 devices are randomly deployed into this area. Frame size is fixed to 4095 bytes.

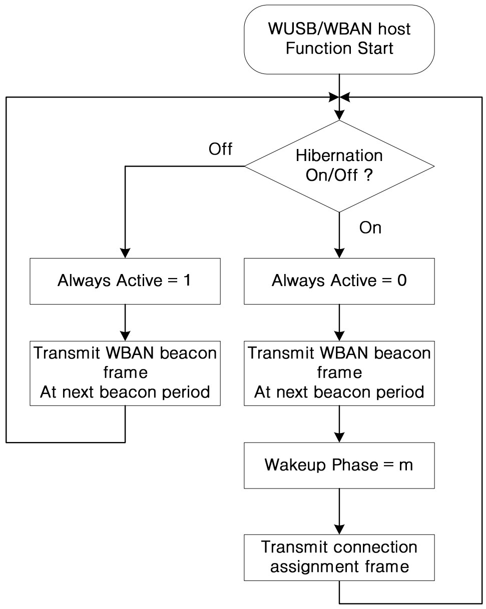

Figure 1. WUSB private channel allocation procedure at the m-periodic hibernation.

Figure 2 shows the consumed energy per superframe of a WUSB/WBAN device according to number of wakeup periods. In Fig. 2, the longer wakeup period reduces the consumed energy per WUSB/WBAN device except the case where the only one device exists. But, it increases more at the larger number of WUSB/WBAN devices. This result is caused by more transmissions and receptions in a device due to the increased MMC scheduling overhead.

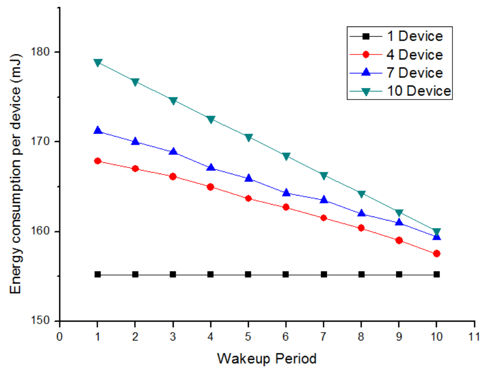

Figure 2. Energy consumption of a WUSB/WBAN device at each wakeup period.

In the simulation for Fig. 3, there are four WBAN data streams between WUSB/WBAN host and its WBAN slave devices in a WBAN cluster. In that situation, each WUSB/WBAN device enters into that cluster and associates with the WUSB/WBAN host one by one. As the number of WUSB slave devices increases, the allocated RAP2 periods to WUSB channels become longer. Therefore, without LHT, this phenomenon leads non-WUSB WBAN devices to have longer scheduling delay and consume more energy. But, in LHT, the Wakeup Period is set to six in the hibernation scheme. Then, the consumed energy of non-WUSB WBAN device does not change up to five WUSB slave devices. This result is caused by the LHT mechanism that the WUSB/WBAN host allocates the inactive periods for WUSB private channels by setting the beacon's RAP2 length field to the length of inactive periods while the other non-WUSB WBAN devices enter into sleep mode during consecutive five superframes.

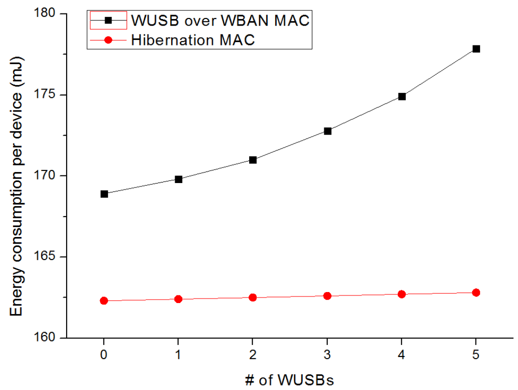

Figure 3. Energy consumption of a non-WUSB WBAN device at each number of WUSB slave devices.

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참 고 문 헌

[1] Patel, M. and Wang, J., Applications, challenges, and prospective in emerging body area networking technologies. Wireless Communications, 17 (2010), 80-88.

[2] Palit, R., Singh, A. and Naik, K., An Architecture for Enhancing Capability and Energy Efficiency of Wireless Handheld Devices. International Journal of Energy, Information and Communications, 2 (2011), 117-136.

[3] Certified Wireless USB 1.1. USB-IF (2010), http://www.usb.org.

[4] Kim, J., Hur, K., Park, J. and Eom, D., A distributed MAC design for data collision-free wireless USB home networks. IEEE Transaction on Consumer Electronics, 55 (2009), 1337-1343.

[5] IEEE 802.15 WPAN Task Group 6 Body Area Networks (BAN). IEEE (2010), http://www.ieee802.org.

[6]. Nguyen, V. C., Pham, V. T. and Moon, B.-K., A New Energy Saving Mechanism in IEEE 802.16e/m. International Journal of Energy, Information and Communications, 2 (2011), 157-168.

[7] Kim, K.-I., Adjusting Transmission Power for Real-Time Communications in Wireless Sensor Networks. Journal of Information and Communication Convergence Engineering, 10 (2012), 21-26.

[8] Mana, M., Feham, M. and Bensaber, B. A., SEKEBAN (Secure and Efficient Key Exchange for wireless Body Area Network). International Journal of Advanced Science and Technology, 12 (2009), 45-60.