Contemporary Engineering Sciences, Vol. 7, 2014, no. 15, 755 - 760
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ces.2014.4686

WBAN Beaconing for Efficient Resource Sharing in Wireless Wearable Computer Networks

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Abstract

In this paper, we focus on an integrated system of the wireless USB over the IEEE 802.15.6 wireless body area networks (WBAN) for wireless wearable computer networks based on WiMedia MAC. However, current WBAN devices cannot share wireless channel with the existing WiMedia devices, efficiently. Existing researches are not suitable for WiMedia MAC protocol based on distributed architecture, since they focused on MAC protocol based on centralized architecture. Therefore, in this paper, we propose a WBAN beaconing method between WBAN and WiMedia Networks. Using proposed scheme, WBAN devices can share the resource more efficiently with WiMedia devices for wireless wearable computer networks.

Keywords: WBAN (Wireless Body Area Networks), Wireless Home Networks, WUSB (Wireless Univeral Serial Bus), Wearable Computers

1 Introduction

A wearable medical system may encompass a wide variety of components: sensors, wearable materials, smart textiles, actuators, power supplies, wireless communication modules and links, control and processing units, interface for the user, software, and advanced algorithms for data extracting and decision making. 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. Because WUSB specifications have defined high-speed connections between a WUSB host and WUSB devices for compatibility with USB 2.0 specifications, the wired USB applications are serviced directly [1-6].

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. Each intelligent node has sufficient capability to process and forward information for diagnosis and prescription [7].

In this paper, we focus on an integrated system of the wireless USB over the IEEE 802.15.6 wireless body area networks (WBAN) for wireless wearable computer networks based on WiMedia MAC. However, current WBAN devices cannot share wireless channel with the existing WiMedia devices, efficiently. Existing researches are not suitable for WiMedia MAC protocol based on distributed architecture, since they focused on MAC protocol based on centralized architecture. Therefore, in this paper, we propose a WBAN beaconing method between WBAN and WiMedia Networks. Using proposed scheme, WBAN devices can share the resource more efficiently with WiMedia devices for wireless wearable computer networks.

2 WEARABLE COMPUTER NETWORK CONFIGURATION

WUSB allows a DRD to operate separately in time as a WUSB host and as a WUSB device on a single transceiver. A number of scenarios are possible for DRD devices including ‘combination’ and ‘point-to-point’ scenarios [4]. In the combination scenario, the DRD operates as a WUSB device connected to a WUSB host. Separately in time, the same DRD also operates as a WUSB host that manages other WUSB devices. On the other hand, in the point-to-point scenario, two DRDs connect themselves with each other as both a WUSB host and a WUSB device. In the WUSB specification [4], the WUSB host operating mode in a DRD is denoted as DRD-host, and the WUSB device operating mode in a DRD is denoted as DRD-device.

A WUSB cluster tree topology is formed to configure multiple WCNs. Basically, a single WCN operates based on WUSB over WBAN protocol. And the host in each WCN denoted as H1 takes a role of DRD-host or DRD-device. The WUSB/WBAN flows in a WCN are manipulated in a time period during a WBAN superframe. On the other hand, the DRD flows between WCNs are manipulated in a time period during a WiMedia D-MAC superframe. By adopting the D-MAC, our WCN solves the SOP problem in the centralized IEEE 802.15.3

MAC. In the D-MAC, each node broadcasts its own beacon containing IEs per a superframe. The IEs convey certain control and management information. The distributed nature of D-MAC protocol can provide a full mobility support and a scalable and fault tolerant medium access method to a multiple WCN environment.

In this WUSB cluster tree, the DRD-device H2 in WUSB cluster 2 and the DRD-device H3 in WUSB cluster 3 are connected with the DRD-host H1 in WUSB cluster 1. And the DRD-host H1 in the WUSB cluster 1 can manage WUSB devices belonging to WUSB cluster 2 and WUSB cluster 3 as well as WUSB member devices in its own WUSB cluster. In this way, large scale multi-hop WCNs can be constructed.

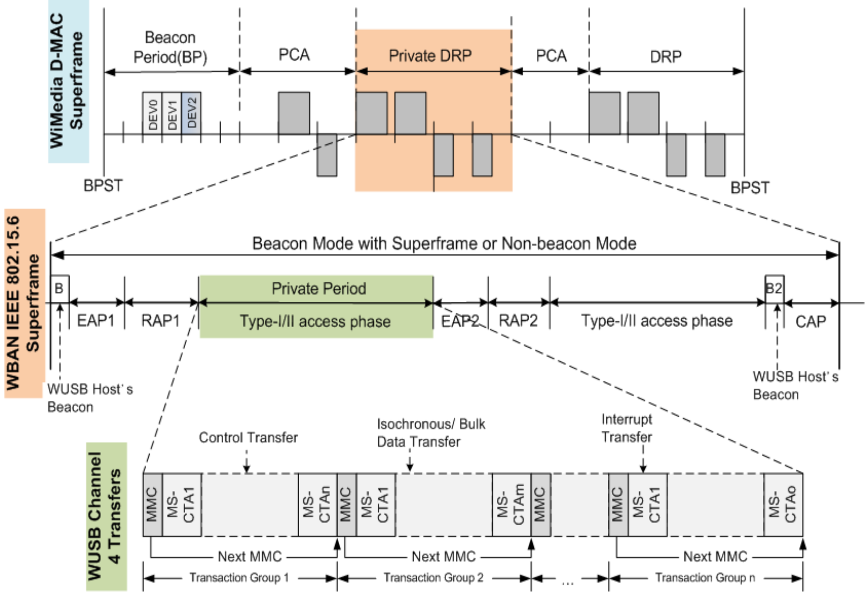

Fig. 1. WUSB flows and DRD flows allocation for multiple WCNs

3 WBAN Beaconing for Resource sharing between WBAN and WiMedia D-MAC

Because WiMedia devices have been developed to transmit high-speed and high-quality video data, they are free from the constraint of hardware performance and energy. However, in the case of small devices used in healthcare or fitness applications, the constraint of hardware performance and energy is large. Thus, it is impossible to receive all beacon frames used in WiMedia network. Therefore, in this subsection, we proposed simplified beacon frame and beacon transmission scheme considering energy consumption.

Proposed beacon frame follows the beacon frame defined by WiMedia standard. For our proposed scheme, Frame Subtype in WBAN beacon frame is set to ‘one’ and Resource Sharing IE field in WBAN beacon frame is included to communicate with WiMedia devices. To allocate the resource for WBAN, WBAN device includes the Resource Sharing IE in its own beacon. Network Identifier field is a field used to identify each WBAN network and resources that are assigned to each WBAN network. Network Identifier field is set to the beacon slot number of each WBAN hub. Request Sharing field is set to the necessary resource for devices in WBAN to communicate with each other.

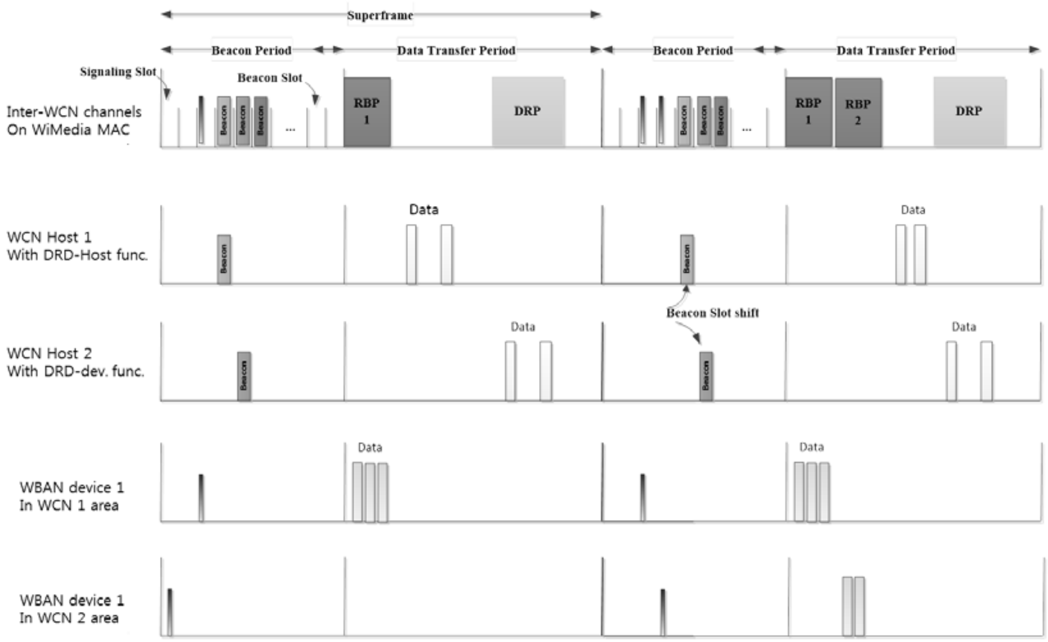

Fig. 1. Joining Process of WBAN devices into Inter-WCN channels on WiMedia MAC

To associate with the existing Inter-WCN WiMedia beacon group, WBAN device must archive the beacon slot number in beacon period. Thus, after WBAN device scans first superframe duration, it transmits a beacon frame in Signaling slot of beacon period. WiMedia devices (WCN Hosts) that receive the beacon frame of WBAN device in Signaling slot set the beacon slot number to the value of their own beacon slot number plus 1. After that, WBAN device broadcasts its own beacon frame in the empty beacon slot according to the process for WBAN device to join newly to the existing beacon group.

When a WBAN device 1 in WCN1 area discovers new Inter-WCN WiMedia beacon group (Beacon Group 1), it transmits its own beacon frame in signaling slot. WiMedia WCN Hosts that receive the beacon frame of WBAN device 1 in WCN1 area in Signaling slot move their own beacon slot one by one and secure the beacon slot for WBAN device 1. In this case, the existing WCN Hosts do not move their own beacon slot. If there is an empty beacon slot by old WCN Hosts deviated from beacon group, new WBAN device 1 in WCN1 area selects the empty beacon slot and transmits its own beacon frame.

4 Simulation Results

To evaluate the performance of proposed method, WiMedia WCN Hosts beacon group and WBAN devices are deployed. To create the environment in which frame collisions occur, we set up that WiMedia WCN Host network and its WBAN devices are configured in the adjacent area. The simulations are run for 2000 seconds. The WBAN started its operation at 0.0 second and the WiMedia WCN Host beacon group started its operation at 500 seconds with traffic load 0.5. The transmission power is fixed and other parameters follow the UWB MAC/PHY specifications [8].

When WiMedia WCN Host traffic load is small, the interference level occurred by the adjacent WiMedia beacon group would not be high enough to trigger the WBAN beaconing procedure. Thus, when WiMedia traffic density is less than 0.1, WBAN beacon loss rate of both proposed scheme and legacy scheme is equal.

Fig. 4 depicts the sum of received data frames at a WBAN device 1 in WCN1 area with respect to time. In the legacy WCN protocol, the sum of received data frames do not increase since device does not receive data anymore after data frames begin to collide after 500 seconds. However, the sum of received data frames at the WBAN device 1 in WCN1 area increases after some delay time when using the proposed WBAN beaconing scheme. . To allocate the resource for WBAN, WBAN device includes the Resource Sharing IE in its own beacon. And the joining process of WBAN devices into Inter-WCN channels on WiMedia MAC starts to operate.

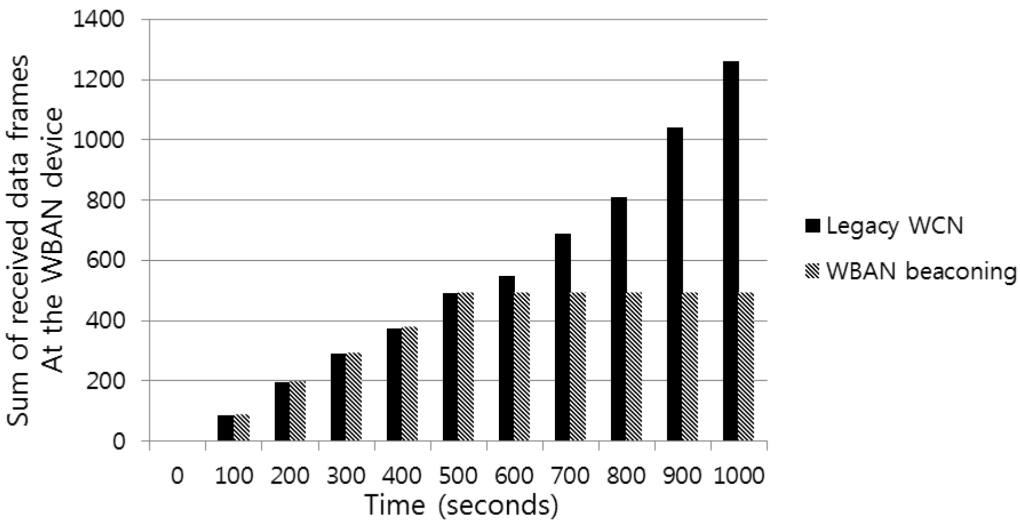

Fig. 2. Effect of proposed WBAN beaconing under WCN Host traffic load

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Received: May 1, 2014