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Conflict-free Channel Allocation for Wireless Wearable Computer Networks

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Abstract

A Wireless USB cluster tree topology is formed to configure multiple Wearable Computer Networks (WCNs). Basically, a single WCN operates based on WUSB over WBAN protocol. And the host in each WCN 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. However, if multiple WCNs exist within the same environment, various conflicts among independent WCNs can occur frequently. In order to solve this problem, we propose a channel allocation scheme to avoid the conflict between adjacent WCNs. The proposed scheme can scan new idle channel and detect its time offset where a WCN device can transmit a new beacon frame and data frames without conflicts. Simulation results demonstrate that the proposed scheme can minimize the possibility of data frame collisions.

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

1 Introduction

Wearable computing can describe a broad range of devices and concepts. At the time of this writing, wearables are generally equated with head-up, wearable displays; one-handed keyboards; and custom computers worn in satchels or belt packs. Ideally, wearable computing can be described as the pursuit of a style of interface as opposed to a manifestation in hardware. Several authors have defined wearable computers by desirable characteristics [1].

WUSB is the USB technology merged with WiMedia PHY /MAC, and it can be applied to WPAN applications as well as PAN applications like wired USB. Because WUSB specification has defined high speed connection between WUSB host and WUSB devices for the compatibility with USB 2.0 specification, the wired USB applications are serviced directly. Unlikely wired USB that physically separates the USB host and USB device, WUSB allows a device to separately in time function as both a WUSB host and WUSB device on a single transceiver, referred to as the Dual Role Devices (DRD) [2-6].

The IEEE 802.15.6 Wireless Body Area Network (WBAN) is a standard for short range, wireless communication in the vicinity of, or inside, a human body (but not limited to humans) [7]. The IEEE 802.15.6 Wireless Body Area Network (WBAN) standard is used in or around a body.

A Wireless USB cluster tree topology is formed to configure multiple Wearable Computer Networks (WCNs). Basically, a single WCN operates based on WUSB over WBAN protocol. And the host in each WCN 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.

However, if multiple WCNs exist within the same environment, various conflicts among independent WCNs can occur frequently. In order to solve this problem, we propose a channel allocation scheme to avoid the conflict between adjacent WCNs. The proposed scheme can scan new idle channel and detect its time offset where a WCN device can transmit a new beacon frame and data frames without conflicts. Simulation results demonstrate that the proposed scheme can minimize the possibility of data frame collisions [8].

2 WEARABLE COMPUTER NETWORK

The 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 of Fig. 1, 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.

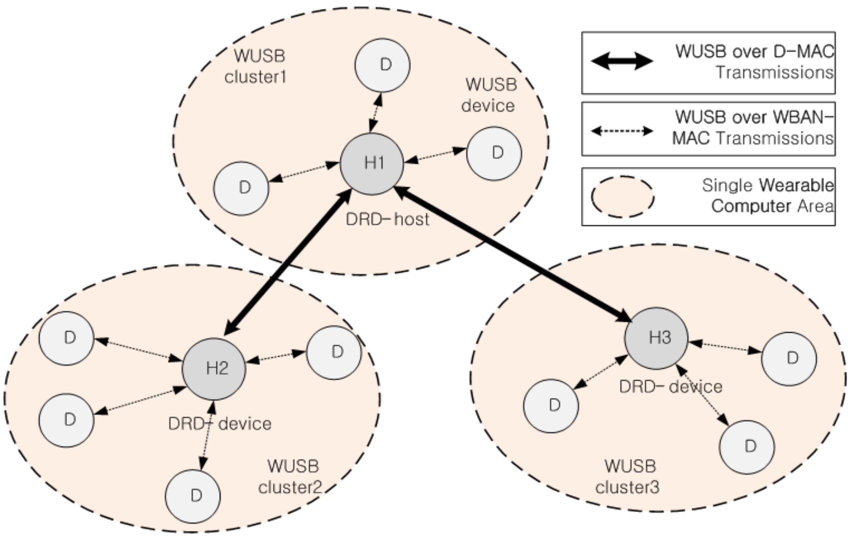

Fig. 1. A WUSB cluster tree topology formed to configure multiple WCNs

3 Channel Allocation Scheme for Collision Free WCNs

It is first assumed that a variety of WCNs coexists in an adjacent area, and is operated at the same time. All of the WCNs utilize WiMedia PHY and operate on each application independently. Also, in each WCN, one more bridge devices exist to communicate with external network, and they communicate with external network using Ethernet protocol. WUSB host performs the role of the Bridge device in the WCN using WUSB protocol. In the WCN using WiMedia protocol, a device connected to external network using Ethernet protocol acts as the bridge device, the bridge device initializes and configures the WCN.

Basically, to maximize the channel utilization, all of the dynamically available channels are used by performing the channel scan during the idle period. Also, we deal proactively with prospective collisions by analyzing the information in the data frames of devices associated with other WSSs (WCN Service Sets). Therefore, if a device notifies its bridge device of a data collision, the bridge device commands the device to change its channel to the candidate channel in the next Inactive period. These operations are performed very rapidly and safely. Thus, the proposed algorithm utilizes multiple channels through dynamic transitions. Also, WCNs on the same channel can be dynamically scheduled by overhearing each other.

Device that detects the collision must notify the collision to bridge device belonging to its own WCN. In this paper, we propose a new WCN Collision IE to announce the collision to a bridge device. After the device that detects the collision reflects the collision duration into a Collision Period Bitmap field, it includes the WCN Collision IE to its own beacon frame and transmits the beacon frame to bridge device. The bridge device that receives WCN Collision IE selects one of idle channel and announces the channel to move to WSS members. To provide the information of channel migration to WSS members, the bridge device broadcasts a beacon frame including the WCN Channel Change IE.

Element ID	Length	WSSID	Dev Addr	TTL	Collision Period Bitmap
1 octet	1 octet	16 octetS	6 octetS	1 octet	1 octet

Fig. 1. The format of WCN Collision IE

Element ID	Length	Channel Change Countdown	New Channel Number
1 octet	1 octet	1 octet	1 octet

Fig. 2. The format of a WCN Channel Change IE

A bridge device stores the information of channel to move in New Channel Number field and stores the information of superframe in the Channel Change Countdown field to perform the channel migration. WSS members that have received the WCN Channel Change IE move to the selected channel and continue to perform the existing communications.

Let us assume that device 1 is associated with bridge 1. Bridge 1 (WCN Host 1) operates normally on channel X during the active period and knows that it can allocate superframes on channel Y through the idle channel scan process on channel Y during the inactive period. WCN Device 1 (D1) in the overlapped region of the transmission ranges of WCN Host 1 (WCN H1) and WCN Host 2 (WCN H2) cannot receive data frames. If the number of ACK frames that D1 loses consecutively is more than the threshold value, D1 transmits the beacon frame including WCN Collision IE to WCN H1. WCN H1 that receives the WCN Collision IE selects one of idle channels (Y) and broadcasts the WCN Channel Change IE to WSS members. After WSS members that have received the WCN Channel Change IE move to the new channel (Y) at the specific WiMedia D-MAC superframe, they continue to perform the existing communications adaptively.

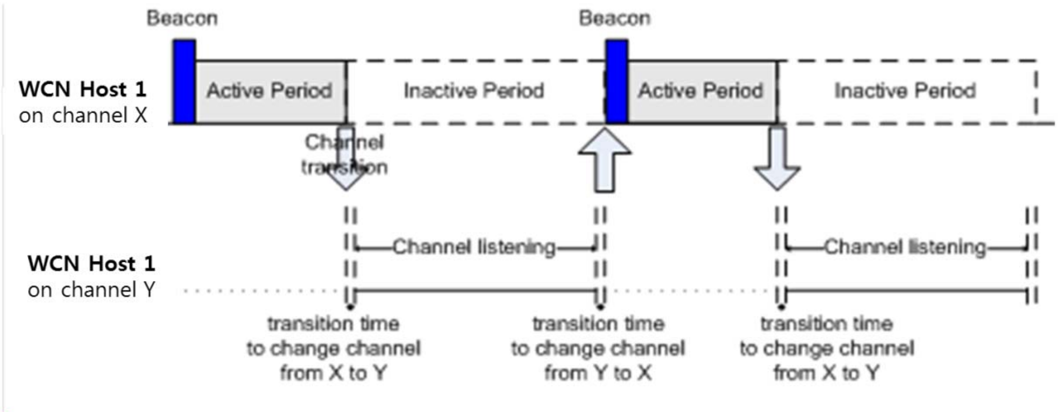

Fig. 3. Intra-WCN channel switching due to inter-WCN collision

4 Simulation Results

To create the environment in which a WCN frame collision occurs, we set up that two WCNs reserve the overlapped MASs and transmit data frames in the reserved MASs. The simulations are run for 1000 seconds. The WCN1 started its operation at 0.0 second and the WCN2 started its operation at 500 seconds. Fig. 4 depicts the sum of received data frames 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 increases after some delay time when using the proposed scheme. If the bridge device (WCN Host) wants to find the clean channel to switch after a data frame collision, it must perform the clean channel scan for inactive duration and notifies the new clean channel to the client device.

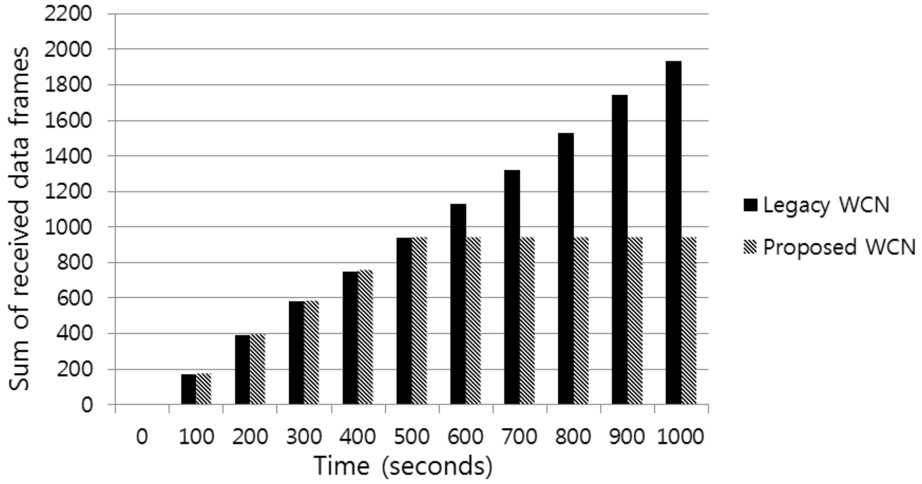

Fig. 4. Effect of proposed WCN channel switching at the collision case

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