Channel Scheduling scheme for Beacon Collision Avoidance in IEEE 802.15.4

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Abstract. In order to solve beacon collision problem in IEEE 802.15.4, in this paper we introduce a novel channel scheduling scheme which is an adaptive method with fast recovery. The proposed scheme can minimize the possibility of beacon collisions by efficiently managing the multiple available channels in a hybrid manner combining proactive and reactive methods.

Keywords: IEEE 802.15.4, Wireless Personal Area Network, LR-WPAN, Zigbee, Wireless Sensor Networks

1 Introduction

IEEE 802.15.4 (15.4) is a standard which specifies the physical and medium access control for low-rate, low-cost, low-power Wireless Personal Area Networks (LR-WPANs) [1]. Nowadays, due to its advantages of low power and low cost, IEEE 802.15.4 is widely used in a large number of applications such as health care monitoring, wireless sensor networks, and several industrial automation fields. With the recent increase in the importance of the beacon collision problem, several possible solutions have been proposed. These can be divided into two categories: proactive and reactive methods. However, due to their inherent limitations, neither type has provided substantial solutions to the beacon collision problem. In order to solve the various beacon conflict problems, in this paper, we introduce a novel channel scheduling scheme which is an adaptive method with fast recovery. The proposed scheme can minimize the possibility of beacon collisions by efficiently managing the multiple available channels in a hybrid manner combining proactive and reactive methods.

2 Proposed Scheme

In this section, we introduce a novel beacon collision avoidance algorithm which is designed on the basis of the guidelines detailed in the previous section.

The proposed algorithm utilizes multiple channels through dynamic transitions. Also, PANs on the same channel can be dynamically scheduled by overhearing each other. The core idea in the proposed scheme is to scan other candidate channels during the idle period and, then, if a device identifies a beacon collision, the coordinator re-associates with the device via the candidate channel, which was previously confirmed to be clean, while the original channels are used for other devices during their active period. A coordinator has Active and Inactive periods which are used to form the duty cycles of the devices. If a device notifies its coordinator of a beacon collision in the next Active period, the coordinator commands the device to change its channel in the next Inactive period. The coordinator that receives the beacon conflict notification command frame sends device a channel switching command frame. The channel switching command frame contains a clean channel that the coordinator finds by scanning during the inactive period and a time offset, which is the difference between the original beacon transmission time and the transmission time of the new beacon frame to transmit on the new clean channel. The coordinator switches to new clean channel that is contained in the channel switching command frame on this channel. After receiving the beacon frame that the coordinator transmits on new channel, device can communicate normally with the coordinator.

3 Simulation

We now evaluate the proposed scheme through simulation. In this simulation, the beacon order of each device and coordinator is equal to 5 and the superframe order is equal to 3. The whole simulation time is 300 seconds and the first beacon collision happens at 31.015s. In Figure 1, we present the delivery success rate versus the probability of packet loss. In this simulation, the delivery success rate is equal to 77.14% when the probability of packet loss is equal to 20%. Considering beacon loss by a transmission error, a device adopting proposed scheme lost only 2.86 % beacon frames.

In Figure 2, we show the average recovery time after a device detects a beacon collision. In the case that superframe order is more than 3, the average recovery time is related to the superframe order because the PAN coordinator using proposed scheme transmits a new beacon frame to a device that detects a beacon collision on the new clean channel in the inactive period. In case that superframe order is less than 2, the average recovery time is affected by beacon order because the channel switching message transaction completes at the superframe of next beacon frame.

4 Conclusion

In this paper, we propose a channel scheduling algorithm which is an adaptive method with fast recovery designed to solve the beacon conflict problem in environments where a number of devices use IEEE 802.15.4 as their wireless communication platform. Proposed scheme can shorten the recovery time after a beacon collision occurs by identifying an available channel to switch to by scanning in advance during the inactive period. The simulation results show that proposed scheme can solve the beacon conflict problem efficiently and rapidly, irrespective of the number of coordinators in the adjacent area.

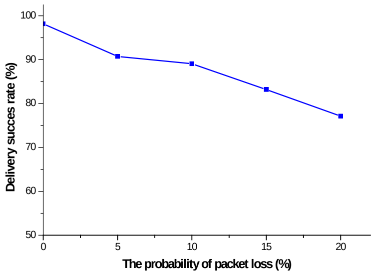

Fig. 1. Delivery success ratio

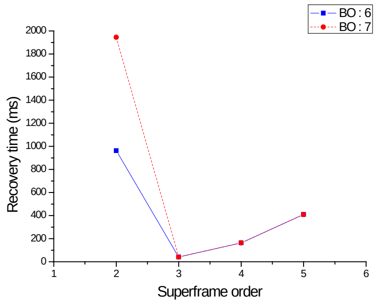

Fig. 2. The average recovery time

Acknowledgments

This work was supported by Priority Research Centers Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2009-0093828). "This research was supported by the MKE (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) support program supervised by the NIPA (National IT Industry Promotion Agency)"(NIPA-2012-H0301-12-2005).

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