A Study of Transmission Power Control Algorithms in Wireless Body Sensor Systems

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Abstract. In wireless body sensor systems (WB-SNSs), sensor nodes should be energy-efficient due to battery limitation. The transmission power control (TPC) is a representative technique to reduce energy consumption in WB-SNSs. Therefore, in this paper, we summarize representative TPC algorithms such as linear, binary, and dynamic algorithms. Then, we review a general TPC model and a closed loop TPC mechanism which can be used in wireless body sensor systems.

Keywords: transmission power control, wireless body sensor systems, closed loop system, sensor

1 Introduction

In the future development of technologies, many applications of wireless body sensor systems (WB-SNSs) will be used to help people in such areas as patient recovery and human monitoring in the real environment [1–3]. In this environment, all sensor nodes are dynamically deployed in, on, or around a human body. So, they mostly operate with limited batteries. However, when the sensors are deployed out of the reach of humans, it is difficult to change the batteries. For this reason, we need very-low-power wireless technologies that extend the lifetime of sensor nodes. There are two representative technologies for extending the battery lifetime: medium-access control (MAC)-based sleep scheduling [4–6] and transmission power control (TPC) [7–10]. Between them, we focus on TPC techniques in this paper.

In Wireless Sensor Networks (WSNs), TPC techniques have been widely researched as an important technology. The ultimate goal of TPC techniques is to extend the lifetime of sensor nodes using an optimal transmission power level (TPL), which ensures a balance between energy consumption and packet loss on links. Therefore, in this paper, we introduce representative TPC algorithms such as linear, binary, and dynamic algorithms. Then, we summarize a general TPC model and a closed loop TPC mechanism which can be used in wireless body sensor systems.

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2 Representative TPC Algorithms

According to the previous studies, there are three representative TPC algorithms: linear, binary, and dynamic. The linear search algorithm [11] is the simplest search algorithm for finding a particular TPL value. This algorithm finds a desirable TPL by linearly incrementing or decrementing the current transmission power based on the RSSI values. The desirable TPL is a particular point on which the current RSSI value falls within the target RSSI margin. The binary search algorithm [12] finds a desirable TPL by exponentially increasing or decreasing the current transmission power. That is, if the current RSSI value is lower than the target RSSI margin, the next TPL is chosen to be the midpoint level between the current and the maximum possible TPL. Similarly, if it is above the target RSSI margin, the next TP level is chosen as the midpoint level between the current and minimum possible TPL. The dynamic search algorithm [13] uses the equation of a straight line for assigning the best possible TPL. This algorithm needs up to two RSSI values to make the equation. After making a new straight line equation, this algorithm finds the desirable TPL using the created equation.

3 General Transmission Power Control Model

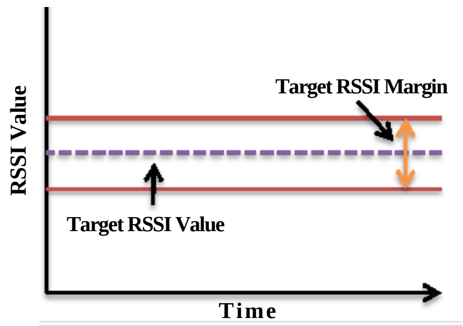

Fig. 1. Transmission power control model

We demonstrate a TPC model, as shown in Fig. 1. In this model, the target RSSI value means the optimal TPL spot that has both a suitable packet delivery rate and energy efficiency. This point is predefined before or adjusted during system operation. A highly defined target point brings high TPL and results in energy inefficiency. Correspondingly, a low target point brings the opposite. The target RSSI margin is a range of desirable thresholds that reduces the number of TPL control packets that occur from the irregular channel environment in WB-SNSs. Its width can be adaptively controlled by system operators. However, if it is extremely large or small, the sensor system can be inefficient in energy consumption or unstable in dynamic environments.

4 Closed Loop TPC Mechanism

A large majority of sensors in WB-SNSs periodically collect various data about human vital signs such as pulse, body temperature, breathing rate, and blood pressure. Therefore, such sensors need to operate a real-time system for energy management. As shown in Fig. 2, the closed loop mechanism can realize this requirement by continually communicating between the nodes of transmitters and receivers as follows. The transmitter node sends a data packet to the receiver node. Next, the receiver node measures the RSSI values of the received data packet. Then, if the measured RSSI is out of the target RSSI margin, it searches for a new TPL using a particular TPC algorithm. After, the receiver node sends a control packet including this TPL to the transmitter node. Through these steps, sensor nodes can control transmission power.

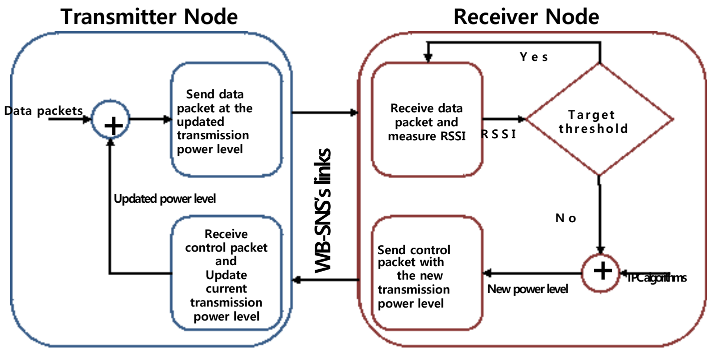

Fig. 2. Closed loop mechanism

5 Conclusion

In this paper, we reviewed representative TPC algorithms such as linear, binary, and dynamic algorithms. Then, we summarize a general TPC model and a closed loop TPC mechanism which can be used in wireless body sensor systems. For the future work, we will compare the performance of these representative TPC algorithms in a real sensor system with diverse environments such as sensor placements and body motions.

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