A Study of Channel Characteristics in Wireless Body Sensor Network Systems

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Abstract. Unlike existing wireless sensor network (WSN) environments, wireless body sensor network (WBSN) environments can have dynamic channel characteristics depending on sensor placements, human movements, and surrounding environments. In this study, to analyze such WBSN channels, the stomach, back, forearm, wrist, thigh, and ankle were set as sensor placements and standing, walking, and running were set as human movements to conduct experiments. Channel environments were analyzed through the experiments and the variations of the characteristics of received signal strength indication (RSSI) values depending on individual sensor placements and human movements were compositely analyzed.

Keywords: wireless body sensor network, received signal strength indication, transmission power level.

1 Introduction

In WBSN environments, channels are affected by human movements, the locations of sensors attached, and surrounding environments. Therefore, these factors should be analyzed to design WBSN systems. Accordingly, the analyses of sensor placements and human movements must be conducted first.

Many previous studies analyzed link channels in relation to human bodies. Study [1] experimented and analyzed accuracy, latency, and battery lifetimes in WBSN environments. However, [1] is limited as it considered only the wrist and the ankle as sensor locations. Although [2] arranged sensors at diverse locations, it considered only standing states for human movements. In addition, both [1] and [2] used CC2420 radio chips, but the characteristics of modules and the characteristics of link channels used in [1] and [2] are different from those used in this study [3]. Therefore, unlike previous studies, CC1000 radio chips will be used in this study to examine the composite effects of diverse human movements and sensor placements on channel environments to analyze the characteristics of RSSI values.

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2 Experiment Environments & Results

In this chapter, wireless body sensor network environments for actual experiments are constructed and the results of the experiments are explained.

2.1 Experiment environments

In this paper, experiments were conducted using a Cricket Mote fabricated by Crossbow Technology [4] to construct actual sensor network environments. The Cricket Mote was fabricated using CC1000 Radio modules [5]; its frequency band was 868MHz. There were a total of six sensor nodes located in the stomach, back, forearm, thigh, and ankle and a sink node was arranged on the chest. Diverse channel conditions were considered in standing, walking, and running states as human movements.

2.2 Experiment results

Figure 1 shows graphs for average RSSI values for movements and sensor locations. Sensor placements are affected by certain factors, such as areas, distances, and obstacles, so that RSSI values vary. As human movements become more active, RSSI values become smaller. Gradual decreases in average RSSI values from -57.9 to -58.3 and to -63.8dBm for movements in standing, walking, and running, respectively, could be identified through experiments.

In standing states, RSSI values of the stomach are highest followed by the values for the forearm, wrist, ankle, back, and thigh in order of precedence. However, in walking and running states, RSSI values of the back are lower than those of the thigh. This is because the distances to the thigh and the number of obstacles decrease in walking or running states, as the thighs repeatedly comes forward despite the thighs being dynamic areas.

The stomach is a static area close to the sink node that has no obstacle. Therefore, its channel conditions are relatively better than those of other locations; thus, its RSSI value is the highest at -50.7dBm regardless of movements, as indicated in the experiment. The forearm and the wrist show no difference or minor differences between standing and walking states. In walking states, the forearm does not move very much because the arms are swung gently and the wrists have a larger radius of movements, thus showing larger differences in RSSI values than the forearms. A notable fact is that the differences in RSSI values between walking and running states are largest on the wrists. This is because the radii of movements of the wrists are the largest in running states, and the heights of the sensors in running states are different from those in walking states. Through these experimental results, the importance of channel conditions consisting of those factors such as distances and obstacles could be seen. The thighs and the ankles showed higher RSSI values in walking states than in standing states in the experimental results because the distances are repeatedly reduced and the number of obstacles decreases. Although the differences were minor,
the experiment showed that even slight movements could positively affect RSSI values.

Fig. 1. Average RSSI values when the transmission power level is 22. Individual graphs show the values for the stomach, back, forearm, wrist, thigh, and ankle beginning in the top left graph and ending at the graph on the right bottom, in order of precedence. The x-axis in the individual graphs shows human movements, i.e., standing, walking, and running states. The y-axis shows RSSI values.

3 Conclusions

In this study, human movements and sensor placements were set diversely to conduct experiments. As expected, average RSSI values decreased as human movements became more active. In order of precedence in standing states among human movements, the RSSI values of the stomach were the highest followed by the values of the forearm, the wrist, ankle, back, and thigh. The RSSI values of the back were lower than those of the thigh in walking or running states. RSSI values showed different characteristics in relation to the set factors. Among them, the stomach had the most stable channel conditions and showed the smallest differences in RSSI values regardless of
movements. The wrist showed the largest differences in RSSI values between walking and running states. Through these results, it can be seen that human movements and sensor placements are important factors in WBSN. Based on these findings, if diverse factors are compositely considered, efficient WBSN systems can be designed.

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References