Cooperative Relaying and Outage Performance in Narrowband Wireless Body Area Network

Karma Wangchu[1], Minseok Kim[2], and Jun-ichi Takada[3]

[1]Graduate School of Science and Engineering, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550 Japan and karmawangchu@ap.ide.titech.ac.jp, [2] mskim@ide.titech.ac.jp, [3] takada@ide.titech.ac.jp

Abstract

Body area network (BAN) has gained a lot of attention in last the few years due to the huge opportunities for application in fields such as healthcare and patient monitoring, sports, military, space applications, business and entertainment among others. In general a BAN node has to be compact, comfortable and safe to be worn by the subject for long durations, while being reliable at the same time. The nodes therefore need to be highly energy efficient and operate at low transmit power. However on the other hand, at low transmit power BAN could suffer from serious reliability issues because of the large attenuation caused by body, body motion and the environment. Additionally a BAN channel is found to be quasi-static nature [1]; BAN channels are composed of dominant slow fading components such that during the packet transmission the channel effectively remains constant, resulting in burst errors that are difficult to be corrected by the simple error correction codes recommended in the BAN standard [2]. Narrowband BAN will also suffer from reliability issues due to interference from other wireless systems such as wireless LAN, Bluetooth and ZigBee with which it has to coexist. In this work cooperative relaying is proposed to improve the outage performance of on-body BAN.

2-hop relaying is already recommended and included as an option in the BAN standard. There are already few works on two hop cooperative relaying, although most of the existing works are based on only single hop channel measurements and fixed cooperative relaying. Knowing that BAN channels are highly influenced by the relative position of the nodes (or antennas) on the body, the body motion, posture and the surrounding environment, to better understand the possible gains due to cooperative relaying we made simultaneous multi-link channel measurement for all realistic biomedical sensor locations on the body, when the subject covered regular everyday motion scenarios in a typical office environment. Using the measurement and the narrowband PHY layer specifications of the BAN standard, we constructed equivalent 1-hop channel models for three cooperative relaying schemes; simple decode-and-forward (S-DF), cooperative decode-and-forward (C-DF), and incremental decode-and-forward (I-DF) relying. Incremental decode-and-forward relaying, the non-regenerative equivalent of which is proposed in [3], has not been discussed in the context of BAN in existing literature to the best of our knowledge.

Knowing the statistics of the equivalent 1-hop channel, the outage probabilities of the three cooperative relaying schemes were then compared to the direct transmission for all possible combinations of source, cooperator and destination node. It was found that at 10% SNR outage probability I-DF relaying provided the greatest improvement in the outage threshold, with up to 16 dB improvement when the best cooperator was chosen. The statistically best coordinator or hub node location in the recommended star topology was also determined based on the gains. On average for any coordinator node location cooperative relaying always provided a net average improvement in the outage threshold, with minimum of more than 5 dB in case of the I-DF relaying. Although more realistic considerations based on actual BAN hardware would be needed to analyze the actual gains in energy due to cooperative relaying, we have demonstrated that the outage performance can be greatly improved by implementing cooperative relaying.

References

1. M. Kim, K. Wangchuk, and J. Takada, “Link correlation property in WBAN at 2.4 GHz by multi-link channel measurement,” in *2012 6th European Conference on Antennas and Propagation (EUCAP)*, pp. 548–552, IEEE, Mar. 2012.

2. *IEEE Standard for Local and metropolitan area networks – Part 15.6: Wireless Body Area Networks*, IEEE 802.15.6, 2012.

3. J. Laneman, D. Tse, and G. Wornell, “Cooperative Diversity in Wireless Networks: Efficient Protocols and Outage Behavior,” *IEEE Transactions on Information Theory*, vol. 50, pp. 3062–3080, Dec. 2004

978-1-4673-5225-3/14/$31.00 ©2014 IEEE