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Cooperative Diversity based WBAN by using STBC

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Abstract **–** This paper is focused towards a cooperative diversity-based wireless body area network (WBAN) by using Alamouti's space-time block code (STBC) with rotational precoding scheme along with Max-Min and Harmonic Mean relay selection procedure. The considered WBAN model is served for healthcare service in order to mitigate the undesired effects of WBAN due to high path loss and fading as well as to keep a low transmit power while meeting to the desired WBAN quality of services.

Keywords *–BER, Precoding, STBC, WBAN.*

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I. INTRODUCTION

The development of WBAN brings a number of research challenges such as interoperability, scalability, reliability, QoS, and energy efficiency to the design of communication protocols. As we mentioned, the energy resources are very constrained in WBAN. Utilizing energy efficient communication protocols to maximize the network lifetime is important for WBAN applications. Reducing transmit power can be a potential approach. Note that, to avoid negative impact of electromagnetic radiation on human body, it is critical to keep a low transmit power in WBAN. However, the path loss in WBAN is usually larger than 50 dB [1], causing severe attenuation on wireless signals, and thus, without sufficient transmit power the link quality is very likely to be deteriorated. Recently, it is observed that, with 1mW transmit power at 2.4GHz, the on-body (off-body) links of WBAN are intermittently disconnected up to 14.8% (14.9%) of the time when people sleep on bed [2]. As such, the network topology of WBAN could be frequently partitioned [3]. Further, the data packets in WBAN mostly consist of medical information with the demands of high reliability and low delay. As a result, how to design communication protocols to ensure an end-to-end reliable communication with the least energy consumption becomes a key challenge in WBAN.

Cooperative communications have the advantage of spatial diversity, thus improving both link reliability and energy efficiency [4, 5]. The power consumption with cooperation in wireless sensor network is studied in [4]. It is shown that, for a large distance separation between the source and destination, cooperative transmission is more energy efficient than direct transmission. The energy efficiency of cooperative communication is further illustrated in the clustered wireless sensor networks in [5], and similar results are revealed. Motivated by these researches, we are interested in the use of cooperative communications in WBAN and the associated performance in terms of energy efficiency.

Moreover, cooperative diversity techniques, where some relay nodes provide the alternative paths to transmit information from a source to a destination, have also considerably drawn the attention and exploited in wireless networks [6], [7] and wireless body area networks (WBANs) [8]. The relaying paths can provide the better WBAN links when the direct path (from a source to its destination) disappear or is not reliable which always occurs due to high path loss and fading in WBAN. Cooperative communication can enhance the network performance of WBAN extremely, e.g., increasing spectral and energy efficiency, expanding network coverage, and reducing bit error rate etc. Three cooperative transmission protocols, exploited in the relay node, are amplify-and-forward (AF), decode-and forward (DF), and compress-and-forward (CF). AF mode will be exploited in this research because the sensor nodes of a WBAN have the computing time and energy limitations. In order to employ 2×2-Alamouti's space-time block code (STBC) in practical, a wireless node is needed to have two antennas. In the other hand, if the pre-coding scheme is employed to the STBC, a single antenna of the wireless node can be used and the high gain can still be achieved without loss of transmission rate. Pre-coding scheme is generally exploited in down-link because a transmitter must know one's own transmit channel state information (CSI). The performance is deteriorated if the received CSI from receiver is not perfect. However, this event is alleviated possibly as the data symbols are sent by using STBC with rotational pre-coding (STBC-PC) scheme [6].

The main objective of this paper is to evaluate the bit error rate (BER) performance of a cooperative diversity-based wireless body area network (WBAN) by using (2×2) Alamouti's space-time block code (STBC) with rotational pre-coding scheme and a relay selection procedure (RSP). Zero Forcing and Minimum Mean Square Error equalizers are used for equalization.

II. System Model

A WBAN consists of some sensor nodes as shown in Figure 1, where the sensor nodes transmit their data to a central node. The symbols for each propagation link in the proposed WBAN model are also shown. A central node is a receiver which acts as a gateway to a computer room or other wireless networks. Each node is placed on the human body and composed of a sensor, electronics module, and a single antenna.

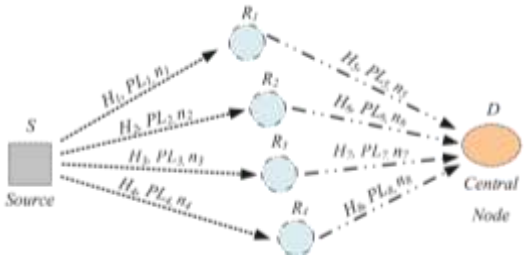

Figure 1: A WBAN model and propagation channels in WBAN [9]

The received signal for a link of any pair of nodes i and j (y_j) is modeled as:

$$y_j = h_{ij}\, x_i + n_j \qquad (1)$$

Rotational Precoding

The main aim of rotational precoding is to direct all the power to the sub-streams along their corresponding Eigen directions of the channel, which can be achieved by the selection of appropriate codeword from the set that minimizes the distance:

$$d(W_k, W_l) = \frac{1}{\sqrt{2}} ||W_k W_k^H - W_l W_l^H||_F \qquad (2)$$

Where d is the chordal distance.

III. Conclusion

Cooperative Max-Min and Harmonic Mean relay selection schemes have been developed. To evaluate system performance Rayleigh fading scenario has been considered. It can be seen that the Harmonic Mean relay selection scheme outperforms the Max-Min relay selection scheme.

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