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GENETICALLY OPTIMIZED PRECODED ALAMOUTI SCHEME FOR WIRELESS BODY AREA NETWORKS

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ABSTRACT
The WBANs find their use in wide variety of fields starting from medical to sports to military. However the main concern for WBANs is their energy efficiency that in turn illustrates the network longevity. 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. Additionally, the Genetic Algorithm (GA) is also used for the optimization of Precoded-Alamouti scheme which shows satisfactory results. The proposed 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. Bit Error Rate (BER) performance is compared for proposed approaches having BPSK and QPSK modulation techniques.

KEYWORDS: BER, GA Precoding, STBC, WBAN, ZF.

I. INTRODUCTION
In present era people grow-up to depend on wireless technology, interest for high data rate in wireless communication develops significantly more. This issue is brought on not just in light of expansion in the quantity of users who frequently use this technique, additionally due to the way that the data which must be transformed has likewise become altogether. Despite the fact that improvement in the wireless innovation has been rapid, some physical parameters are as yet restricting the utility of the wireless technique. In most of the cases, battery life, limited frequency band and severe fading channel are causes which have get to be difficulties for specialists to succeed.

Wireless sensor network technology for medical monitoring is an attractive alternative to traditional medical systems. Today, biomedical sensors are used in few health surveillance applications, so they are not yet integrated into communication networks [1]. It is important to communicate the measured data in a sensing device (sensor) to other devices in which the information will be concentrated and processed. Therefore, it is crucial to have a biomedical sensor communication network. This would have a radical impact on the quality of life of patients and their success rates. It could also have a wide range of future applications, such as cardiovascular disease surveillance, diabetes and asthma, case consultation through telemedicine or health systems, etc.

Wireless Body Area Networks (WBANs) have recently emerged as a product to do so. They are a new generation of wireless sensor networks (WSN), suitable for monitoring the human body [2].

A WBAN consists of a set of small nodes, equipped with biomedical sensors, motion detectors and wireless communication devices. These nodes collect the vital signs of the body and then transmit them wirelessly to a central unit where all the information collected is processed. Due to their wireless nature, WBAN nodes have many advantages, such as ubiquitous connectivity, mobility and interoperability. Some nodes may also be equipped with actuators, such as pacemakers or instruments for storing and injecting medications. Smart phones can be used to transmit all information collected with the outside world (medical, emergency services, etc.) [3]. 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-andforward (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).ZeroForcing and Minimum Mean Square Errorequalizers are used for equalization.

II. SYSTEM MODEL

A WBAN consists of some sensor nodes as shown in Figure1, 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.

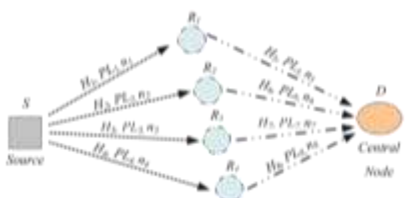

Figure 1: A WBAN model and propagation channels in WBAN [9]

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.

Relay Selection

The optimal relay selection scheme works on the principle of selecting relay with minimum symbol error rate (SER), while in practice it is hard to analyze. Therefore a sub optimal relay selection scheme which selects relay with minimum SER and which is analyzable is required. Max-min relay selection and Harmonic Mean relay selection schemes works on such principle and they are analyzable as well. Let h_{si}, h_{id} denotes the instantaneous channel condition between source and i^{th} relay, i^{th} relay and destination. Bletsas et al. [10] proposed two formulas to select any relay among a set of relays: under Policy I, the base of the two is chosen, while under Policy II, the consonant mean of the two is utilized:

Under Policy I:

$$h_i = \min\{|h_{si}|^2 |h_{id}|^2\} \quad (3)$$

Under Policy II:

$$h_i = \frac{2}{\frac{1}{|h_{si}|^2}+\frac{1}{|h_{id}|^2}} = \frac{2|h_{si}|^2|h_{id}|^2}{|h_{si}|^2+|h_{id}|^2} \quad (4)$$

Optimization of Precoded-Alamouti is done using the Genetic Algorithm.

Genetic Algorithm

Genetic algorithms (GA) are a fairly wealthy family and very interesting stochastic optimization algorithms based on the mechanics of natural selection and genetics. The choice of GA among other methods is justified based on the following four properties [11]:

- The GA use encryption settings and not the settings themselves.
- The GA are working on a population of points, rather than a single point.
- The GA use only the values of the studied function, not its derivative or other auxiliary knowledge.
- The GA use probabilistic transition rules, not deterministic.

In addition, the GA using two major strategies to find a solution or set of solutions. These strategies are: exploration and exploitation. They allow to find the global maximum (solve the problem) because they are complementary [12]. If the exploration is investigating all solutions of the search space, the operational phase in turn uses the found knowledge to previously visited solutions to help find better solutions. The combination of these two strategies can be quite effective but the difficulty is to know where the best solution is.

The GA operate with a population comprising a set of individuals called chromosomes. Each chromosome is composed of a set of genes. Each individual is assigned a value calculated by a function called adaptive or fitness. In practice, from a population of chromosomes is generated in a random manner during initialization. To set the size of the population, Marczyk, A. [12] reported that this size varies from one problem to another. In each cycle of genetic operations, a new population called generation is created from the chromosomes of the current population. Why some chromosomes called 'parents' are selected to develop the genetic operations. The genes of these parents are mixed and recombined to produce other chromosomes called 'children' forming the new generation. The steps of the GA are repeated in cycles t, the judgment of the algorithm is fixed according to a stopping criterion. There can be several stopping criteria:

- The number of generation originally set has been reached.
- The value of the adaptation function has reached a set value a priori.
- The absence of changes in the value of the fitness function of individuals in a population to another.
- The chromosomes have reached a certain degree of homogeneity.

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Figure 2 shows the steps of a simple GA:

```
Simple Genetic Algorithm
{t = 0;
        Initialization (P (t));
        Evaluation (P (t));
        While not end to t =
        t+1;
              P'= select (P (t));
          Recombining (P'(t);
          Mutation (P'(t));
          Evaluation (P '(t));
               P = Survival (P, P'(t));
}
```

Figure 2: Steps of a simple GA

Figure 3 shows the evolutionary cycle for Genetic algorithm

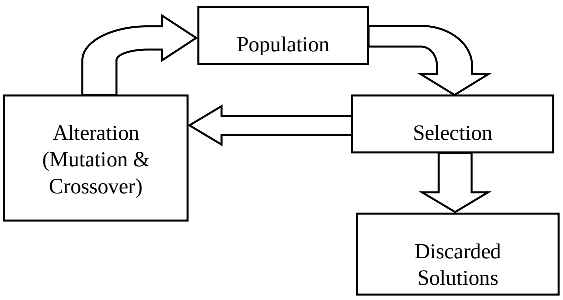

Figure 3: Genetic algorithm evolutionary cycle [12]

III. SIMULATION AND RESULTS

The performance of proposed algorithms has been studied by means of MATLAB simulation.

Comparison of Bit Error Rate (BER) performance for Max-Min and Harmonic-Mean relay selection schemes is shown in Figure 4.

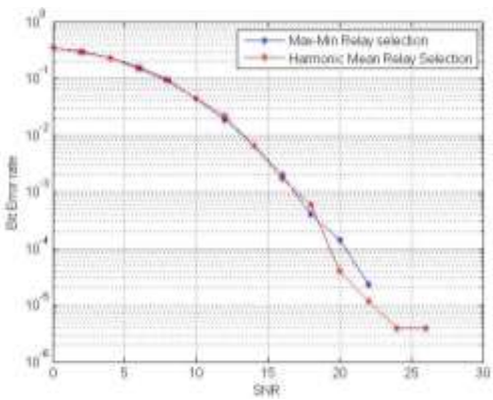

Figure 4: Comparison of BER performance for Max-Min and Harmonic-Mean relay selection schemes

On observing BER at10^{-4}, it can be seen that Harmonic-Mean achieves this level at 19 dB SNR, while Max-Min at 21 dB. Clearly Harmonic-Mean shows 2 dB better performance than Max-Min scheme.

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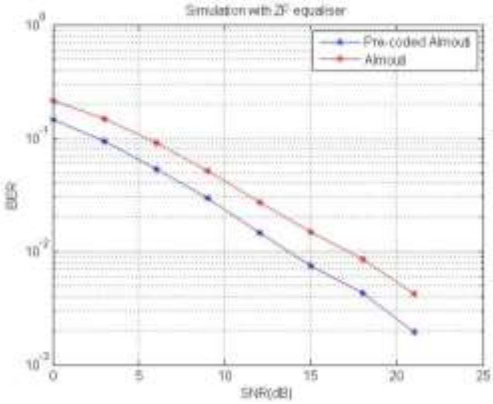

Figure 5: Comparison of BER performance of Alamouti and Precoded-Alamouti schemes in ZF equalization

Comparison of Bit Error Rate (BER) performance of Alamouti and Precoded-Alamouti schemes in ZF equalization is shown in Figure 5. On observing BER at10^{-2}, it can be seen that Precoded-Alamoutiachieves this level at 14 dB SNR, while Alamouti at 17 dB. Clearly Precoded-Alamoutishows 3 dB better performance than Alamouti scheme.

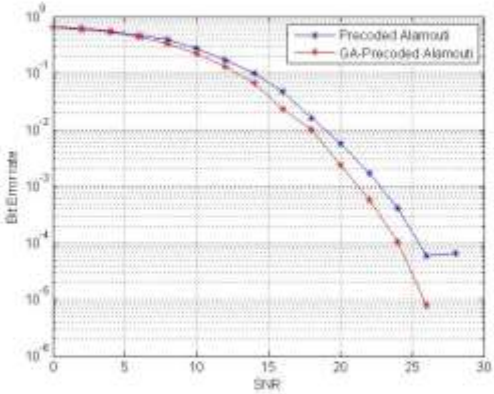

Figure 6: BER performance comparison of Precoded-Alamouti and GA optimized Precoded-Alamoutischemes in ML equalization for QPSK

Comparison of Precoded-Alamouti and GA optimized Precoded-Alamouti schemes in ML equalization for QPSK is shown in Figure 6. On observing BER at10^{-4}, it canbe seen that GA optimized Precoded-Alamoutiachieves this level at 21 dB SNR, while Precoded-Alamoutiat 23dB. Clearly GA-Precoded-Alamoutishows 2 dB better performance than Precoded-Alamouti scheme.

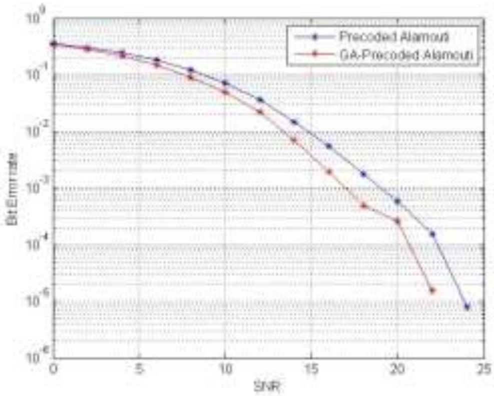

Figure 7: BER performance comparison of Precoded-Alamouti and GA optimized Precoded-Alamoutischemes in ML equalization for BPSK

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Comparison of Precoded-Alamouti and GA optimized Precoded-Alamouti schemes in ML equalization for BPSK is shown in Figure 7. On observing BER at10^{-4}, it canbe seen that GA optimized Precoded-Alamoutiachieves this level at 21 dB SNR, while Precoded-Alamoutiat 23dB. Clearly GA-Precoded-Alamoutishows 2 dB better performance than Precoded-Alamouti scheme.

IV. CONCLUSION

Wireless Body Area Networks (WBANs) are emerging technologies that enable a wide variety of interesting applications, mainly in the field of monitoring of body signals for medical, sports and / or military purposes.In terms of health care, this technology has great potential because it is possible to keep physicians informed about the health status of their patients in a remote way, thus lowering many of the costs of hospitals and health centers. Health in the use of available beds. In addition to elements called sensor-actuator nodes, it is feasible to provide a necessary medication to users automatically, only with the activation of an alert generated by the sensor itself, which can help prevent crises caused by diseases or health disorders.

Comparison of bit error rate (BER) performance for cooperative diversity-based wireless body area network (WBAN) using PrecodedAlamouti's STBC and its optimization with Genetic Algorithm have been represented in this research work. 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. Simulation results also show the BER performance comparison between the Precoded-Alamouti and GA optimized Precoded-Alamouti for BPSK and QPSK modulation techniques. It was found that the genetic algorithm provides better results in terms of BER.

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