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Optimization Mechanism for Multi-User Detection of SDMA-OFDM Systems

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Abstract: *In recent studied we found that there are many optimization methods presented for optimal multiuser detection in SDMA-OFDM system, however each method is suffered from limitations. Hence in this paper we are presenting new method which is combination of two recent methods such as Genetic Algorithm and Partial Swarm Optimization (PSO). This approach is presented to overcome this limitations associated with existing methods of detecting multiuser in SDMA-OFDM systems. This two methods GA and PSO are easy to simulate as well as less complexity. These techniques are shown to provide a high performance as compared to the other detectors especially in a rank-deficient scenario where numbers of users are high as compared to the base station (BS) antennas. The proposed hybrid multiuser detection system (MUD) is simulated and its performance is compared against two MUDs such as MMSE (minimum mean square error) and ML (Maximum Likelihood). From the practical results it is cleared that proposed approach for MUD is performing better as compared to existing methods.*
Keywords: *OFDM, SDMA, Multiuser Detection, Spectral efficiency, ML, MMSE, GA, PSO, BER.*

I. Introduction

In the introduction we are first discussing about the concept of smart antennas which is vital for any communication system. The mechanism of using the several antenna elements as well as innovative signal processing in order serve more intelligently the wireless communications is introduced since from long time. In the defense systems, already the concept of smart antenna applied which is of varying degrees and relative costly [1]. Still to the date, such barrier of cost of using the smart antennas was prevented in commercial applications. The DSPs (Digital Signal Processors) which is low cost and powerful advent as well as innovative software oriented signal processing tools made the intelligent antenna systems for the real time deployment in wireless communication systems. Now days, as the solutions which are spectrally efficient are enhancing the business imperative, such systems are supporting for the wider coverage area, interference rejection highly, as well as substantial capacity improvements. Thus, the solutions of smart antenna required as the interference, number of users, and the propagation complexity growing out. [2] [3]

The wireless communication system’s exponential growths as well as the limited availability of bandwidth for those systems are creating several problems for the big organizations working. Recently the advances in central processing unit as well as digital signal processor resulted into the more improvements in the algorithms and smart antenna system’s experimental validations build the environment where the use of cost effective smart antennas is feasible in different kinds of wireless markets. [3]

Due to the various activities involved in the smart antenna systems that are provided by them space of smart antenna is quite busy. First thing is that multipath fading effect in the wireless communication systems can be reduced significantly. As the quality and reliability of the wireless communications system is heavily based on the rate and depth of fading, such variation reduction of the signal means the fading results into the higher robust communication link. After that the second thing is that, battery life for the handsets which is used for transmitting the base station is less as compared to the one required for conventional systems [4]. This is only because of fact that base station antenna array achieving the diversity gain as well as nullifying gain, and hence needed transmit signal is reduced for the handset. The third thing, the QoS (Quality of Service) of communication network is improved by the smart antenna via the range extension, better building presentation and whole filling. Thus, the benefits of QoS in smart antenna systems infrastructure costs decrease as a result. at last, smart antenna system, frequently head (to intervene) is limited by the ratio used to enhance the proportion of wireless communication systems is Sir by smart antenna systems and therefore increases the system enough [4].

On other hand, Orthogonal frequency division multiplexing (OFDM), which is the fundamental unit of all multi-carrier communication systems, has been receiving wide interest especially for high data-rate broadcast applications because of its robustness in frequency selective fading channel Transmitter and receiver, which is widely referred to as MIMO technology to both employ multiple antennas on high throughput wireless communication [1] [3] constitutes a cost- effective approach for SDMA technology as wireless communication based. Systems to solve a range of the most promising technologies is a subclass of MIMO systems, as well as multiple users various SDMA. Geographic locations to share the same bandwidth enables the spatial dimension also exploitation. Time/frequency/code domain, thus the system capacity [1] [4] growing when they identify individual users for Makes it possible i.e. detection technologies more loaded position, especially in the many challenging issues currency. A large number of users are to be more challenging customization tasks, estimated [4] to be made due to the rapid increase in the number of dimensions.

OFDM-SDMA systems for efficient research of MUDs in development in recent years have

generated much interest, and many detection algorithms have been proposed in the literature [9]. Various MUDs, MUDs and classical linear MMSE ZF at the expense of a limited demonstration among the less complexity. High complexity optimal ml soil provided here an exhaustive search [10]

[11] [12] to achieve the best performance with. However, nonlinear ml detector complexity generally uses especially with many practical systems users and avoids the major constellations. QR Decomposition tree using one of the most promising algorithm, which can be applied with less complexity and optimal solutions [13] [14] near.

Most classic detection techniques suffer from the lack of scenarios specific rank ranges. based on non-linear Suboptimal MUDs to constant interference (SIC) or parallel interference cancellation techniques (PIC) may also be used, but the error propagation [1, 5, 6] are prone to gasman-OFDM systems efficiently in the family can be involved and thus many challenging issues in GA better convergence properties. Literature, technology based and with lower computational complexities is discussed in detail. In addition to other optimization techniques to implement GA likely latest PSO algorithm for implementation of stochastic and strong leadership.

TGn has been widely used for channel IEEE 802.11 wireless local area network (WLAN) standards, and indoor network bandwidths up to 100 MHz, 2 and 5 GHz. Use TGn channel model, designed for frequencies of a highly dispersive environments received actual performance. Because in combination with OFDM, SDMA and benefit of future both high data rate wireless communication systems has emerged as a promising solution to work these days prime importance. In below sections, first in section II, we are first presentation of the problem definition and proposed architecture for MUD in SDMA-OFDM.

II. Proposed Technique

Problem Definition

There are many papers were already presented by different researchers over Genetic algorithm based multi user detection of SDMA-OFDM Systems, however there is still needs to be have more optimal solution for such systems by improving the GA approach. GA based approach surpasses the conventional low complexity methods, such as the minimum mean-square error (MMSE), and approaches the optimal performance of the Maximum Likelihood (ML) detector, while maintaining reduced complexity, however their still chances to improve the BER ratio.

Proposed Method

Presents such a genetic algorithm (GA) and Particle Swarm Optimization (PSO) OFDM- SDMA multi-user detection (mud), as proposed in this work, therefore, two popular evolutionary algorithms that classical detectors [5] [6] the limits of. they implement simple andOh and their complexity in terms of decision-metric evaluations much less likely maximum detection (MLD) is compared to these techniques, especially the lack of a post where the number of users compared to the base station (BS) antennas are high compared to other detectors in the landscape to provide a high-performance are shown in this scenario. Zero forcing (ZF) and severe performance degradation

[7] [8] based on minimum mean square error (MMSE) MUDs exhibit. To investigate almost realistic performance of a wireless communication system, it is important to use a proper channel model. Since the simulation parameters in this work are based on IEEE 802.11n wireless local area network (WLAN) standard, TGn is the channel model used.

Following figure 1 showing the GA based MUD approach.

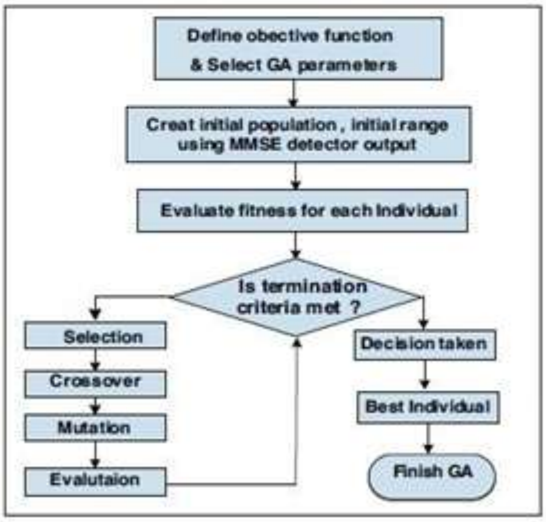

Figure 1: GA based MUD for SDMA-OFDM

Following are the methods and architecture which is nothing but the combination of both GA and PSO based MUD methods. This below figure 2 is indicating the proposed approach for this hybrid MUD method.

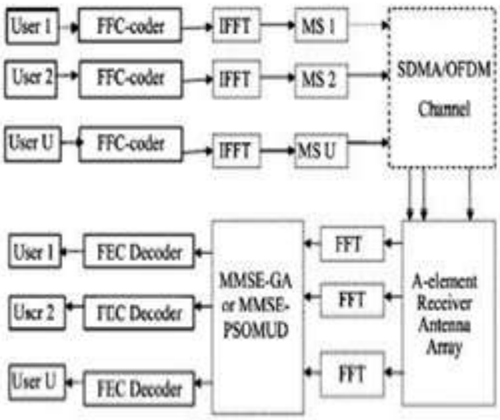

Figure 2: Proposed MMSE-GA or MMSE-PSO hybrid multiuser detected SDMA-OFDM uplink system

III. Simulation Models

In this section we are presenting the simulation environment for ML, MMSE, ZF and proposed method presented in this paper along with their results.

We have simulated below four methods for performance investigation:

1. MMSE (Minimum Mean Square Error)
2. ML (Maximum Likelihood)
3. ZF (Zero Forcing)
4. Hybrid GA Based Method (Proposed)

Before discussing these methods and their results, we are first presenting the simulation model and assumptions made for each of this method.

a. OFDM-MIMO Model

In a 2×2 MIMO channel, probable usage of the available 2 transmit antennas can be as follows:

i. Consider that we have a transmission sequence, for example $\{x_1, x_2, x_3 \ldots x_n\}$
ii. In normal transmission, we will be sendingx_1 in the first time slot, $x_2$in the second time slot, x_3 and so on.
iii. But as we now have 2 transmit antennas, we may group the symbols into groups of two. In the first time

slot, send $x_1$and x_2 from the first and second antenna. In second time slot, send $x_3$and $x_4$from the first and second antenna, send x_5 and x_6 in the third time slot and so on.

iv. Notice that as we are grouping two symbols and sending them in one time slot, we need only $\frac{n}{2}$ time slots to complete the transmission.

v. This forms the simple explanation of a probable MIMO transmission scheme with 2 transmit antennas and 2 receive antennas.

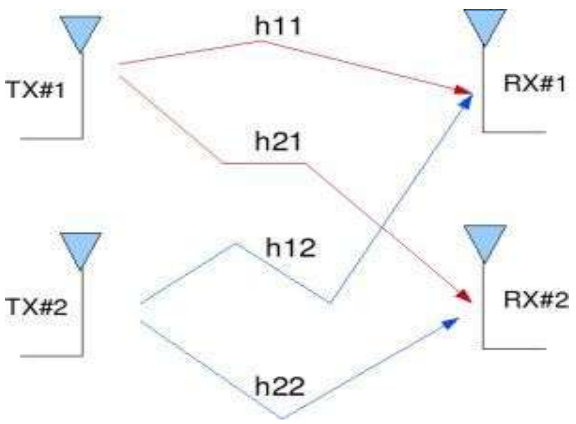

Figure 3: Transmit 2 Receive (2×2) MIMO channel

b. Simulation Assumptions

1. The channel is flat fading – In simple terms, it means that the multipath channel has only one tap. So, the convolution operation reduces to a simple multiplication.
2. The channel experience by each transmit antenna is independent from the channel experienced by other transmit antennas.
3. For the i^{th} transmit antenna to , j^{th} receive antenna, each transmitted symbol gets multiplied by a randomly varying complex number. As the channel under consideration is a Rayleigh channel, the real and imaginary parts of $h_{j,i}$ are Gaussian distributed having mean is equal to 0 and

Variance a^2

$$h_{j,i} = \frac{1}{2}.$$

4. The channel experienced between each transmit to the receive antenna is independent and randomly varying in time.

5. On the receive antenna, the noise n has the Gaussian probability density function with

$$P(n)=\frac{1}{\sqrt{2\pi a^2}}e^{\frac{-(n-\mu)^2}{2a^2}} \text{ with } \mu = 0 \text{ and } a^2 = \frac{N0}{2}$$

7. The channel $h_{j,i}$ is known at the receiver.

c. Simulation Results

MMSE

In the first time slot, the received signal on the first receive antenna is,

$$Y_1 = h_{1,1}x_1 + h_{1,2}x_2 + n_1 = [h_{1,1}\ h_{1,2}]\begin{bmatrix} s1 \\ s2 \end{bmatrix} + n_1$$

The received signal on the second receive antenna is,

$$Y_2 = h_{2,1}x_1 + h_{2,2}x_2 + n_2 = [h_{2,1}\ h_{2,2}]\begin{bmatrix} s1 \\ s2 \end{bmatrix} + n_2$$

Where

Y_1 and Y_2 are the received symbol on the first and second antenna respectively,

$h_{1,1}$ is the channel from 1^{ct} transmit antenna to 1^{ct}receive antenna, $h_{2,1}$ is the channel from 2^{nd} transmit antenna to receive antenna, $h_{1,2}$ is the channel from1^{ct} transmit antenna to 2^{nd} receive antenna, $h_{2,2}$ is the channel from 2^{nd} transmit antenna to 2^{nd} receive antenna, $x_1$and $x_2$are the transmitted symbols and
n_1 ,n_2 Is the noise on$1^{ct}$and 2^{nd} receive antennas. We assume that the receiver knows, $h_{1,2}$
$h_{1,1}$ $h_{2,1}$ and $h_{2,2}$. The receiver also knows Y_1 and $Y_2$and For convenience, the above equation can be represented in matrix notation as follows:

Equivalently, $Y=HG + n$
The Minimum Mean Square Error (MMSE) approach tries to find a coefficient W which minimizes the criterion,

$E\{[wy - x][wy - x^K\}$

Solving,

$W=[H^K + N_0\mathbf{I}]^{-1}H^K$

Following as per the above formulation following graph in figure 4 is showing the performance of simulating MMSE. As compared to the Zero forcing method which is presented next, at 10^{-3}BER point, it can be seen that the Minimum Mean Square Error (MMSE) equalizer results in around 3dB of improvement.

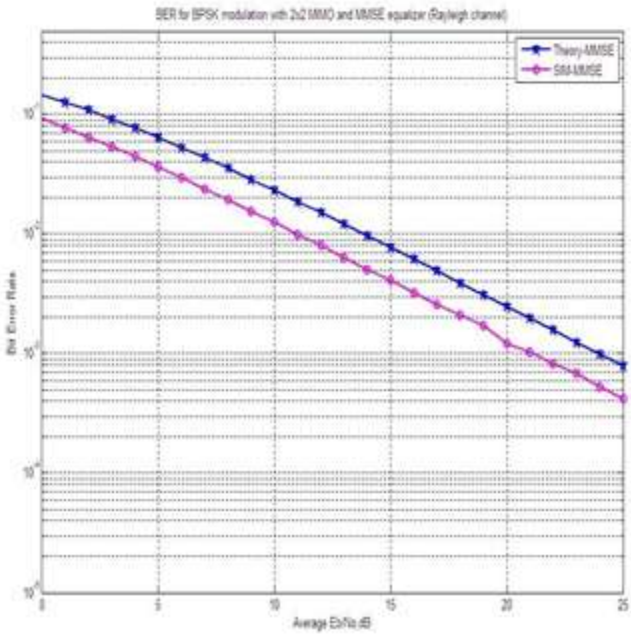

Figure 4: Performance of MMSE Channel Estimation Method

Maximum Likelihood (ML)
The Maximum Likelihood receiver tries to find x which minimizes, $J = [y - HG]^2$
Since the modulation is BPSK, the possible values of
x_1 is +1 or -1 similarly x_2 also take values +1 or -1. So, to find the Maximum Likelihood solution, we need to find the minimum from the all four combinations of$x_1$and x_2
The estimate of the transmit symbol is chosen based on the minimum value from the above four values i.e.
If the minimum is$j_{+1,+1} \prec [1,1]$if the minimum is,

$j_{+1-1} < [1,0]$ If the minimum is

$j_{-1,+1} < [0,1]$ and If the minimum is.

$j_{-1-1} < [0,0]$ Following figure 5 is showing the result for ML equalizer. This

matrix is also known as the pseudo inverse for a general m x n matrix.

The term,

$$H^K H = [\ h_{1,1}^{*} \times h_{1,2} \quad h_{2,1}^{*} \times h_{2,2} \quad h_{1,1}\, h_{1,2} \quad h_{2,1}\, h_{2,2}\ ]$$

Following is the result for this method simulated here in figure 5:

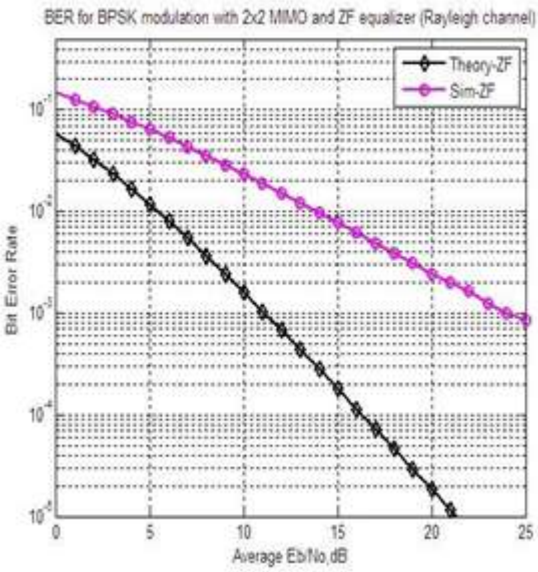

Figure 5: Simulation Result for ML Equalizer

This ML method is performing poor as compared to the above simulated MMSE method.

Zero Forcing (ZF)

To solve problem described in MMSE section, here we need to find the matrix W which satisfies WH=I . The Zero Forcing (ZF) linear detector for meeting t his constraint is given by,

$W=((H^K H)^{-1} H^K$

Hybrid Multiuser Detection Method

This the proposed method which is based on the concepts of GA and PSO method described in above sections. Mathematically we have done following work to simulate this method.

- Traditional methods of the receiver arbitrarily estimated symbol (for example the second spatial dimension, the transmitted symbol), and then subtract the received symbol and effect. once removed, the effect of a new channel becomes the antenna transmitted, will be obtained and improved malaria case 2 antenna research combining greater ratio equals (Center).
- But here we must first subtract the effect of first or whether we choose to have more intelligence. That decision, we can transmit high power on the receiver came on symbol (with the channel multiplication) detect corresponding to the transmitted symbol strength achieved both antennas.

Px_1 Σ Px_2 $Px_1 = [h_{1,1}]^2 + [h_{2,1}]^2$
The received power at the bth the antennas corresponding to the x_1 and x_2 tansmitted symbolis, $Px_2 = [h_{1,2}]^2 + [h_{2,2}]^2$Removed, the new channel becomes a one transmit antenna, 2 receive antenna case and the symbol on the other spatial dimension can be optimally equalized by Maximal Ratio Combining (MRC).

IV. Conclusion And Future Work

In this paper we have discussed the mathematical representations of OFDM systems, after that multiuser detection method like ML and MMSE. We have also discussed the how smart antenna systems used equalizers for efficient communication and spectrum frequency utilization. Smart antenna is basically used the SDMA-OFDM based communication architecture. Optimal detection of multiuser system in OFDM resulted into efficient spectrum and power efficiently, as well as improving the PAPR, and BER ratios. ML and MMSE are the existing methods which are used previously as multiuser detection system for SDMA-OFDM. However from many surveys we addressed the limitations of these methods, therefore we later introduced the proposed method which is based on PSO and GA based MUDs. This proposed method resulted into better performance as compared to existing methods. For the further work we like to improve and investigate this method by increasing the scalability of MIMO.

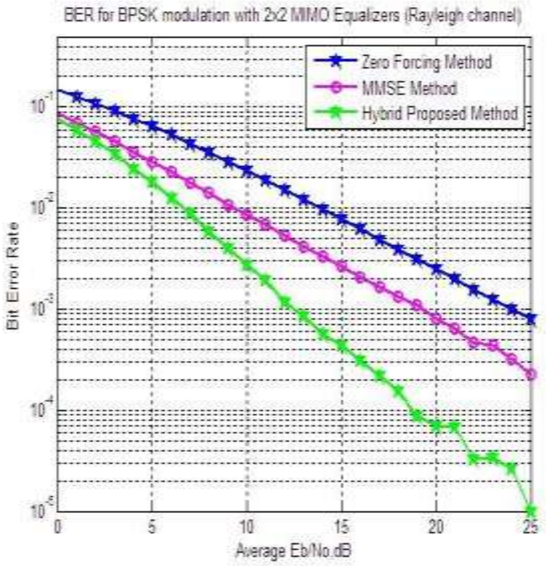

Figure 6: Performance of BER for Proposed Method of Equalizer

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