Performance Analysis for 3x3 multiple-input multiple-output communication networks

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ABSTRACT

In this paper, we consider the problem of zero-forcing equalizer is studied for 3x3 multiple-input multiple-output communication system in which MIMO source (three antennas) and destination (three antennas) pairs communicate simultaneously. Zero-forcing (ZF) equalizer are employed at destination to maintain lowcomplexity. The resulting expression is simple and easy to compute. The performance analysis of the proposed algorithm is demonstrated through numerical simulations can be significantly improved.

Keywords: Multiple-Input Multiple-Output, Zero Forcing, Bit-Error-Rate.

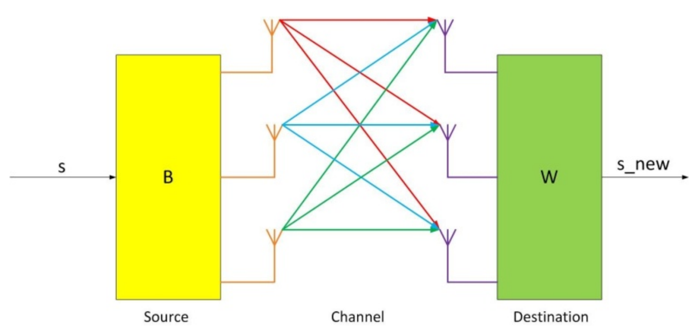
1. Introduction

Very few technologies have had as much impact on the trajectory of evolution of wireless communication systems as multiple input multiple output (MIMO) systems. Multiple-input multiple-output (MIMO) is order to provide a reliable wireless transmission, one needs to compensate for the effects of signal fading due to multipath propagation and strong shadowing. A relatively recent idea of extending the benefits of MIMO systems to multi-user scenarios seems promising in the context of achieving high data rates envisioned for future cellular standards after 3G. Although substantial research has been done on the theoretical front, recent focus is on making multi-user MIMO (MU-MIMO) practically realizable. It offers an enormous scope for further research in the coming years. These advantages make MIMO a very attractive and promising option for future mobile communication systems especially when combined with the benefits of orthogonal frequency-division multiplexing (OFDM) [4]-[9]. In this paper, we investigated the performance of zero-forcing (ZF) algorithm in a MIMO communication system in terms of bit-error-rate (BER) that are not included in [3]-[12]. In this paper, we study the ZF algorithm in MIMO communication system for filtering effectively decouples the channel into N_s parallel channels so that a scalar decoding may performend on each of these channels. Our results show that algorithms in MIMO communication system have significant performance improvement.

The rest of the paper is organized as follows: the system model is described in Section II; in Section III we study the zero-forcing linier receiver in a MIMO multi-relay communication system; Section IV shows the simulation results with ZF equalizer algorithms under various system scenarios and the conclusion is given in Section V.

2. Research Methods

Fig. 1 illustrates a MIMO communication system consisting of one source node, and one destination node. We consider a MIMO system with N_s transmit and N_d receive antennas communication through a frequency flat-fading channel. The generalization to the system with different number of antennas at each source node is straightforward. The communication process between



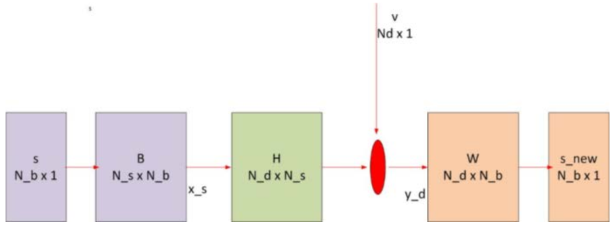


Figure. 1. System model for MIMO Channel.

the source and destination nodes is completed in a time slot. In the $N_b \times 1$ modulated symbol vector **s** is linearly precoded as

$$\mathbf{x}_s = \mathbf{B}\mathbf{s} \tag{1}$$

Figure. 2. Blok Digarma MIMO Channel

where **B** is an $N_s \times N_b$ source precoding matrix. We assume that $E[\mathbf{s}\mathbf{s}^H] = \mathbf{I}_{N_b}$, where $(\cdot)^H$ denotes matrix (vector) Hermitian transpose, $E[\cdot]$ stands for statistical expectation, and $\mathbf{I}_n$ is an $n \times n$ identity matrix. The precoded vector $\mathbf{x}_s$ is transmitted to the destination nodes and the received signal at the destination node can be written as

$$\mathbf{y}_{d,i} = \sqrt{E_s}\mathbf{H}_{s,i}\mathbf{x}_{s,i} + \mathbf{v}_{d,i} \qquad i = 1,\cdots,K$$

$$\mathbf{y}_d = \sqrt{E_s}\mathbf{H}_s\mathbf{x}_s + \mathbf{v}_d \tag{2}$$

where we define:

$$\mathbf{H}_s \triangleq [(\mathbf{H}_{s,1})^T, (\mathbf{H}_{s,2})^T, \cdots, (\mathbf{H}_{s,K})^T]^T$$
$$\mathbf{v}_d \triangleq [(\mathbf{v}_{d,1})^T, (\mathbf{v}_{d,2})^T, \cdots, (\mathbf{v}_{d,K})^T]^T.$$

where $\mathbf{H}_{s,i}$ is the $N_d \times N_s$ MIMO channel matrix the destination node, $\mathbf{y}_d$ and $\mathbf{v}_d$ are the total received signal and the additive Gaussian noise vectors at the destination node, respectively where $E[\mathbf{v}_d\mathbf{v}_d^H] = \mathbf{I}_{N_d}$. The diagram of the equivalent MIMO system described by (2) is shown in Fig. 2.

In this paper, we try to improve the system BER performance by using minimal mean-squard-error (MMSE) equalizer. A simple approach to design the $P_s > 0$ is the transmit power available at the source, and $(\cdot)^H$ denotes matrix Hermitian.

We study the following detection algorithms for MIMO communication networks such as the ZF equalizer. If we consider the received signal vector at the destination in (2) then our proposed MIMO channel (Fig. 1) reduces to a Blok Diargam MIMO channel (Fig. 2) into MIMO channel with the equivalent channel matrix of **Hs** + **v** where $\mathbf{H} = \mathbf{H}_s\mathbf{B}$, the signals vector of **s** and the equivalent noise vector of $\mathbf{v} = \mathbf{v}_d$. Now we can analyze the signal detection at the destination receiver with the ZF equivalent MIMO channel. One possibility is to minimize the total resulting noise to fine W using the decoding technique to be described in this paper is the performance ZF technique at destination. The ZF technique meeting the constraint as

$$E\{[\mathbf{W}\mathbf{y}_d][\mathbf{W}\mathbf{y}_d]^H\}. \tag{3}$$

where E is statistical expectation. The solution to this problem is given by the classical MMSE filter

$$\mathbf{W} = \sqrt{\frac{N_s}{E_s}}\{\mathbf{H}^H\mathbf{H}\}^{-1}\mathbf{H}^H. \tag{4}$$

The estimated signal at destination (2) is given by

$$\mathbf{s}_{new} = \mathbf{W}_H\mathbf{y}_d. \tag{5}$$

W is also known as denoting the Moore-Penrose pseudoinverse. ZF filtering effectively decouples the channel into N_s parallel channels so that a scalar decoding may be performend on each of these channels. The filtering reduces to matched filtering as $N_d \times N_b$ matrix and $(\cdot)^{-1}$ indicates simple matrix inversion. In order for a pseudo-inverse to exist, N_d must be greater than or equal to N_b. Using the ZF technique approach described above at the destination.

3. Results And Discussions

In the simulations, the transmission signaling is in spatial multiplexing mode (i.e., the source transmits independent data streams from different antennas) with total transmit power uniformly distributed among the transmit antennas. We study the performance of the proposed ZF technique algorithm for MIMO communication networks. All simulations are conducted in a flat Rayleigh fading environment using the BPSK constellation, and the noises are i.i.d. Gaussian random variables with zero mean and unit variance. The channel matrices have zero-mean entries with varianσ_s^2/N_s for $\mathbf{H}_s$. We transmit 1000 randomly generated bits in each channel realization, and the bit-error-rate (BER) results are averaged through 200 channel realizations.

In the example, we study the effect of the number of source antenna nodes and compare the system BER performance of the ZF technique at destination algorithm (proposed algorithm) with the without ZF (WOZF) technique at destination algorithm [3]. We choose variances of N_s and N_d. From Fig. 3, it can be seen that the WO-ZF algorithma has the worst performance. The ZF technique algorithmas outperform the WO-ZF approaches. It can be seen that BER = 10^{-2}, we achieve a

1.5-dB gain from the [3] to the proposed algorithm (ZF algorithma MIMO 2 × 2). Also, we achieve a 7-dB gain from ZF algorithma MIMO 2×2 to ZF algorithma MIMO 9 × 9.

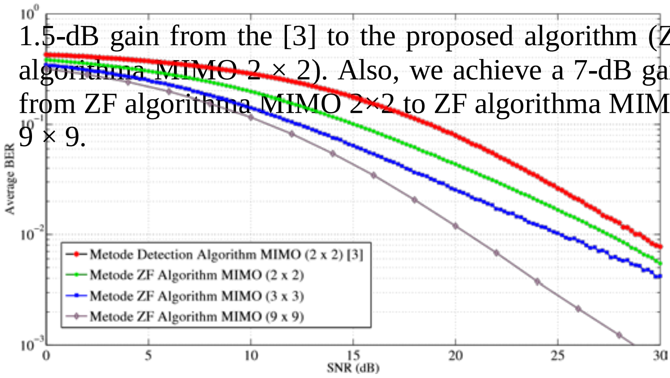


Figure 3. BER versus SNR_s. N_s = N_d =2,3,9 for MIMO channel

4. Conclusions

In conclusion, we have demonstrated the advantage of using ZF equalizer algorithm in MIMO communication network. Our results demonstrate that ZF equalizer algorithms outperform [3] algorithm. Future works may include analysis the ZF equalizer for MIMO relay communication networks and optimizing the source and the relay matrices to allocate power efficiently in a MIMO relay network.

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