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A Successive SLNR Based Pre-processing Matrix for Downlink Multi-user MIMO Systems

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Abstract

Aiming to co-channel interference (CCI) for LTE downlink multi-user MIMO-OFDM system, maximizing the successive signal to leakage plus noise ratio (SSLNR) interference cancellation algorithm based on Pre-processing is proposed. The algorithm utilizes SSLNR based on precoding matrix scheme to process emission signal and the known leakages is canceled by dirty paper coding (DPC) algorithm at the transmitter. At the receiver, the received signal are treated by preconditioned matrix, the interference between different users are eliminated in further, the sum-capacity is improved by pre-processing Matrix. Meanwhile, the algorithm is not limited by the number of transmit and receive antennas. The performance improvement is verified by simulation, when BER is 10^{-4}, signal noise ratio (SNR) is improved about 4dB.

Keywords: SSLNR, pre-coding matrix, dirty paper coding, MIMO-OFDM;

1. Introduction

The research of precoding has promoted in the multi-user MIMO (MU-MIMO) communication to increase the Quality of Service (QoS) of mobile units (MUs). In order to simplify the terminal equipment, the pre coding technology is applied in the base station. The precoding schemes can be classified as linear and nonlinear, the linear zero-forcing (ZF) / minimum mean square error (MMSE) precoding schemes have been proposed in [1-3], that the linear precoding schemes can to some extent cancel interference between different users, But these schemes exist

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error propagation under many circumstances, which to some extent restrict the improvement of system performance, the spatial degrees of freedom and the capacity of the system. Nonlinear precoding can improve the performance and the channel capacity. The literature [4-5] proposed Tomlinson-Harashima precoding (THP) scheme, which introduced nonlinear operation of modulo at the transmitter and at the receiver. The THP scheme not only guarantees that the transmit power is constrained but also increase the spatial degrees of freedom, In this scheme, however, and the nonlinear modulo operation may cause sum-capacity loss[6][7]. Maximizing the SLNR algorithm has been proposed in [8-9], which not restricted on the number of antennas, but the algorithm not completely eliminate the interference between different user, at the high Signal Noise Ratio(SNR) regions, the noise interference is as nothing compared to the residual interference, if the scheme continues to increase SNR, the system performance improves not obvious. In [10], the authors derived the SSLNR based precoding scheme, which not only eliminated the known leakages but also reduced computational complexity by combined the SLNR algorithm with the THP algorithm. Although the algorithm is not limited by the number of transmit and receive antennas. and to some extent improves system performance, the algorithm caused sum-capacity loss because of the nonlinear operation.

In this paper, a successive SLNR based pre-processing matrix for downlink multi-user equalization algorithm on the premise of no sum-capacity loss is proposed. The algorithm utilizes (DPC) algorithm and the SNLR algorithm to cancel the known leakages at the transmitter. at the receiver, the interference between different users is eliminated by preconditioned matrix, and then the sum-capacity is improved. The PP-SSLNR-ZF-THP and PP-SSLNR-MMSE-THP are proposed.

2. PP-SSLNR based on Precoding algorithm

In precoding scheme based on SLNR for multi-user MIMO systerm[8-9], each user suffers the interference of multi-antenna, so it is need to be eliminated the interference of multi-antennas by precoding matrix $\boldsymbol{W}_k$. However, it is hard for the user to obtain the information of matrix $\boldsymbol{W}_k$ because $\boldsymbol{W}_k$ is generated at the transmitter. To solve this problem, successive SLNR scheme based precoding has been proposed in [10]. Adding precoding scheme, the equation(1) can be written as

$$\boldsymbol{y}_k = \boldsymbol{H}_k \boldsymbol{W}_k \boldsymbol{x}_k + \sum_{i=1}^{k-1} \boldsymbol{H}_k \boldsymbol{W}_i \boldsymbol{x}_i + \sum_{i=k+1}^{K} \boldsymbol{H}_k \boldsymbol{W}_i \boldsymbol{x}_i + \boldsymbol{n}_k \tag{1}$$

The algorithm combines SLNR with THP, the second item $\sum_{i=1}^{k-1} \boldsymbol{H}_k \boldsymbol{W}_i \boldsymbol{x}_i$ in (1) is known by the kth user. According to [10], the SSLNR of the kth user can be written as

$$SSLNR_k = \frac{\left\| \boldsymbol{H}_k \boldsymbol{W}_k \right\|^2}{\sum_{i=1}^{k-1} \left\| \boldsymbol{H}_i \boldsymbol{W}_k \right\|^2 + N_k \sigma_n^{\ 2}} = \frac{tr(\boldsymbol{W}_k^{\ H} \boldsymbol{H}_k^{\ H} \boldsymbol{H}_k \boldsymbol{W}_k)}{tr[\boldsymbol{W}_k^{\ H} (\tilde{\boldsymbol{H}}_k^{\ H} \tilde{\boldsymbol{H}}_k + \sigma_n^{\ 2} \boldsymbol{I}_{N_T}) \boldsymbol{W}_k]} \tag{2}$$

Where $\tilde{\boldsymbol{H}}_k = \left[\boldsymbol{H}_1^T \boldsymbol{H}_2^T \cdots \boldsymbol{H}_{k-1}^T \right]^T$, ||•|| denotes Frobenious norm, $tr(\bullet)$ denotes the trace, the superscript H denote the conjugate transpose, the superscript T denote the transpose.

Form [10], the specific descriptions of the precoding matrix of the kth user is provided, this theory will not discuss it. The $\boldsymbol{W}_k$ can be selected from the corresponding generalized eigenvalues to the N_k largest generalized eigenvalues of the pair $\left\{ \boldsymbol{H}_k^H \boldsymbol{H}_k, \tilde{\boldsymbol{H}}_k^H \tilde{\boldsymbol{H}}_k + \sigma_n^2 \boldsymbol{I}_{N_T} \right\}$.

In [10], through the algorithm introduces modulo operation and then the transmit power is restricted, the algorithm introduces a new problem, namely modulo loss, which causes the sum-capacity decline. In order to deal with modulo losses, our hypothesis is that once an optimal receiver will be applied, modulo losses would be mitigated. We intend to demonstrate this hypothesis by developing a close to optimal receiver. In this paper, a successive SLNR based pre-processing matrix is proposed. The complete block diagram of PP-SSLNR-THP scheme is shown in Fig.1.

At first, the precoding matrix is given by (1). In order to reduce the modulus loss, we utilize maximizing the sum-capacity rules of the system. PP-SSLNR -ZF-THP and PP-SSLNR-MMSE-THP are proposed.