

Beamformer in Huge MIMO-IDMA Downlink Systems based on MMSE

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ABSTRACT

Today Massive multiple-input multiple-output is a promising technology because of the savings in both spectrum and energy costs that may be achieved by relatively simple signal processing. Recently, however, it has been shown that using code domains NOMA in mMIMO may enhance the SE performance in an overloaded situation where the number of UEs is greater than the number of antennas, leading to a worse error rate performance. Interleaved divisional multiple access (IDMA) has also received considerable interest as a potential NOMA (non-orthogonal multiple access) standard for the coding domain. This research makes two distinct proposals: first, an exceed the permissible inputs and generates a report (MIMO) and IDMA network infrastructure is jointly offered, in which transmitters on the base station serve users concurrently in the same frequency range. The numbers of both and are rather huge. Second, for a large MIMO-IDMA system with downstream communication restraints, it is proposed to use a beamformer based on the minimal mean square error (MMSE) to battle propagation loss and the influence of multiple access interfering (MAI). Performance of the suggested system using MMSE beamforming has been analysed by plotting the bit error rate (BER) against the signal-to-noise ratio (SNR), based on simulation results.

Keywords: MMSE; MIMO; IDM; 5G.

1.0 Introduction

As the amount of users and the demands for higher data rate services continue to rise, there is an urgent need for better wireless networks with more capacity and quality. By 2020, there might be as many as 26 billion connected devices, according to estimates from ABI research [1]. This would mean that the number of mobile devices could reach 49 million. Therefore, a reliable communication infrastructure is necessary to meet the demands of the future. Researchers have recently been interested in the mMIMO system [2], which improves spectrum and energy efficiency by equipping the base station with a bigger antenna array than the active user gear. Recent debates random matrix theory have shown that the disappearance of uncorrelated noise and rapid fading effects as the number of antennas in a single cell increases in size [2]. Furthermore, base stations often have more antennas than users, resulting in a large number of degrees of freedom (DoF) that may be used to simply modify the broadcast signal to reduce interference [3]. Better energy efficiency as compared to a single antenna system is only one example of the possible benefits of massively multiple-input, multiple-output (mMIMO). However, the spectrum efficiency and, by extension, the error performance of the mMIMO system, degrade under an overload situation where

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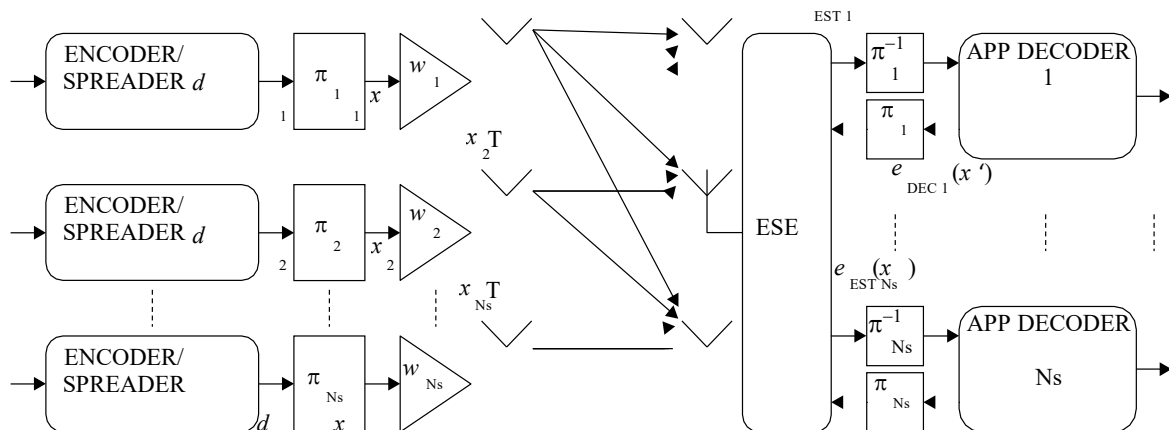
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the number of UEs higher than the number of bs antennas. In the worst propagation circumstances of UEs, when error rate performance is also degraded, it has been discovered that using coding domain NOMA in mMIMO communications may increase the SE [4].

In addition, 5G communication standards [5] recognize Interleave division multiple access (IDMA) as an effective code domains non orthogonal multiple access (NOMA) technique. Samsung’s IGMA, MediaTek’s RDMA, and Nokia’s IDMA are all code-based NOMA systems. These systems derive from the fundamental idea of IDMA [6] and are interleaving-based NOMA schemes. To differentiate between users, the interleaved patterns are used in the Interleaving based NOMA (IDMA) system. The log-likelihood ratio (LLR) estimations are utilised for decoding in the IDMA receiver, which is implemented using the low-complexity ESE method [6, 7].

Thus, it is suggested that the massive MIMO and IDMA communication systems be combined to provide a highly reliable communication system. Despite the fact that a small number of academic articles have proposed combining massive MIMO with NOMA, it has not yet been implemented. Yet the vast majority of them thought of NOMA in the power domain [8]. Since power domain NOMA calls for UEs with non-orthogonal channels, mMIMO’s primary characteristic is to make all the UEs’ channels substantially orthogonal [8-9], the improvements are often limited.

Figure 1: Model of the Massive MIMO-IDMA System



The combination of NOMA (IDMA) with m MIMO. Additional improvements to the proposed system’s performance are possible by the use of transmission beamformers. Beamformers improve signal strength for desirable users while simultaneously decreasing strength for unwelcomed ones. In spread spectrum systems (IDMA), the optimum beam-forming weights are determined by minimizing the mean square error between both the spread signal and the reference signal [10-12]. The microprocessor level least mean error (MMSE) beamformer can be used immediately alongside other beamforming algorithms.

2.0 System Model for a Large-Scale Mimo-Idma Network

To facilitate interaction between NR users’ single-antenna devices, we take into account a Massive-MIMO-coded NOMA (IDMA) communication system with a wide antenna array (NS 64). (UE). The intermediate channel is what’s known as a flat fading channel. The time-of-arrival of a signal modulated using BPSK without any precoding may be written as:

$$Z[t] = H \cdot x^T + n[t], t \in (1, 2 \dots N) \quad \dots(1)$$

$$X = \sum_1 w_k H_{xk} \quad \dots(2)$$

The transmitted message signal is denoted by $x = [x_1, x_2, \dots, x_{NR}]$, while the fading channel coefficients are denoted by $H \sim N^{NS \times NR} (0, 1)$ and the noise is denoted by $n[t] \sim N(0, \sigma^2)$ is a $N_S \times 1$ Gaussian noise vector. The bits of information $bk[t]$ are further assumed to be independent and identically distributed with a symbol duration T on the transmitter side. To a similar extent, the processing gain $N = T/T_c$ where T is the time period and T_c is the chip period. Perfect microcontroller synchronization is also expected for the downlink transmission. The k th user's service is the main coefficient $K(k)$ characterizes the transmitted signal in equation 2. The de-interleave operation is conducted at the receiver once the received signal has been linked to the spreading sequence.

3.0 MIMO-CODED NOMA Beamformer

Without narrowing the scope too much, we might assume that the intended signal would cause interference for other users (multiple access interference), which should be minimized so as to improve the quality of the communication connection. Beamforming may be the only method now available to counteract the impact of MAI. In addition, MMSE beamforming is well-liked and advantageous in comparison to other beamforming methods due to its strong performance measure of bit-error rate (BER) performance, while other beam-forming systems give sum-rate derived from an idealised capacity equation [11-12].

Furthermore, it has been shown that the MMSE beamforming improves system performance of both BER and total amount. Therefore, this study proposes MMSE beamforming for use in Massive MIMO- IDMA systems. The beamformer's weights were calculated by finding the smallest possible spread-to-estimated-output signal discrepancy. The criteria for updating weights may be stated as:

$$\arg[\min E\|X - Y\|^2] \quad \dots(3)$$

Where X is the predicted chip spread signal vector Y of the k th user, and Y is the transmitted signal vector. It is also possible to elaborate on an MMSE-based beamformer criteria that operates on a chip, as

$$J = \arg \min E\|X - (WHX + \eta)\|^2 \quad \dots(4)$$

In the above equation the transmitter precoder (beam-former) can be represented by transformation matrix.

4.0 Performance Analysis

The signal-to-noise ratio (SNR) effectiveness of the suggested system is described below. Since we have previously covered the optimal weights of the MMSE beamformer in (11), the mobile receiver's output signal may be represented as

$$y_k = x_k + \text{interfering signal} + \text{noise} \quad \dots(5)$$

The noise samples are AWGN process ie $\eta \sim N(0, \sigma^2)$ and $\sigma^2 = n_0/2$. Signal-to-noise ratio (SNR) is defined as the ratio of the strength of a signal to the level of noise.

$$\text{SNR} = \frac{E(\|x_{k(j)}\|^2)}{V_{c_k}} \quad \dots(6)$$

In addition, we may express the performance of the BER as a function of the SNR for user k , as follows: $\text{BER} = g(\text{SNR})$. Now, after spreading (length = 16) and interleaving (randomly k in to x_k), the information bits ($bk = 1000$) are being transferred for simulation purposes. At the receiver, the

optimal beamforming vector is applied to the interleaved data to generate the signal vector ie x Number of iterations it = 10. At the receiver end, we utilise a method called iterative detection, which is based on turbo processing. To further illustrate the superiority of the huge MIMO-IDMA system over the MIMO system in downlink communication, the BER vs. SNR performance curve is presented.

The processing gain in the simulation experiment is based on using the 16th number of transmitting antennas ($M_S = 128$ and $N = 64$). The findings are compared to those obtained with a basic MIMO setup, where the broadcast and receive antennas are the same ($N_S, N_R = 2$). The simulation plot is shown in Figure 2, which vividly illustrates the performance boost provided by the proposed system (i.e., the BER in huge mMIMO- IDMA is on the order of 10^{-5} at the 15 dB SNR, while it is at 10^{-1} with MMSE-MIMO).

Figure 2: BER Effectiveness of a Large MIMO-IDMA System With $N_S = 128$ and $N_R = 64$.

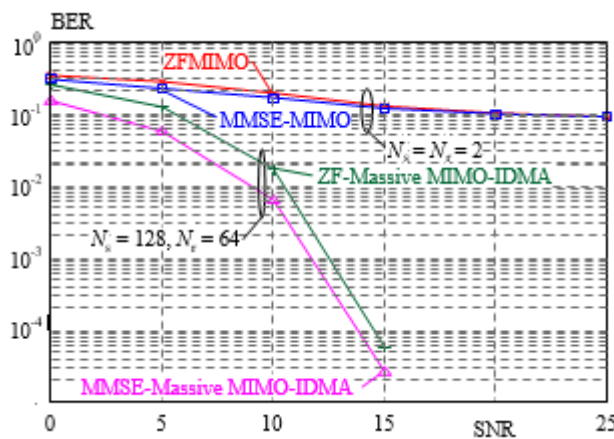
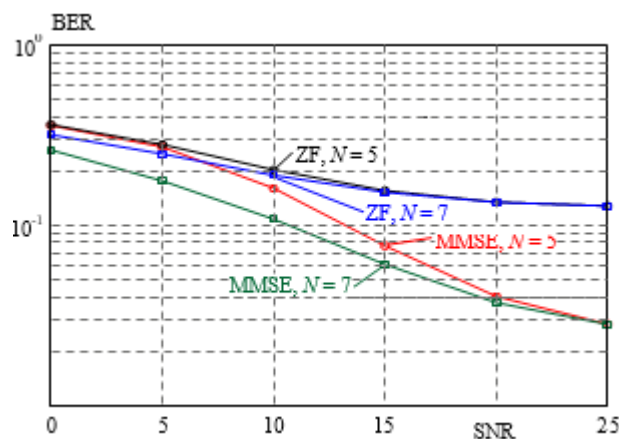


Figure 3: SINR Performance of Huge MIMO-IDMA for $N = 5, 7$



Efficacy of massive MIMO-IDMA is shown for two distinct user counts ($N = 5$ and $N = 7$) in Fig. 3. Figure 3 shows that across a wide range of user densities, massive MIMO-IDMA using an MMSE beamformer outperforms ZF beamforming. At relatively high values of SNR, the suggested system’s performance does not degrade as the number of users increases.

5.0 Conclusion

The goal of this research was to present a revolutionary Massive MIMO- IDMA system architecture for high data rate 5G wireless communications. More MMSE beamforming is suggested to further improve the SINR of the current system. Best condition for the weight vector was derived using the MMSE criterion. Performance of the suggested system has been measured through simulation. The simulation findings reveal that the Massive MIMO-IDMA system significantly outperforms a traditional 2X2 MIMO system in terms of BER. The proposed method takes use of the random multiplexed in order to keep as straightforward as feasible. However, in the future, the memory needed may be lowered by using a robust interleaving approach, and the signal-to-noise ratio (SNR) may be enhanced by increasing the width of the antenna array.

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