An Approach for spectral efficiency and Performance Optimisation by Using Adaptive Hybrid Beamforming in Multi-User massive MIMO OFDM Systems

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ABSTRACT:

In this paper, we consider multiuser massive multiple input multiple outputs (MIMO)-orthogonal frequency division multiplexing (OFDM) hybrid beamforming designs. We propose a closed-form approach that needs no iterations and is low in complexity to maximise spectral efficiency and performance. Matrix decomposition is used for analogue beamforming, and weighted MMSE is used for digital beamforming. Despite the fact that it isn't expected to optimise spectral efficiency, it shows some performance degradation. We proposed an adaptive hybrid precoding system that combines analogue as well as digital processing. To solve this problem, use the optimised minimum mean square error (MMSE) algorithm. Additive white Gaussian noise (AWGN) interferes with the signal in a broad MIMO communication channel with several users, each with a different number of data streams, and additive white Gaussian noise (AWGN) interfering with the signal along the direction, an adaptive hybrid beamforming structure is proposed to minimize the number of radio frequency chains. A bit error rate (BER) of the proposed system versus various fully digital beamforming methods under various conditions, Multi-user interaction is avoided as data is broadcast over a wireless channel, and hybrid MMSE and adaptive hybrid optimise MMSE are used at the receiver end, resulting in improved performance and spectral efficiency improvement is compared .Which is evaluated through simulation.

Index Terms— Optimize minimum mean square error (MMSE), Adaptive hybrid precoding, orthogonal frequency division multiplexing (OFDM), multiple input multiple output(MIMO).

I. INTRODUCTION

Multiple-input, multiple-output system (MIMO) is a common technology that increases the capability of a radio connection by using multiple transmits and receives antennas. The base station (BS) in future wireless systems could be fitted with hundreds, if not thousands, Huge MIMO is the product of a large number of antennas. Huge MIMO is a MIMO extension that can achieve much higher gain and spatial multiplexing is the process of combining two or more different than standard MIMO [1–3]. However, in traditional MIMO systems, fully-digital beamforming necessitates the use of a dedicated radio frequency (RF) chain for each antenna, which is no longer suitable for massive multiple-input, multiple-output (MIMO). If the number of RF chains grows, so does the cost of hardware, device complexity, and power usage, posing deployment challenges. To fix this issue, hybrid analogue and digital beamforming architectures have been proposed, By distributing RF chains through many antennas, RF chains are reused [4]–[8]. A frequency selective channel is for hybrid beamforming are more difficult. on the other hand Analogue beamforming can only be "frequency flat" since it is performed in the time domain by analogue components or in other words, since the analogue beamforming is the same across all subcarriers. In OFDM (orthogonal frequency division multiplexing) narrowband hybrid beamforming designs are no longer valid. Furthermore, while there have been a number of articles on multiuser digital precoding, there have been even fewer contributions on multiuser analogue precoding, suggesting that analogue precoding is a greater part of hybrid precoding. However, in multiuser systems with little scattering in the channel, To achieve optimum spectral efficiency and performance, frequency flat precoding and combining are required as shown in [14]. The focus of this paper is on optimizing For downlink large MIMO systems, MMSE-based adaptive hybrid precoding is proposed. The BS and the MS have a narrow feedback channel. is used in the proposed modified algorithm, with analogue and digital precoders selected from a quantized beamstearing codebook [7]. The beamstearing method is used to reduce the difficulty of a codebook. Adaptive hybrid precoder the goal is to design is to maximise the system's total rate and spectral performance. Output comparisons in the proposed optimize MMSE based adaptive hybrid beamforming algorithm, adaptive hybrid based MMSE algorithms and analogue only beamforming is demonstrated. Furthermore, the effects of optimize Focused on the MMSE adaptive hybrid beamforming parameters on device efficiency are explored. The number of BS antennas, mobile station antennas, efficient channel quantization bits, and RF beamforming quantization bits are all variables to remember, among other things are among these parameters. A study of coverage probability using a total rate threshold is also included. This paper's contributions can be summarized as follows:

• Examining a situation adaptive For large MIMO systems, a adaptive hybrid optimize MMSE-based precoding algorithm.

• The modified algorithm is used to investigate live output spectral efficiency and performance optimization when the number of antennas at the transmitter and receiver is greatly increased.

• Investigating the coverage likelihood and solving the optimizing of achievable rates optimization issue.

The following is the structure of this paper: Section II will show a model of a adaptive hybrid precoding scheme. The altered adaptive In Section III, hybrid precoding will be available. The Discussions and simulation results will be Section IV.

Finally, conclusions would be made in Section V.

II. SYSTEM MODEL

Figure 1 shows a large scale MIMO for a device for multiple users to stream (a single stream per MS). The optical precoder F_{BB} is used to precoder the N_s baseband data streams at the BS. Build the outputs with N_{RF}. Each MS user as a result, v reflects total number of MS.

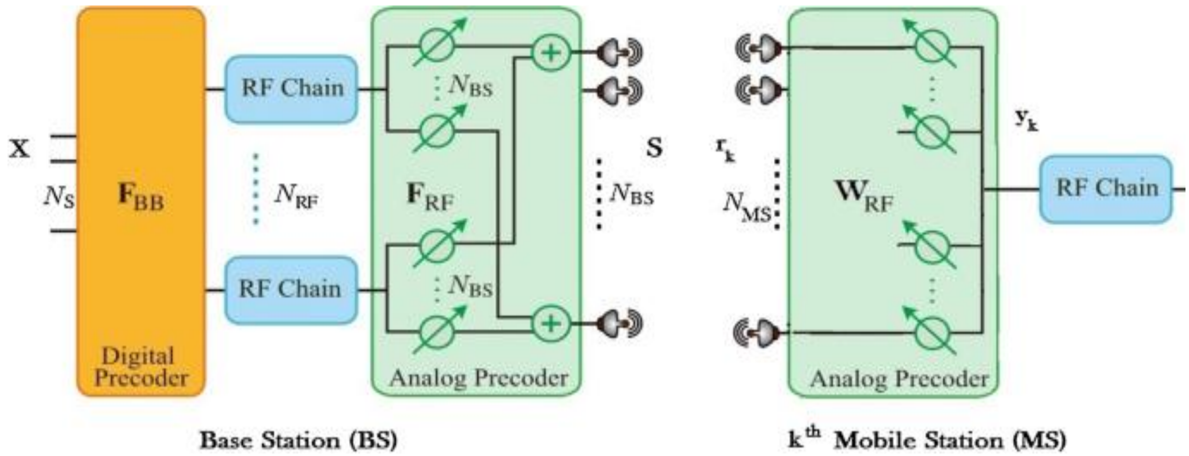

Fig: The Adaptive hybrid precoding system

The radio frequency (RF) mapped to N_{BS} antennas F_{RF}, a digital precoder, is up converted from the baseband. The number of RF chains is less than the number BS antennas to save energy and money, the antenna elements $(N_{BS} > N_{RF})$. The analogue precoders complete complexity structure is used to achieve this [18].

Only the analogue precoder is assumed at the MS [20]. The obtained signals from the N_{MS} Antennas are first grouped together to generate the RF signal, which is then down converted to its baseband signal using the analogue precoder W_{RF}.

If the input $N_S x1$ vector baseband is X=$[x_1, x_2, \dots, x_{N_s}]$T, then the transmitted $N_{BS}x1$ vector can be written as;

$$S=F_{RF}F_{BB}X \quad (1)$$

Where F_{RF} is the only precoder $N_{BS}xN_{RF}$ matrix and F_{BB} is the digital precoder $N_{RF}xN_s$a matrix. [18, 20] is used as the channel model. As a consequence, the knowledge obtained N_{MS}x1 the kth MS vector can be written as;

$$r_k=H_kS+n_k = H_kF_{RF}F_{BB}X+n_k \quad (2)$$

The channel between BS and the kth MS is represented by the matrix H_k, and n_k a N_{MS}x1 There is a Gaussian noise vector at the kth MS. Finally, the analogue precoders output signal can be expressed as;

$$y_k = (W_{RF})_K^* n_k \quad (3)$$

$$= (W_{RF})_k^* H_k F_{RF} F_{BB} X + (W_{RF})_k^* n_k \quad (4)$$

The massive MIMO With a minimal scattering, are proposed [3, 20] As a consequence, L_k disperses can be used to characterize between the BS and the kth MS channel. From the BS to the kth MS, each scatter is viewed as a single propagation channel or direction. After that, there's the channel. H_k can should be referred to as;

$$H_k= \sqrt{\frac{N_{BS}N_{MS}}{L_k}} \sum_{i=1}^{L_k} \alpha_{k,i} a_{MS}(\theta_{k,i}) a_{BS}^*(\emptyset_{k,i}) \quad (5)$$

In which $\alpha_{k,i}$ is the gain of the direction $\theta_{k,i}$ and $\emptyset_{k,i}$ there are two types of angles: angles of arrival (AoAs) and angles of departure (AoDs). The two types of angles.$a_{MS}(\theta_{k,i})$ For the kth MS antenna, is the vector of the array. $a_{BS}(\emptyset_{k,i})$ For use of BS antennas is the vector of the sequence.

III. The modified Adaptive hybrid precoding scheme

This paper's primary aim is to design analogue and hybrid digital precoders for base stations, as well as analogue combiners for mobile stations. Furthermore, the BS uses the MMSE algorithm for its digital precoder. The goal is to improve the system's overall rate. The system's total achievable rate[5] can be written as;

$$R=\sum_{k=1}^{N_s}\log_2\left[1+\frac{|(W_{RF})_k^* H_k F_{RF}(F_{BB})_k X_K|^2}{\sum_{u=1, u\neq k}^{N_s}|(W_{RF})_K^* H_k F_{RF}(F_{BB})_u X_u|^2+\sigma_k^2}\right] \quad (6)$$

Where σ_k^2 is the kth MS's average noise power. $|X_k|^2$ is the overall signal power's average. Following that, the optimum precoder values at the BS and MS should be configured to optimise the total amount of system rate that can be achieved. As a result, this is how the optimization problem is described:

$$\{F_{BB}^{'}, F_{RF}^{'}, W_{RF}^{'}\} = \arg\max(R) \quad (7)$$

This is an optimization problem involving mixed integer programming. Large feedback and training overhead signals are needed to solve this optimization problem [20] Computations are broken down into two stages to solve this problem:

1. Primary stage: This is the stage where, $F_{RF}^{'}$and $W_{RF}^{'}$ are obtained without taking into account the impact of user intervention. As a result, As shown below, the a problem of optimization be reduced to enhancement of the total obtained signal strength.

$$\{F_{RF}^{'}, W_{RF}^{'}\} = \arg\max\|(W_{RF})_K^* H_k F_{RF}\| \quad (8)$$

Where $\|.\|$ the Euclidean mean. As a result, analogue precoders are generated and combined at both BS and each MS. After that, the optimization problem is solved to get the analogue precoders' the best conditions $F_{RF}^{'}$and$W_{RF}^{'}$. It's worth noting that explicit channel estimation isn't needed to solve the problem as defined.

2. Secondary stage: In this stage, $F_{BB}^{'}$ the successful Mobile stations have outlets. First calculated depending on optimised values from stage 1, taking into account the user interference effect. MS kth effective channel is measured the following:

$$H_k^e=(W_{RF}^{'})_k^* H_k F_{RF}^{'} \quad (9)$$

Then, using B_{BB} bits, each MS quantizes its approximate effective channel. As a result, the codebook has expanded in the scale is$2^{B_{BB}}$. Following that, this quantized channel H_k^q is returned according to the BS. Finally, The BS makes use of input quantized channels to build the digital precoder. Instead of using ZF, an MMSE-based digital precoder is proposed. As a result, the following is the digital precoding matrix:

$$F_{BB}^{'} = H^{q*}(H^q H^{q*} + \sigma^2)^{-1} \quad (10)$$

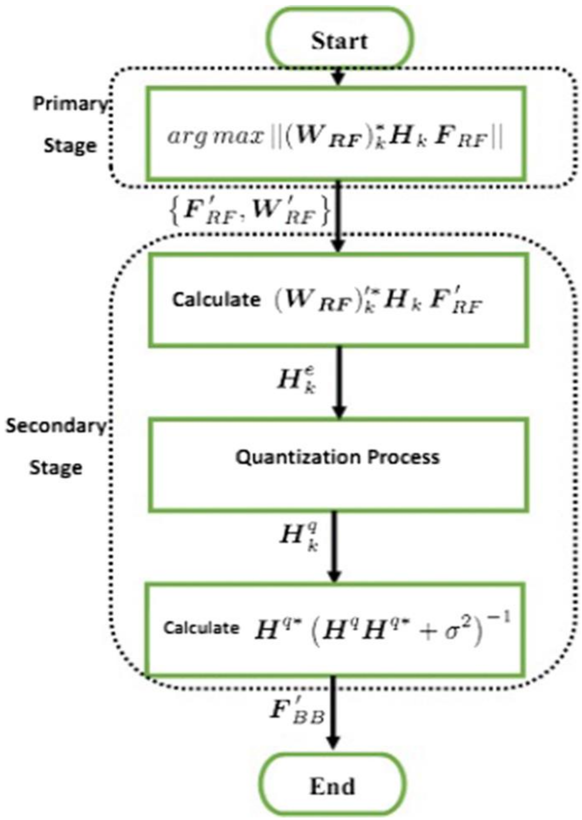

Fig2: Optimize MMSE based Adaptive hybrid precoding algorithm

Figure 2 depicts the two-stage MMSE-based hybrid precoding algorithm's flow chart.

IV. SIMULATION RESULTS AND DISCUSSION:

This project uses a multi-user MIMO-OFDM system to demonstrate the partitioning of the pre-coding into optical baseband and RF analogue components on the receiving end. One of the most important factors to consider is spectral efficiency device quality characteristics of a 5G network system. The effective channel is believed to be ideal, with uniformly distributed AoDs and AoAs. The azimuths and elevations are distributed in the ranges $[0, 2\pi]$ and $[-\pi/2, \pi/2]$. SNR is$\rho\sigma^2/K$, and noise variance (2). The proposed adaptive hybrid optimised MMSE precoding technique's achievable rates are investigated. For each of the four users in the method, the proposed adaptive hybrid beamforming spectral efficiency weights is compared to that of the completely Optimal weights or wireless beamforming, and a particular number of data streams for each user. The bit error rate (BER) for each user is the next parameter to compare. With Results of the BER being compared to prior adaptive hybrid beam-forming research techniques. For the first part of this experiment, the simulation parameters are as follows listed in the table I. Four users are given separate independent data streams to work with in this section user 1 gets three users 2 and 4 data streams get two user 3 and data streams gets one. To find out more impact of these settings on the device, the number of transmitter and receiver antennas will be varied in the simulation.

Simulation parameters

s.no	Parameters	Values
1	Number of users(U)	4
2	Transmitter antennas(N_t)	16
3	Receiver antennas(N_r)	4
4	Number of RF chains (N_{RF})	4
5	Bits for sub carrier(k)	4(16QAM)

Figure 3 shows the adaptive hybrid beamforming technique's BER VS SNR for each device, together with s denoting with The BER of user 1 who uses three data streams is obviously the highest, User 1 has the lowest BER since he only uses one data stream. For users 2 and 4, the BER is almost similar since they both have the same number of data streams. At 8dB SNR, Consumer 3's BER approaches 10^{-3} and then drops zero, when the user 1's At 13 dB SNR, the BER is $0.5*10^{-2}$ demonstrating the previously stated relationship between the number of data streams and the BER

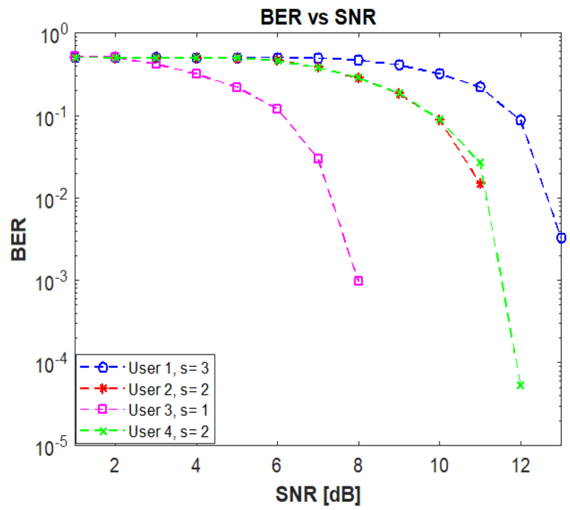

Figure 3: BER vs. SNR for each user with N_T=16 and N_R=4 for adaptive hybrid beam-forming.

Demonstrates the adaptive hybrid beamforming technique achieves an efficiency that is very close to optimum precoding while reducing the main aim is to increase complexity.

Figure 4 contrasts the spectral efficiency of hybrid MMSE versus optimal adaptive hybrid MMSE beam-forming techniques. The SE of users 2 and 4 are shown to be similar since they accept the same number of data sources, which is reasonable According to their separate data streams, user 1 has the highest spectral efficiency and user 3 has the lowest spectral efficiency. When comparing the SE of the adaptive hybrid approach to determining the best Weights are pre-coded for each user with fewer data streams, the adaptive hybrid technique's spectral efficiency is very close to that of the optimal technique. User 3 has nearly equal Values of spectral efficiency with both strategies whereas user 1 has nearly identical results, the optimal technique having a slight advantage. This demonstrates the adaptive hybrid beamforming technique achieves an efficiency that is very close to optimum precoding while reducing the main aim is to increase complexity.

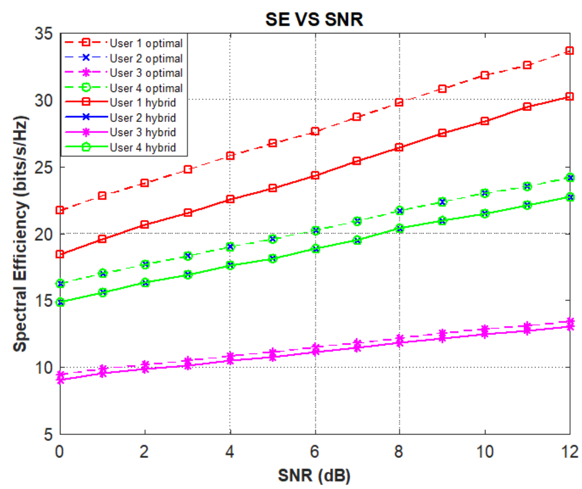

Figure4. Spectral efficiency comparison of Hybrid MMSE vs. Optimize MMSE for all users with N_T=16 and N_R=4.

If the number of transmitter and receiver antennas increases, the simulation findings show that rises, so does the number of transmitter and receiver antennas as the number of data streams increases and as well as for users who use several data sources. It's additionally worth noting this SE levels obtained by using hybrid beam-forming are very similar and with users fewer data streams performing to achieving optimum beamforming efficiency. Furthermore, a large number of receiver antennas, while providing a higher SE ratio, results in a higher BER. Despite the fact that the number of transmitter antennas is lower, which results in a lower BER As a result, the second configuration with higher NT and lower NR produced the best BER performance.

V. CONCLUSION:

This paper introduces a 5G adaptive OFDM system with hybrid MU MIMO. it is tested for four users, each with their own data streams, and The device's spectral efficiency and bit error rate is equivalent to the best pre-coding weights, often referred to as completely digital beamforming. Adaptive hybrid beamforming was shown to produce SE results that were very close to ideal precoding although preserving a fair and BER that is appropriate. Furthermore, it effects of adjusting these parameters were clearly demonstrated by adjusting the number of antennas used for transmitting and receiving assigned to each user. The proposed adaptive hybrid beamforming system achieves near optimal results while requiring less hardware complexity, expense, and power loss to implement.

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