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Successive Blind Interference Alignment Using Reconfigurable Antenna

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ABSTRACT: Interference alignment is new interference mitigation technique. In latest studies many experiments evolutions are proved only for interference alignment. But very less have given attention to the blind interference alignment. Interference alignment and other reduction technique require channel state information at the transmitter (CSIT). But blind interference alignment dost not require channel state information. The main concept is that the transmitter uses the knowledge of channel coherence intervals & receiver utilizes reconfigurable antennas. In this work we present a novel experimental evolution of reconfigurable antenna system for achieving blind IA. We present a Blind IA technique based on reconfigurable antennas for two user MISO-BC implemented on a software defined radio platform where each of RX is equipped with a reconfigurable antenna. We will compare BIA with TDMA, and evaluate SNR, BER and AEVMS.
keywords: interference alignment, reconfigurable antenna, coherence intervals, CSIT.

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I. INTRODUCTION

Interference is a major limiting factor in the performance of cellular radio systems. Interference is anything which modifies or disrupts a signal as it travels along a channel between transmitter and receiver. It can limit the capacity and effect the signal. So we can say interference have direct correlation with the quality of service. The Physical objectives like ,Electromagnetic radiations, and Environmental parameters these can create interference in signal. For that Interference mitigation techniques are required. The scope of mitigation technique is to take measures against the factor causing interferences and to help the receiver recover the useful data from the received signal. The interference mitigation techniques usually measures the SINR or BER and will try to optimize them in order to ensure a high SINR value and a low BER, corresponding to a good transmitter channel. The alignment of the interference is one of the recent technique. The basic idea of interference alignment is to appropriately precode the transmitter so that interference from undesired transmitter is aligned at the intended receiver. If the interference is strong then the interfering signal can be decoded along with the desired signal. And if the interference is weak the interfering signal is treated as noise. Many of existing studies gives precoding complexity at the transmitter, by assuming perfect or global transmitter-receiver channel state information. The assumption can not be successive in practical because obtaining accurate CSIT will require additional bandwidth and turn around time that severally impacts the spectral efficiency. So, implementing CSIT-based IA schemes become challenging. To overcome these challenges a technique called blind interference alignment, which does not require CSIT was proposed[2]. Without knowing the CSIT, blind IA is able to align the interference based on knowledge of channel autocorrelation structure of users. Most of exiting approaches to IA place an complexity by assuming perfect TX-RX CSIT. Obtaining accurate CSIT requires additional BW & turnaround time that effects efficiency. In [1] blind IA was uses to exploit the fading nature of wireless channel for every link to perform alignment. To improve from that to create artificially temporal autocorrelations in the channels using reconfigurable antenna was proposed in [2] [3].

In this paper we are evaluating performance of successive blind AI system based on reconfigurable antenna implementation on our multiple input single output orthogonal frequency division multiplexing (MISO OFDM). Reconfigurable antennas have gained significant attention in recent years for both single user system [6],[7],as well as multi user system[8],[9]. And here we are using reconfigurable antenna for successive blind IA instead of using multiple antennas for simulations.

Reconfigurable antenna gives more efficient system in terms of cost and space and performance, since at receiver single antenna can generate the required channel fluctuations and eliminate requirement for multiple antennas. To obtain successive blind interference alignment we did not require channel state information.

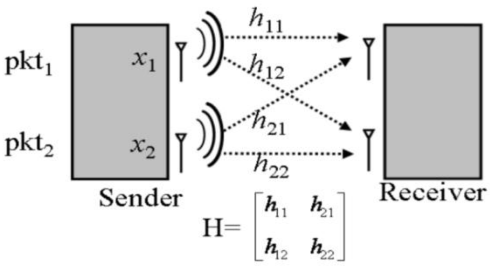

Fig1.2X2 MIMO transmission

For a normal interference alignment we use CSIT that is the knowledge whether the channel is free or not at receiver .as shown in fig 1 if channel coefficient are h11 ,h12, h21 ,h22, then receiver can estimate the channel vector H. Receiver will use this channel vector H to solve signal equations. We can understand by fig2.

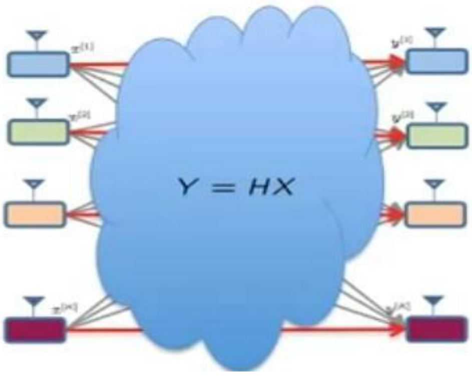

Fig2.channel vector

The use of MIMO system has emerged as means of achieving high capacity communication. In MIMO network IA uses the spatial dimension offered by multiple antennas for alignment. From a sum rate perspective, with k user pairs, the interference alignment scheme achieves the sum throughput on the order of k\2 interference free links. Basically each user can effectively get half the system capacity.

II. SUCCESSIVE BLIND INTERFERENCE ALIGNMENT

For successive blind interference alignment here is an assumption that is the channel variation pattern, even though the transmitter does not know the channel coefficients values, it knows the channel variation pattern. Consider two transmitters 1 & 2, and two receiver a & b, and we will look at channel as three channel users. At receiver a, the channel coefficient whatever their values remains the same in channel use one and channel use two.

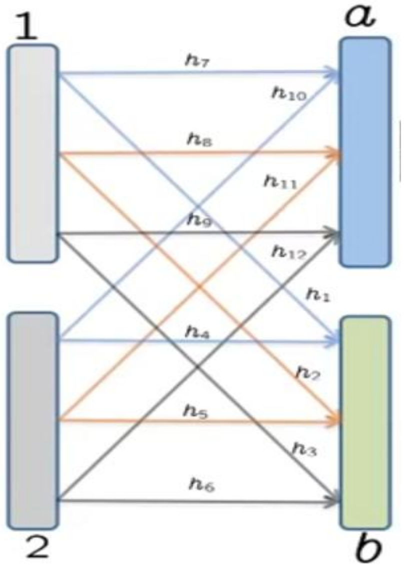

Fig3:2x2 channel coefficients for 3 signals

During the first two uses the channel does not change for receiver1. But the third channel use will be different for channel realization. Whereas for receiver b , channel coefficient remains same in channel use two and three, where as channel use one will be different for channel realization

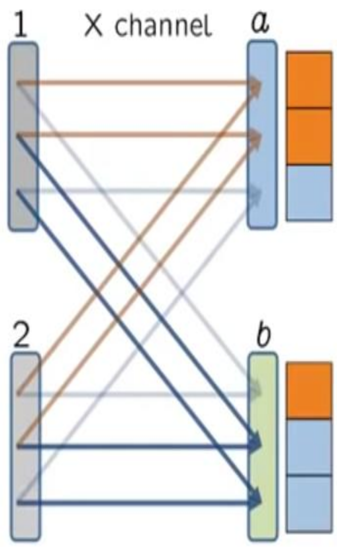

Fig4:Channel variation patterns of the signals

To happen this we are using reconfigurable antenna at receiver, that uses antenna switching, which means at any point receiver can switch from antenna one to antenna two, which will change its channel. So you can't control which channel will be but you can control when the channel will different.

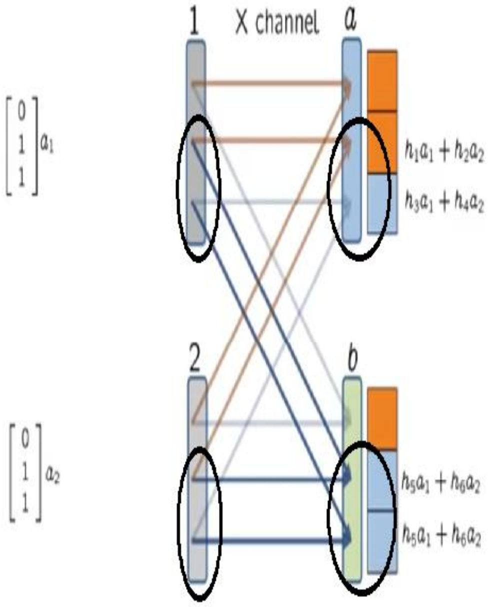

Fig5:Equations for variation pattern.

The idea is very simple, the transmitter will use the repetition, it will just repeat the information over those channel influences where the desired channel is different, but the undesired channel is same. Consider a_1 & a_2 are intended for receiver a. As shown in fig,5 see the 2 channel users where the desired receiver channel changes when the undesired receivers channel remains same. Those are channel users 2 & 3, over these receiver a changes channel variation pattern whereas receiver b remains same. So repeat a_1 & a_2 over these channel users. That's what precoding vector means.

At desired channel because of channel change you will see two different linear combination of a_1 & a_2.but at interfering receiver b_2 channel has remain same you will see same linear combination of a_1 & a_2.similarly these linear combinations of b_1 & b_2 will appear at the receiver a and b, as shown in the Now we have 3 equations in variables at each reciver, at reciever a undisered variables are b_1 & b_2 appears twice the same way we can cancel them, you will left with a_1 & a_2. Similarly for receiver b as shown in fig6, we can cancel undesired variables, as the interference by solving equations for undesired variables.

III.RECONFIGURABLE ANTENNA

A reconfigurable antenna is capable of changing its frequency and radiation patterns[9]. Smart antennas are different from reconfigurable antenna as reconfiguration mechanism lies inside the antenna .There are four types of reconfigurable antenna frequency reconfiguration, radiation pattern reconfiguration, polarization, polarization reconfigurable and compound reconfiguration.

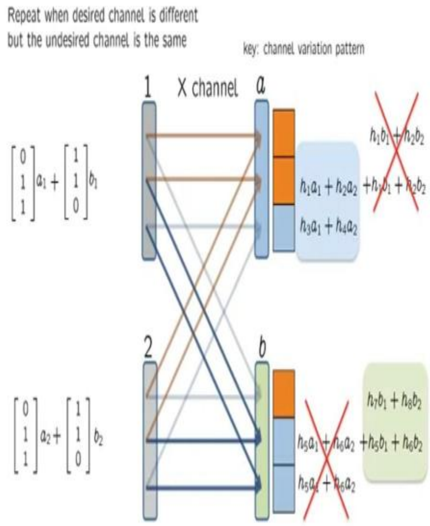

Fig6:Undisered signal cancelling

We are using same reconfigurable antenna from previous work, that is Alford loop antenna[9],a plannar reconfigurable antenna with integrated control circuitry design. This pattern reconfigurable antenna is composed of 4 ,90^0 microstrip elements symmetrically placed on substrate. With use of pin diodes these elements can be individually switched on and off. The radiation pattern of antenna will be omnidirectional, when all the elements are turned on. And also each elements can be individually turn on to generate four directional beam with 90^0 spacing. These directional & omnidirectional patterns are shown in fig7.Usage of different elements to generate different beam patterns is also possible. Because of its integrated channel circuitry this antenna is used in successive blind interference alignment.

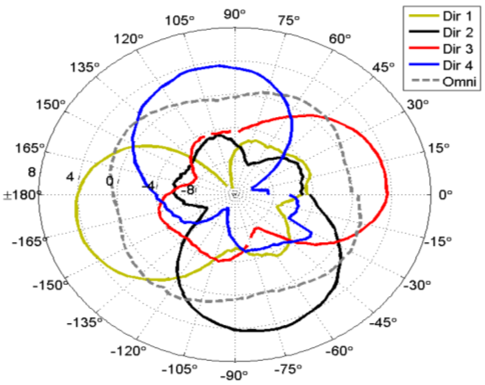

Fig7:Radiation pattern of reconfigurable antenna

IV. IMPLEMENTATION

We are implementing successive blind interference alignment using MATLAB .We are using the concept of correlation of signals. We are assuming that signals are auto correlated with each other. As we know autocorrelation of same signal is zero. The transmitter will perform the QAM modulation on our OFDM signal. We will perform the IFFT operation using butterfly structure as it will increase the speed. Then we will add the cyclic prefix then we will add channel filter. The receiver then performs the OFDM demodulation , interference cancellation.

V. RESULTS:

In this section we present the measurement results from our implementation. We will compare our successive BIA implementation with BIA & TDMA using three evaluation metrics :sum rates, average error vector magnitude squared, and bit error rate.

A. Sum rate performance

If we see the sum rate performance of blind IA and TDMA compared to our successive blind IA, this is estimated from measured data in fig8, if we see for SNR values large than 10db,the capacity of successive blind IA grows at much faster rate than TDMA & BIA. For low SNR , TDMA has better rate performance .At 30db SNR, approximately 8bits/s/Hz rate is achieved by successive blind IA, while rate of TDMA is just above 6bits/s/Hz .So this ratio is giving 4/3 rate gain by successive blind IA over other orthogonal schemes such as TDMA.

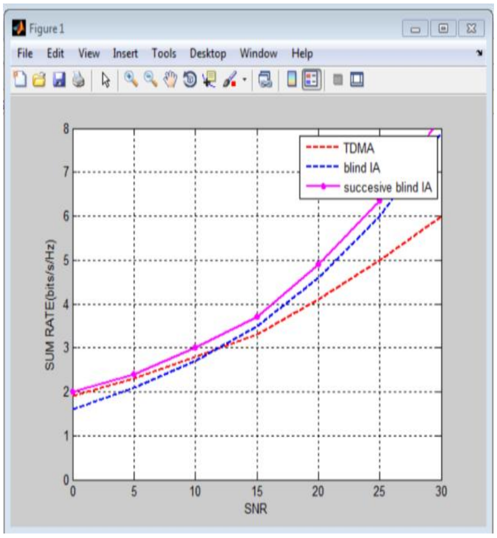

Fig8:Sum rate performance of three systems

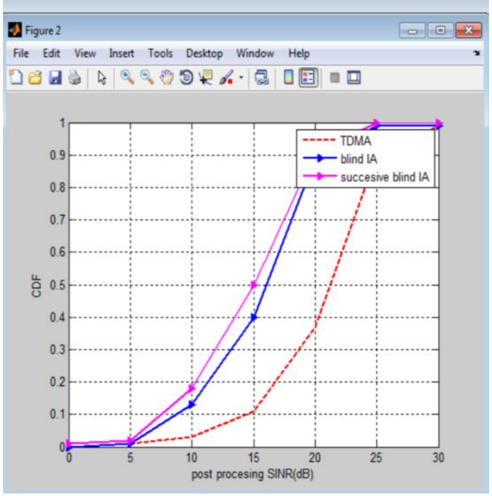

Fig9: CDF of PP SINR

B. Average error vector magnitude performance:

The average error vector magnitude squared performance is the second result. The error vector is defined as difference between the received constellation points and true constellation points and AEVMS, given by,

$$AEVMS=E\{|s[i]|-|\hat{s}[i]^2|\}$$

Where s(i) represents i^{th} received symbol and ŝ(i) represents ideal symbol respectively. For evaluation of hardware experiments AVEMS is suitable metric. It is computed at the input of demodulator so it can be easily measure. In [10] & [11], authors have shown that 1/AEVMS can be used to approximate signal to interference & noise ratio. We expect TDMA to have PP-SINR performance better as the transmitter uses different time slots to send data so the transmission is interference free. Successive Blind IA transmits simultaneous data to both users and also has the interference, so it leads to lower the PP-SINR performance. From fig9 we can say that PP-SINR degradation in successive blind IA with compared to TDMA is less than 5db over the entire distribution.

C. Bit error rate performance:

Finally, we show the BER performance for these systems. From this plot it is clear that BER performance for a given PP-SINR is very similar in both system.

This indicate that interference suppression and MIMO equalization in our successive blind IA does not degrade the BER performance in relation to TDMA.

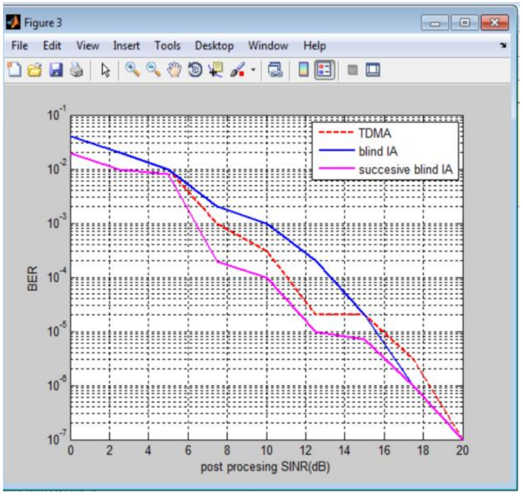

Fig10:Bit error rate performance

VI. CONCLUSION

In this paper we present an experimental study of a succsseive blind IA scheme that uses the pattern reconfigurable antenna. Unlike other mitigation technique our successive blind IA does not require CSIT. Further we studied the performance of our implementation with the blind IA and TDMA. Our result shows usage of antenna achieves good gain in sumrates compared to TDMA. And due to iterfereance in BIA ,our work gives 5db degradation in terms of PP-SINR. where as for given PP-SINR , both systems have same performance. Because of reconfigurable antenna used in this work it has different radiatin patterns to chose from,extension of this project can be study of antenna pattern selection for blind IA.

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