iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** II **Month of publication:** February 2015

DOI:

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Interference Mitigation using Alignment Technique for Broadcasting Channel Scenario

N.Mullaikodi[1], G.Linithra[2] and J.Anusuya[3]
[1,2,3] Dr. S.J.S Paul Memorial College of Engineering and Technology, Puducherry, India

Abstract--The technique to mitigate interference in the channel is very essential to maintain efficient signal transmission. Interference Alignment (IA) deals to mitigate interference and to enhance system efficiency of a wireless communication network. We deal with interference alignment scheme for a network with multiple cells and multiple multiple-input and multiple-output users under a Gaussian interference broadcast channel scenario. At first we go for grouping method already known to a multiple-cells scenario and jointly design transmit and receiver beamforming vectors using a closed form expression without iterative computation. Then we go for a new approach using the principle of multiple access channel (MAC) - broadcast channel (BC) duality to perform interference alignment while maximizing capacity of users in each cell.
Index Terms--MAC, Article, Interference Alignment, Multiple cells, Broadcast channel

I. INTRODUCTION

The recent emergence of the idea of interference alignment for wireless networks has shown that the capacity of wirelessnetworks can be much higher than previously believed [1]. The canonical example of interference alignment is a communication scenario where, regardless of the number of interferers ,every user is able to access one half of the spectrum free from interference from other users [1]. For the interference channel with K transmitters and K receivers and random, time varying channel coefficients drawn from a continuous distribution, reference [1] characterizes the network sum capacity as

$$C_{\sum}(SNR) = \frac{K}{2}\log(SNR) + o(\log(SNR)) \quad (1)$$

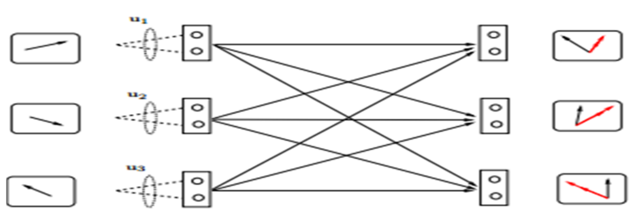


Fig:-1 Interference alignment solution for the three user two antenna case.

The optimality of interference alignment schemes at high SNR is interesting because these schemes treat all interference as noise and require no multi-user detection. Achievable schemes based on treating interference as noise have been explored extensively over the last decade. Prominent among these are the interference avoidance and iterative **water filling** algorithms where each transmitter acts selfishly to align its transmissions along those directions where its desired receiver sees the least interference [3]–[7], and network duality approaches [8]–[11] that are based on the reciprocity of the wireless propagation channel.

A. Interference Alignment

Interference channels, where multiple transmit and receive user pairs communicate using the same radio resources, are a building block of wireless networks. The interference channel is a good model for communication in cellular networks, wireless local area networks, and ad-hoc networks. Conventional thinking about the interference channel is that each user pair has no information about other users in the network and therefore its optimum strategy is to be greedy and maximize its own rate. Unfortunately, the sum of the data rates achieved across all user pairs with this strategy is of the same order as the rate of a single communication link. Recent

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

work on the interference channel by Jafar's group and Khandani's group, however, has shown that sum rates can scale linearly with the number of users at high SNR, using a transmission strategy known as interference alignment. Interference alignment is a linear precoding technique that attempts to align interfering signals in time, frequency, or space. In MIMO networks, interference alignment uses the spatial dimension offered by multiple antennas for alignment. The key idea is that users coordinate their transmissions, using linear precoding, such that the interference signal lies in a reduced dimensional subspace at each receiver. Allowing some coordination between transmit and receive user pairs enables interference alignment. In this way, it is possible to design the transmit strategies such that the interference aligns at each receiver. From a sum rate perspective, with K user pairs, an interference alignment strategy achieves a sum throughput on the order of K/2 interference free links! Basically each user can effectively get half the system capacity. Thus unlike the conventional interference channel, there is a net sum capacity increase with the number of active user pairs. This result has special importance in cellular and ad hoc networks, showing that coordination between users can help overcome the limiting effects of interference generated by simultaneous transmission.

B. Interference Alignment Vs. Interference Cancellation

The synergy between interference alignment and interference cancellation is here. Interference alignment aligns a subset of the packets at the first AP, allowing it to locally decode one packet and hence boot-strap the decoding process. Interference cancellation enables other APs to use the decoded packet to cancel its interference, and hence decode more packets. Neither interference alignment nor cancellation would be sufficient on its own to decode the three packets in Fig. 2.

IAC has the following features:

1) IAC brings in more gains than apparent in the above example and generalizes to any number of antennas. For a MIMO system with M antennas, we prove analytically that IAC delivers 2M concurrent packets on the uplink, and max **(2M−2,⌊ 3/2 M⌋)** on the downlink – i.e., it doubles the throughput of the uplink, and almost doubles the throughput of the downlink for a large number of antennas.
2) IAC delegates all coordination to the APs, which tell the clients how to encode their packets to produce the desirable alignment. Further, the channel estimates required for computing this alignment can be computed from ack packets with negligible overhead.
3) IAC works with various modulations and FEC codes. This is be-cause IAC subtracts interference before passing a signal to the rest of the PHY, which can use a standard 802.11 MIMO modulator/demodulator and FEC codes.

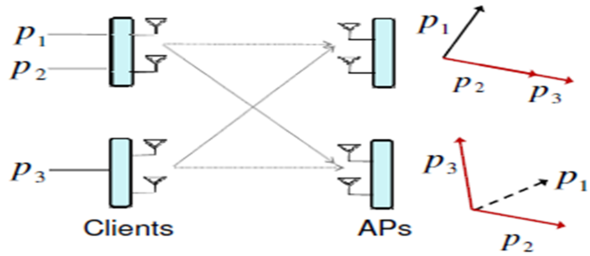


Figure:-2 IAC Example

II. SYSTEM MODEL

The MIMO-IFBC model consists of a cellular network with *L* cells; each cell consists of *K* users. We assume that each user is equipped with *Nr* antennas and each cell has one BS consisting of *Nt* antennas. The channel in each cell can be regarded as MIMO-IFBC. An example for the case of $L = 3$ and $K = 2$ is illustrated in Fig. 1. As shown in Fig. 1, the BS 1 sends data to user 1 while introducing both inter-user interference and inter-cell interference. Similarly, BS 2 and BS 3 introduce interference to other users. We assume each BS aims to convey *ds* data streams to its corresponding user, where $ds \leq \min(Nt, Nr) = Nr$, we assumed $Nr < Nt$. We refer to the *kth* user in the *lth* cell as user [*k, l*]. The signal intended for the *kth* user in the *lth* cell is written as

$$x^{[k,l]} = \sum_{i-1}^{d_s} v_i^{[k,l]} s_i^{[k,l]} = V^{[k,l]} S^{[k,l]} \qquad (1)$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

where $s_i^{[k,l]}$

i denotes the ith transmitted symbol for the *kth* user in the *lth* cell,In our system degree of freedom is obtained from the equation

$$d \overset{\Delta}{=} \lim \lim_{SNR \to \infty} \frac{C_{\Sigma}(SNR)}{\log(SNR)} = \sum_{l=1}^{L} \sum_{k=1}^{K} d^{[k,l]} \quad (2)$$

Then in next section, we extend the interference alignment scheme using a grouping method proposed in [16] for two cells to jointly design transmitter and receiver beamforming vectors for multiple cells using a closed-form expression without a need for iterative computation. The extension as in the following section will be used later to compare other proposed interference alignment methods based on MAC-BC duality.

III. GROUPING METHOD EXTENSION

To maximize the sum rate performance of the MIMO-IFBC, the transmitter and the receiver beamforming matrices are usually designed by applying an iterative optimization algorithm as in [2]. The iterative scheme performs interference alignment implicitly and it normally requires a considerable number of iterations. In this section, we extend the grouping method in [16] to our multi-cell scenario. This interference alignment scheme not only mitigates both ICI and IUI simultaneously in the multi-cell multi-user MIMO-IFBC, but also it does not require any iterative computation. To explain, we start with a simple example of (*NT, Nr, L, ds*) = (10, 6, 2, 3, 2). Suppose the BS *l* wants to transmit two sets of independent symbols **s**[1,*l*] = [*s*[1,*l*] 1 *s*[1,*l*] 2]*T* and **s**[2,*l*] = [*s*[2,*l*] 1 *s*[2,*l*] 2]*T* to user [1, *l*] and user [2, *l*] respectively.

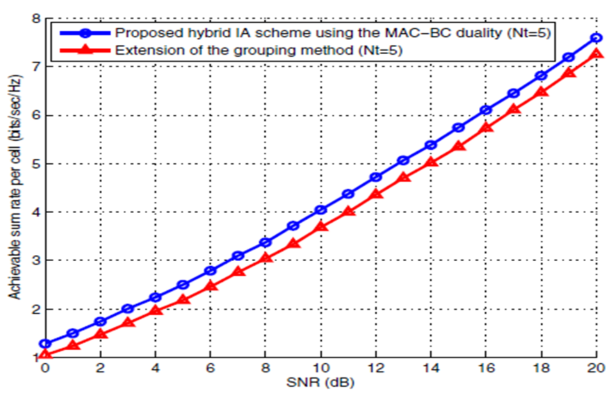


Fig.:-3. The achievable rates for the proposed (DoF = 6).

We then considered the same system but with two data streams transmitted for each user. For the proposed interference alignment scheme using MAC-BC duality, we considered both 8 and 10 transmit antennas for each base station. Fig. 4 depicts the sum rate versus SNR of the proposed algorithm and compares it with the grouping method but with 10 transmit antennas. As seen, the proposed interference alignment scheme, even with 8 transmit antennas, outperforms the extension of the grouping method with 10 transmit antennas. The reason is that although only eight antennas are employed at the BS, the sum rate is maximized using the virtual beamforming matrices **Q**[*k,l*] *m* , hence it outperforms the perfect interference alignment algorithm due to increase subspace dimension for mitigating intra-cell interference.

Then, we show the proposed interference alignment algorithm can also balance all the users' data rate in each cell. All the elements of the data rate balancing vector $\boldsymbol{\rho}$ were set to one. Fig. 5 and Fig. 6 depict the convergence of the data rate for the two users against the adaptation of the Lagrangian multiplier *μk* as explained. All the users attain equal data rate. The data rate without rate balancing constraints is also shown. The total sum rate in this case is 7.5 bits/s/Hz and 14.6 bits/s/Hz for DoF = 6 and DoF = 12 respectively. With the rate balancing constraints,

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

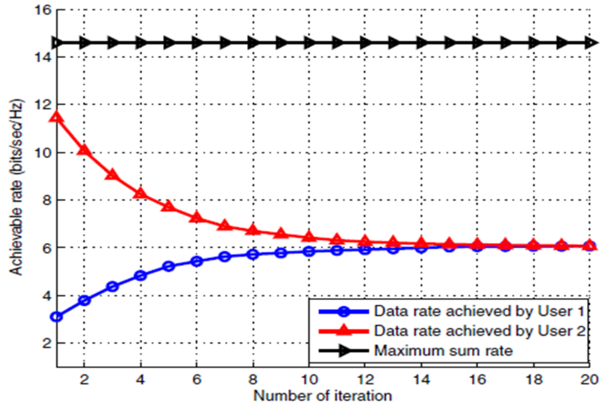


Fig:-4. Rate balancing of the proposed hybrid interference alignment algorithm using the MAC-BC duality (DoF = 12).

IV. CONCLUSION

We have finally tested the project for interference alignment scheme. This paper introduces interference alignment and cancellation (IAC). IAC weaves two signal processing techniques: interference alignment and interference cancellation, such that the combination applies to new scenarios that could not have benefited from either technique alone. We show both analytically and via a prototype implementation that IAC doubles the throughput of MIMO LANs.

We believe that IAC can provide benefits in scenarios other than those explored in the paper. For example, IAC also extends to clustered MIMO networks, which can occur in ad-hoc and mesh settings, where links within a cluster are strong (i.e., high bitrate) and links across clusters are weak (i.e., low bitrate). The throughput of clustered networks is bottlenecked by the low bitrate inter-cluster links. IAC can double the throughput of the inter-cluster bottleneck links. In fact, this scenario is analogous to a WLAN where nodes in the same cluster can be thought of as being connected with a high bandwidth Ethernet. We believe that IAC can naturally increase throughput in these settings. Further exploration of IAC in ad hoc settings is left for future work.

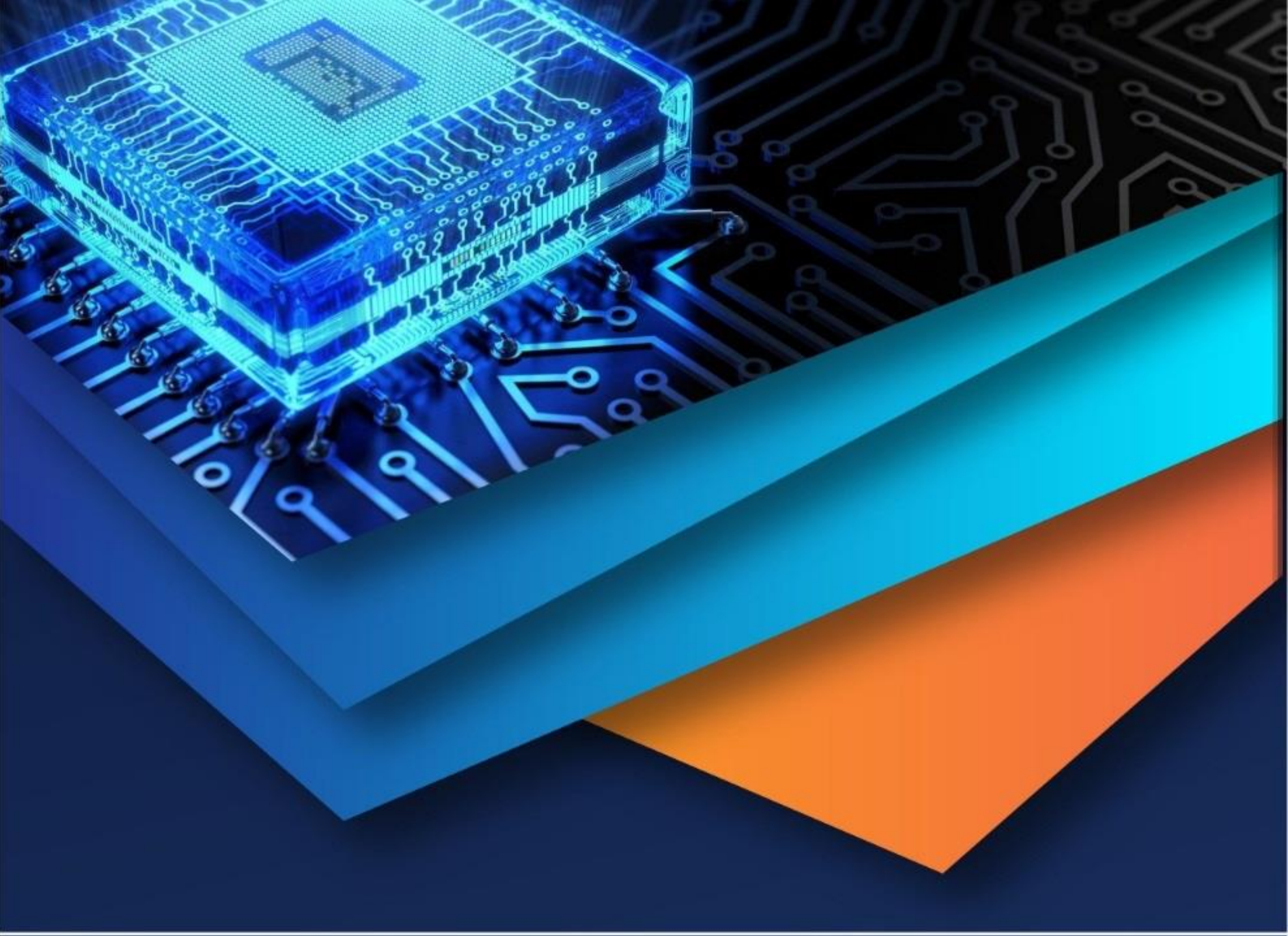
V. ACKNOWLEDGMENTS

We thank our HOD Dr.T.Thirumurugan, Ph.D. (Department of Electronics and Communication Engineering) to help us for creating this paper with his sincere guidance and Technical Expertise in the field of communication. The help of our guide Mrs. S.Jayalakshmi, M.Tech, Department of ECE, Dr, SJS Pauls College of Engineering and Technology is really immense and once again I thank her for her great motivation. I thank Dr. SJS Pauls College of Engineering and Technology to provide me such a standard educational environment so that I am able to understand the minute concepts in the field of Engineering and Technology.

REFERENCES

[1] Antenna selection and RF processing for MIMO systems. IEEE 802.11-04/0713r0, 2004.
[2] System Description and Operating Principles for High Throughput Enhancements to 802.11. IEEE 802.11-04/0870r, 2004.
[3] M. A. Ali, S. A. Motahari, and A. K. Khandani. Communication over MIMO X Channels: Interference Alignment, Decomposition, and Performance Analysis. Tran. on Info. Theory, 2008.
[4] J. Andrews. Interference cancellation for cellular systems: A contemporary overview. IEEE Wireless Communications, 2005.
[5] D. Bliss, K. Forsythe, and A. Chan. Mimo Wireless Communications. Lincoln Journal, 2005.
[6] V. Cadambe and S. Jafar. Interference Alignment and the Degrees of Freedom for the K User Interference Channel. In Trans. on Information Theory, 2008.
[7] P. Castoldi. Multiuser Detection in CDMA Mobile Terminals. Artech house Publishers, 2002.
[8] R. Chandra, P. Bahl, and P. Bahl. MultiNet: Connecting to Multiple IEEE 802.11 Networks Using a Single Wireless Card. In INFOCOM, 2004.
[9] S. Changho and D. Tse. Interference Alignment for Cellular Networks. In Allerton, 2008.
[10] J. M. Cioffi. Multi-channel Modulation. Stanford University.
[11] A. E. Gamal and T. Cover. Multiple user information theory. In Trans. on Info. theory, 1980.
[12] M. Gast. 802.11 Wireless Networks. O'Reilly, 2005.
[13] D. Gesbert, M. Kountouris, R. W. Heath, C. Chae, and T. Salzer. Shifting the MIMO Paradigm: From Single User to Multiuser Communications. In Sig. Proc. Mag., 2007.
[14] S. Gollakota and D. Katabi. ZigZag Decoding: Combating Hidden Terminals in Wireless Networks. In Sigcomm, 2008.

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
[15] S. Gollakota, S. Perli, and D. Katabi. Overcoming the antennas-per-node throughput limit in mimo lans. Technical report, MIT, 2009.
[16] M. Guillaud, D. Slock, and R. Knopp. A practical method for wireless channel reciprocity exploitation throught relative calibration. In Sig. Process. and Apps, 2005.
[17] R. Gummadi and H. Balakrishnan. Wireless Networks should Spread Spectrum Based on Demands. In Hotnets, 2008.
[18] D. Halperin, T. Anderson, and D. Wetherall. Taking the sting out of carrier sense: Interference Cancellation for wireless LANs. In ACM Mobicom, 2008.
[19] J. Hou, J. Smee, H. D. Pfister, and S. Tomasin. Implementing Interference Cancellation to Increase the EV-DO Rev A Reverse Link Capacity. IEEE Communication Magazine, 2006.
[20] C. Huang and S. Jafar. Degrees of Freedom of the MIMO Interference Channel with Cooperation and Cognition. In arxiv: 0803.1733, 2008.
[21] S. Jafar and S. Shamai. Degrees of Freedom of MIMO X Channel. In Tran. in Info. Theory, 2008.
[22] S. Kandula, K. Lin, T. Badirkhanli, and D. Katabi. FATVAP: Aggregating AP BackHaul Bandwidth. In NSDI, 2008.
[23] M. Mitzenmacher. The Power of Two Choices in Randomized Load Balancing. PhD thesis, 1991.
[24] A. Miu, H. Balakrishnan, and C. E. Koksal. Improving Loss Resilience with Multi-Radio Diversity in Wireless Networks. In Mobicom, 2005.
[25] T. Moscribroda, R. Chandra, Y. Wu, S. Sengupta, P. Bahl, and Y. Yuan. Load-Aware Spectrum Distribution in Wireless LANs. In ICNP, 2008.
[26] R. Murty, J. Padhye, R. Chandra, A. Wolman, and B. Zill. Designing High Performance Enterprise Wi-Fi Networks. In NSDI, 2008.
[27] C. Qiu, C. Zhou, G. Nan, and J. Zhang. Time Reversal with MISO for ultra-wideband Communications:
Experimental Results. In Letters on Antennas and Propogation, 2006.
[28] C. Qiu, C. Zhou, J. Zhang, and G. Nan. Channel reciprocity and time-reversed propagation for ultra-wideband communications. In Symp. on Antennas and Propagation, 2007.
[29] D. Tse and P. Vishwanath. Fundamentals of Wireless Communications. Cambridge Press, 2005.
[30] P. Viswanath and D. Tse. Sum capacity of the vector gaussian channel and uplink-downlink duality. In Trans. on information theory, 2003.
[31] G. Woo, P. Kheradpour, and D. Katabi. Beyond the Bits: Cooperative Packet Recovery Using PHY Information. In ACM MobiCom, 2007.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY