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Research paper

Capacity comparison of MIMO and cooperative MIMO

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Abstract

To achieve high capacity and high data rates is the main requirement for today's generation. This paper studies about the performance and capacity comparison of MIMO and cooperative MIMO systems. The comparison of capacity between multiple- input-multiple- output (MIMO) and cooperative MIMO systems helps us to know that which system have better performance and better capacity. The simulation results shows that among SISO, SIMO, MISO and MIMO system the capacity of MIMO will be better but in between MIMO and cooperative MIMO, Cooperative MIMO system have high capacity than MIMO systems.

Keywords *- MIMO systems, Cooperative MIMO, SISO, SIMO, MISO, capacity comparison*

1. Introduction

Now a days the communication system goes to a rapid development. Antenna systems performs major roles in wireless communications. The rapid development of mobile users now a days give rise to a common problem for mankind that how the capacity and data rates of the users can be increased [11.]The main limiting factor for single input antenna systems will be less capacity and less data rates. so to increase data rates and capacity multiple antenna systems should be used now a days. The capacity of MIMO systems will be less as compared to cooperative MIMO because in cooperative MIMO distributes antenna should be used. In MIMO system multiple antenna will used in transmitter side and in receiver side also, so that each user's quality of service can be increased. A new spatial diversity techniques called as cooperative diversity can be introduced. By the help of cooperative diversity each mobile user can access spatial diversity by the help of single antenna[1]. Cooperative diversity techniques can increase the capacity and quality of service of each user and the cross layer routing and resource allocation will be explained in [2]. In [3-8] the gain of cooperative MIMO capacity will be analyse. This paper studies about multiple antenna terminals by Cooperative MIMO systems.In MIMO system due to presence of more number of antennas, so if one path will be facing fading there will be other path which have not facing fading [9-13]. The capacity can be calculated between MIMO and cooperative MIMO keeping same antenna numbers. And the distance between transmitter and receiver should have range from 75 m to 125 m in MIMO antenna for 5G communication [4,14,15]. So taking this distance consideration the distance between transmitter and receiver should be calculated by taking a constant SNR value.

2. Preliminary

2.1 MIMO system models

MULTIPLE-ANTENNA wireless terminals, which have used to achieve diversity and multiplexing have special signal processing techniques, distinguish MIMO systems. The MIMO system utilizes space, time and frequency dimension for data rates. MIMO channel is used to represent by its channel matrix whose elements are channel gains between transmitter-receiver antenna pairs. Wireless communication involves information to transmit over a distance without any sort of cables or electrical conductors.
The MIMO systems model will be shown in fig 1.

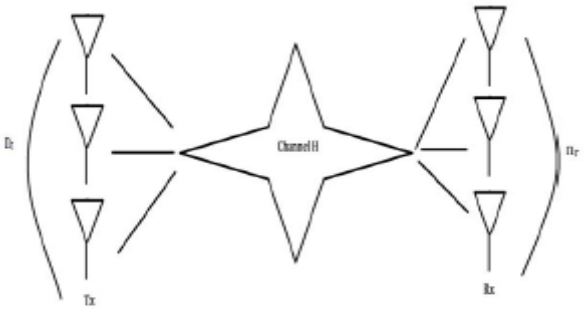

Figure 1: MIMO system model

The MIMO system model will be shown in figure. In this the transmitting antenna will be expressed by nt and receiving antenna will be expressed by nr. The channel matrix can be expressed by H matrix.

$$H=\begin{bmatrix} h_{11} & \cdots & h_{1N_T} \\ \vdots & \ddots & \vdots \\ h_{N_{R1}} & \cdots & h_{N_{RN_T}} \end{bmatrix}$$

2.2 Capacity of MIMO system models

To increase capacity and keeping bandwidth and transmitting power same put more antennas at the transmitter and receiver side. The Rayleigh model which is the random channel has been used. A complex matrix that has identically independent distributed entries with unit variance and zero mean is used to approximate a channel in the frequency domain [5].
The capacity of MIMO system will be given by:

$$C_{MIMO} = M_t M_r B\log_2(1+S/N) \quad (1)$$

Where channel capacity expressed by C, bandwidth of the signal expressed by B, signal to noise ratio expressed by S/N and M_t and M_r will be respective numbers of transmit and receive antenna.
A lower bound generalized capacity formula that is applicable to any MIMO system:

$$C=\log2(\det[\ In_r + (p/n_t)\ H\ H^T]) \text{ bps/Hz} \quad (2)$$

In the above equation, the determinant is symbolized by 'det', Identity Matrix (In_r) having dimensions $n_r \times n_t$ and 'H^T' is the transpose conjugate of the channel matrix H.
Lower bound capacity for the (n, n) in terms of independent chi-squared variable with second degree of freedom is as follows:

$$C> \sum_{k=1}^{n} \log2\ [1+ (p/n).\ \lambda 2k2] \text{ bps/Hz} \quad (3)$$

The optimal ratio combining or receive diversity (NR=NT=n) for the capacity formula is:

$$C=\log2\ [1+p.\ \lambda 2n2] \text{ bps/Hz} \quad (4)$$

3. Cooperative MIMO

Cooperative MIMO techniques is the advance version of multiple antenna systems which can be significantly improve the performance in wireless communication system and among mobile user's by increasing more capacity and data rates as compared to the conventional MIMO antenna array systems. It is generally known as CO- MIMO and network MIMO. Cooperative MIMO now a day's use more as compared to MIMO system in different wireless communication. Cooperative MIMO uses distributed antenna systems and it have more capacity more gain as compared to MIMO antenna systems

3.1 Cooperative MIMO system model

The cooperative MIMO system model shown in fig 2. in proportion to [6].

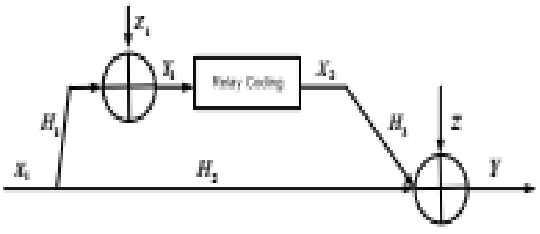

Figure 2: Cooperative MIMO system model

Where the transmitted signals from the source node and the relay nodes are X_1 and X_2 respectively. The received signals are Y_1 and Y at cooperative and destination nodes. H_1, H_2 ,H_3 expressed as the channel coefficient matrix of MIMO channel. Z1 and Z are the expressed as the Gaussian white noise present at the Cooperative node and destination node.

3.2 Advantages of cooperative MIMO

- The main advantages of cooperative MIMO will be its ability to improve the capacity, coverage and group mobility of wireless systems. In cooperative MIMO as distributed antenna systems should use that's why it can be used in different radio devices to achieve theoretical gain of multiple-input- multiple- output systems.

Cooperative MIMO can achieve gains of MIMO even by the use of single antenna per node. Cooperative MIMO have more capacity and data rates than MIMO systems that's why now a days it can be used more in wireless communication as compared to MIMO systems.

3.3 Cooperative MIMO capacity:

According to [6] the provided Rayleigh fading case and for the ergodic capacity of cooperative MIMO channel a upper bound case will be given as

$$C \le C_{upper} = \min(C_1, C_2) \quad (5)$$

C_1 and C_2 are the expections are to be taken and they should be express by channel matrix. The lower bound on the ergodic capacity of Cooperative MIMO will be given by:

$$C \ge C_{lower} = \max(\ C_d, \min(C_3,C_2)) \quad (6)$$

C_d and C_3 are the expectation taken in the lower bound case it will also be taken according to the channel matrix.

4. Simulation results

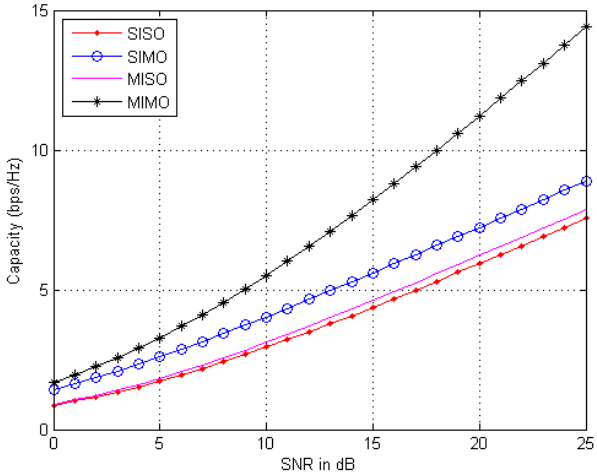

Figure 3: SNR vs capacity of SISO, SIMO, MISO, MIMO

In the above results the number of transmitter and receiver antenna should be 2. SNR should be varry from 0 to 25 dB.taking this consideration it is clear that among this SISO system have less capacity[7] and MIMO system have more capacity as compared to SISO, SIMO and MISO system. The capacity will be increased more when antenna number at the transmitter side and receiver

side will be increased [8]. By taking more number of antennas the data rates will be more and the system can be used for 4G systems to accommodate large number of users [10].
Before calculating the Cooperative MIMO and MIMO capacity we have to consider a case study. According to Rappaport in milimeter wave communication or 5G communication the distance between T_x and R_x will be varry from 75m to 125 m in MIMO antenna system. so we take 2 cases by varying SNR and capacity for show that the distance between T_x and R_x will be 75m and 125m, which is suitable for 5G communication.

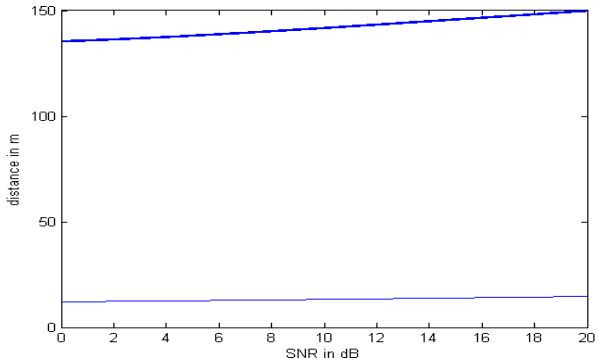

Figure 4: SNR VS Distance calculate between Tx and Rx of MIMO

In the above plot we can varry the SNR from 2 to 18 dB and by varying capacity we get the distance between Tx and Rx will be 125 m, which will suitable for 5G communication[4]

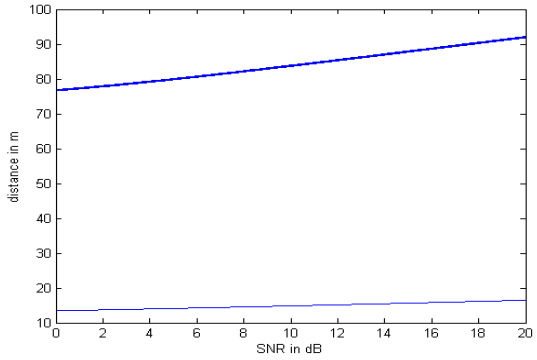

Figure 5: SNR vs Distance calculation between Tx & Rx of MIMO

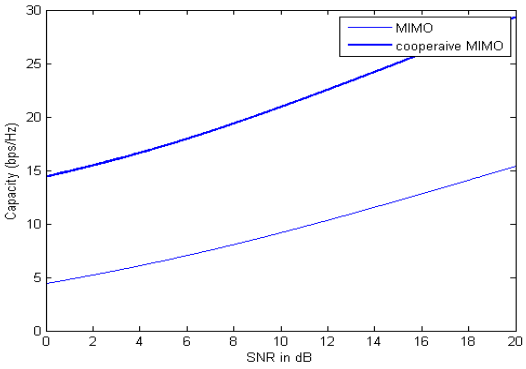

Figure 6: SNR vs capacity of MIMO & cooperative MIMO

In the above results we can varry the SNR from 2 to 18 dB and by varying SNR and capacity the distance between Tx and Rx will be 75m which is suitable for 5G[4].

In the above results number of transmitter and receiver antenna will be 2. SNR will varry from 0 to 20 dB. From the results it is clearly know that the capacity of cooperative MIMO will be high than MIMO systems. That's why cooperative MIMO can be more useful than MIMO systems when capacity, coverage, data rates will be taking in to consideration.

5. Conclusion

The paper analyzed the capacity vs SNR comparison between different diversity schemes antennas. The main factor which would be focused in this paper will be the which system have better capacity and all the capacity vs SNR calculation should done when Rayleigh fading channels should be used.
It is clearly known from the results that cooperative MIMO have better capacity than MIMO systems. Cooperative MIMO have better capacity that's why the data rates in cooperative MIMO will be better than the MIMO systems.

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References

[1] Sendonaris, Andrew, Elza Erkip, and Behnaam Aazhang. "User cooperation diversity. Part I. System description." *IEEE Transactions on communications* 51.11 (2003): 1927-1938.
[2] Cui, Shuguang, and Andrea J. Goldsmith. "Cross-layer design of energy-constrained networks using cooperative MIMO techniques." *Signal Processing* 86.8 (2006): 1804-1814.R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
[3] Shyy, D. J., and James Dunyak. "Cooperative MIMO gateways: A promising technique for fast handoff." *Wireless Telecommunications Symposium, 2005*. IEEE, 2005.Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
[4] Rappaport, Theodore S., et al. "Millimeter wave mobile communications for 5G cellular: It will work!." *IEEE access* 1 (2013): 335-349.M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
[5] A. Goldsmith, "Capacity Limits of MIMO Channels," IEEE Communication, Vol. 21, Issue-5, June 2003.
[6] Nguyen, Trungtan, Weixiao Meng, and Hongyu Wang. "Channel capacity analysis on cooperative MIMO with antenna spatial correlation and multi-path." *Communications and Networking in China (CHINACOM), 2011 6th International ICST Conference on*. IEEE, 2011.
[7] Amrit Mukherjee, Pratik Goswami, Amlan Datta, "HML based Smart positioning of Fusion Center for Cooperative Communication in Cognitive Radio Networks", IEEE Communication Letters, vol. 20, no. 11, DOI:10.1109/LCOMM.2016.2602266, 2016.
[8] Nimay ch. Giri, J.R swain et all., ''Capacity & Performance Comparison of SISO and MIMO System for Next Generation Network (NGN) ''IJARCET, vol 3, issue 9, September 2014.
[9] Rohit U .Naber et al.''Diversity And Outage Performance in space-time Block coded Rician MIMO Channels'', IEEE Transactions on Wireless Communication, vol. 4, no.5, page no. 2519-2532, 2005.
[10] T. Samant, P. Mukherjee, A. Mukherjee, "LEACH – V: A Solution for intra-cluster Cooperative Communication in Wireless Sensor Network", Indian Journal of Engineering and Technology vol. 9, no. 48, DOI: 10.17485/ijst/2016/v9i48/100619, 2016.
[11] B. Chakraborty, et. all., "V-Leach- Vd: A Solution for Higher Energy Utilization in Low Power Communication in Wireless Sensor Network", Journal of Advanced Research in Dynamical and Control Systems, vol. 9, SI-14, pp. 581-591, 2017.

[12] K. Sengar, N. Rani, "Study and Capacity Evaluation of SISO, MISO and MIMO RF Wireless Communication Systems," IJETT, Vol. 9, No. 9, Mar-2014.
[13] A. F. Sengar, N. Rani, "Capacity of MIMO Systems with Antenna Selection," IEEE Transaction, Vol. 4, No. 4, July 2005.
[14] Theodore S. Rappaport, "Wireless Communication: Principles and Practice", Prentice-Hall, 2nd Edition, 2010, India.
[15] P. Mukherjee, et. all., "V-DEEC- VD: A Solution For Multilevel Heterogeneous Protocol For Higher Energy Utilization in Low Power Communication in Wireless Sensor Network", Journal of Advanced Research in Dynamical and Control Systems, vol. 9, SI-14, pp. 715-724, 2017.