Simulation and performance analysis of various space diversity techniques to increase wireless channel capacity

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Abstract- **In the present word, due to rapid growth in communication has increased. Therefore there is need to improve the transmission of the data over wireless media so as to achieve the demand of fast and feasible communication. First of all we used to SISO type antenna in wireless communication, that time data rate of network is very poor. In next wireless communication discover about ergodic capacity of SIMO, MISO, MIMO and also about the space diversity of all channel. Comparison among SISO, SIMO, MISO and MIMO in wireless channel. Having known the disadvantages of the single input single output system, and having computed the advantages of multiple input multiple output. We have compared Shannon ergodic capacity of SISO, SIMO, MISO and MIMO link and its differented realize to wireless channel. To meet the above result better data rate, BER, ergodic capacity as compare to MIMO than SISO. It is shown that wireless channel capacity increases linearly with the increase of multiple antenna both at transmitter and receiver. MIMO can be viewed as an extension of the very popular 'smart antenna'.**

I. INTRODUCTION

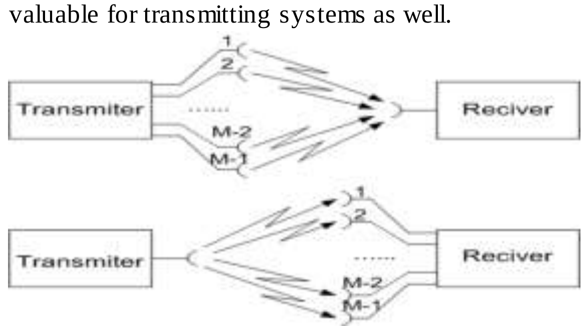
As mobile communications have grown exponentially in recent years and in parallel, The World Wide Web and its applications have spread widely, the possibility to have access to Internet, hospitality and multimedia communications wirelessly has accelerate a similar trend people want to avoid further inconveniences of having to go to a fixed location and establish the necessary communication link to get access to the Internet. Also it is desirable to avoid having to install the corresponding cables inside a building or home and to avoid incurring the related costs.

In the present world, due to rapid growth in communication (over broader distance) has increased therefore there is a need to increase the transmission of the data over wireless media so as to achieve the demand of fast and feasible communication. It is required to have better and increased data rates, BER and quality of signals received at the receiving end side of the system, in the advanced wireless communication.

II. SPACE DIVERSITY

Space diversity, also known as antenna diversity or spatial diversity, is any one of several wireless diversity schemes that uses two or more antennas to improve the quality and reliability of a wireless link. Often, especially in urban and indoor environments, there is no clear line-of-sight (LOS) between transmitter and receiver. Instead the signal is reflected along multiple paths before finally being received. Each of these bounces can introduce phase shifts, time delays, attenuations, and distortions that can destructively interfere with one another at the aperture of the receiving antenna.

Antenna diversity is especially effective at mitigating these multipath situations. This is because multiple antennas offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. While this is primarily seen in receiving systems, the analog has also proven valuable for transmitting systems as well.



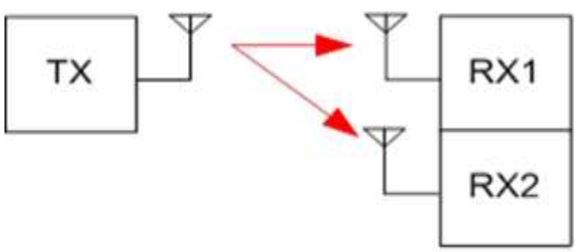
In this type of Space diversity technique, there is only one transmitting at the transmitter end and one receiving antenna at the receiver end. This is also called the SISO. This makes SISO the simplest to implement and easiest to design amongst all the four types of antennas available. Following is the block diagram of SISO system.

SISO

$C = B\log_2(1+S/N)$

Where C is the capacity, B is Bandwidth of the signal and S/N is the signal to noise ratio.

The channel bandwidth of SISO is limited by Shannon's law which states that, theoretical maximum rate at which error-free digits can be transmitted over a bandwidth limited channel the presence of noise



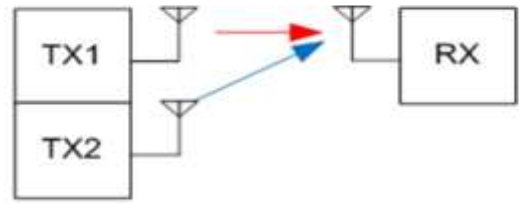
SIMO

$C = M_r B\log_2(1+SNR)$

Where C is the capacity, Mr is the number of antennas used at receiver side, B is Bandwidth of the signal and S/N is the signal to noise ratio.

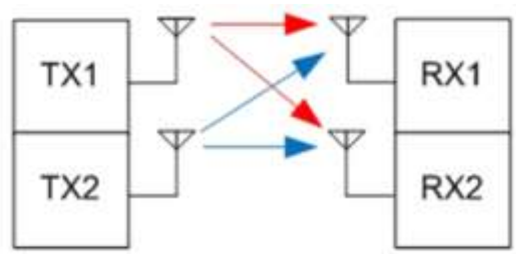
In Transmitter diversity, there can be multiple transmitting antennas from which the signal can be sent, and there I only one receiving antenna to receive the signals coming from multiple transmitting antenna, which means there are different sources available but there is only one destination available. Following is the block diagram of MISO system with two (in this case only two, more than two also possible) transmitting antenna and one receiving antenna at the receiving end for analysis.

In Receiver diversity, there is only one transmitting antenna and multiple receiving antennas at receiving end this helps to increase the receiving diversity at the receiving end as compared with SISO. Following is the block diagram of SIMO system with one transmitting antenna and two receiving antenna at the receiving end for analysis (in this case only two, more than two also possible).



MISO

In Combined space diversity, there can be multiple transmitting antennas from which the signal can be sent, and also there are multiple receiving antennas through which the signal can be received. In MIMO, since there can be multiple transmitting antennas the signal can be transmitted by any antenna and therefore the signal can follow any path to reach to receiving end and this path followed by the signal depends on the position of the antenna i.e. if we move the antenna by small position the path will get change. The fading introduced in the signal from multiple paths can be termed as multipath fading. Following is the block diagram of MIMO system with N(in this case only two considered for practical analysis, more than two also possible) transmitting antenna and M (in this case only two considered for practical analysis, more than two also possible) receiving antenna at the receiving end for analysis



MIMO

The MIMO channel at time k is defined as a matrix H(k) of dimension MR×MT:

$$\boldsymbol{H} = \begin{bmatrix} h11 & \cdots & h1MT \\ \vdots & \ddots & \vdots \\ hMR1 & \cdots & hMRMT \end{bmatrix}$$

The discrete-time MIMO input-output relationship is:

$y = Hx + n$

$$C_{MIMO} = E\left[\log_2 det\left[I + \frac{p}{M_T\ \sigma_n^2} HH^H\right]\right]$$

$$H = U\Lambda V^H$$

Matrix U and V are unitary matrices. And Λ is a MR×MT diagonal matrix with nonnegative singular values λk , k = 1,…..., M_{min},

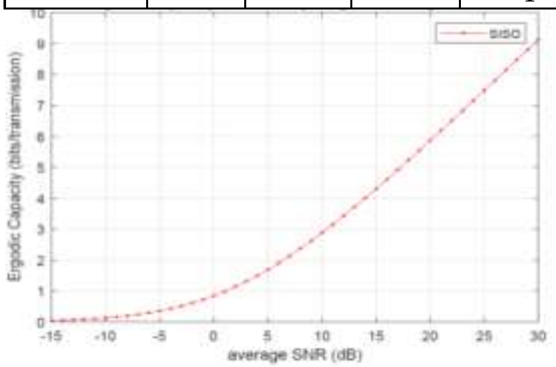
where M_{min} = min(MT,MR).

$$HH^H = \sum_{i=1}^{M_T} \sum_{j-1}^{M_R} |h_{ij}|^2 = \sum_{k=1}^{r_H} \lambda_i^2$$

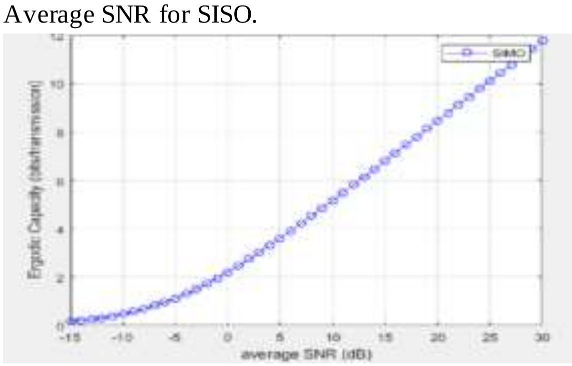
$$C_{mimo} = \sum_{k=1}^{M_{min}} E\left[\log_2\left[1 + \frac{\bar{p}}{M_T}\frac{\lambda_k^2}{\sigma_n^2}\right]\right]$$

III. NUMERICAL RESULTS

parameter	SISO	SIMO	MISO	MIMO
M_T	1	1	4	4
M_R	1	4	1	4
SNR(dB)	-15:30	-15:30	-15:30	-15:30
σ	1	1	1	1
E	-	-	-	1
P	-	-	-	≈ 1

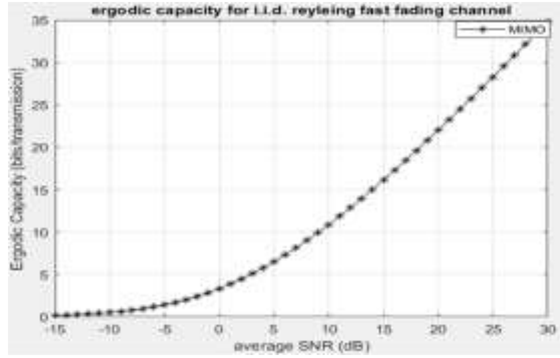


Above graph is Ergodic Channel Capacity VS Average SNR for SISO.

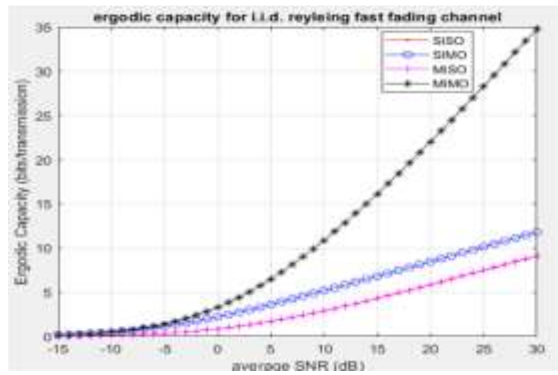


Above graph is Ergodic Channel Capacity VS Average SNR for SIMO

Above graph is Ergodic Channel Capacity VS Average SNR for MISO.



Above graph is Ergodic Channel Capacity VS Average SNR for MIMO.



Above graph is Ergodic Channel Capacity VS Average SNR for Comparison of SISO, SIMO, MISO, MIMO

IV. CONCLUSION

As per above theory and simulation results of various space diversity techniques, we can say that MIMO is more reliable as compare to SISO, SIMO, MISO for Wireless Communication channel. And other words, MIMO system delivers higher data rate due to transmission of multiple data symbols simultaneously using multiple antennas. MIMO communications channels gives solution to the multipath challenge by requiring multiple signal paths. MIMO systems use a combination of multiple antennas and multiple signal paths to gain knowledge of the communications channel. In MIMO, a receiver can recover independent streams from each of the transmitter's antennas. It can be observed that the bit rate of a 4 x 4 (four spatial stream) MIMO configuration exceeds that of the Shannon- Hartley limit at all data rates, making MIMO systems attractive for higher data throughput. While MIMO systems provide users with clear benefits at the application level, the design and test of MIMO devices is not without significant challenges. System benefits such as improvements in data rate and resilience to multipath are likely to motivate continued development of MIMO-OFDM communications systems

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