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Performance Analysis of MIMO-OFDM System in Rayleigh fading Channel

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Abstract- In this paper we show the performance of MIMO-OFDM [1] (Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing) system in Rayleigh Fading Channel [2].MIMO-OFDM system is very popular technique for mobile communication now a day's .We compares Ergodic and Outage Capacity [3] with taking various numbers of Transmitting and Receiving antennas and various performance measures such as SNR, BER etc.

Index Terms- MIMO-OFDM, Ergodic Capacity, BER, SNR Outage Capacity

I. INTRODUCTION

Now a day's integration of Orthogonal Frequency Division Multiplexing (OFDM) technique with Multiple Input Multiple Output (MIMO) systems has been an area of interesting and challenging research in the field of broadband wireless communication. Multiple input multiple output (MIMO) systems using multiple transmit and receive antennas are widely recognized as the vital breakthrough that will allow future wireless systems to achieve higher data rates with limited bandwidth and power resources, provided the propagation medium is rich scattering or Rayleigh fading and the fades are independent and identically distributed. On the other hand, traditionally, multiple antennas have been used to increase diversity to combat channel fading. Hence, a MIMO system can provide two types of gains: spatial multiplexing or capacity gain and diversity gain. However, the capacity and diversity benefits of MIMO systems depend strongly on what kind of fading the channels undergo; whether the fades associated with different transmit and receive antennas are correlated; and whether the channel state information (CSI) is available at the transmitter. This paper presents the progress we have made towards determining the capacity and benefits of multiple antennas under different assumptions about the underlying channel.

Wireless technology is the foundation for the much anticipated ubiquitous communication networks that will allow people and machines to transfer and receive information on the move, anytime and anywhere. This technology will enable an endless array of applications such as wireless phones, wireless Internet access, wireless local area networks (WLAN), automated highways, distance learning, video conferencing, and home audio/visual networks. There are many technical challenges that must be overcome in order to make this vision a reality. One of the toughest challenges faced by wireless engineers and system designers is the bottleneck presented by the wireless link layer as some of the applications e.g., video conferencing, and home audio/visual networks require data rates nearing 1 Gb/s. Moreover WLANs are faced with demands of providing higher data rates due to the increase in rich media content and competition from 10 Gb/s wired LANs. Designing very high speed links that offer good range capability on the wireless channel is a hard problem for several reasons. The wireless channel is a harsh *time-varying* propagation environment. A signal transmitted on a wireless channel is subject to interference, propagation path loss, and delay spread, Doppler spread, shadowing and fading. While it is possible to increase data rates by increasing the transmission bandwidth or using higher transmit power, both spectrum and transmit power are very constrained in a wireless system. The bandwidth, or spectrum, is prohibitively expensive. Increasing transmit power adds interference to other systems and also reduces the battery life-time of mobile transmitters.

II. SYSTEM MODEL

A model of MIMO-OFDM system with N_{Tx} transmit antennas and N_{Rx} receive antennas is depicted in the Figure 1. Let, x_i , y_i and r_i be the transmitted signal, received signal and the Additive White Gaussian Noise (AWGN) for the i^{th} sub-carrier respectively and the system uses frequency selective channel. Then the received signal can be given as

$$y_i = H_i s_i + r_i ; \qquad 0 \le i \le N_S \qquad (1)$$

In Eq. (1), Ns represent the number of sub-carriers H_i is the channel response matrix of i^{th} sub-carrier that is of size $N_{Tx} * N_{Rx}$

The H_i is a Gaussian random matrix whose realization is known at the receiver and it is given as

$$H_i = \sum_{l=0}^{L-1} h_l \exp(-j*2\pi* i*l/ Ns) \qquad (2)$$

In Eq. (2) h_l is assumed to be an uncorrelated channel matrix where each element of the matrix follows the independently and identically distributed (IID) complex Gaussian distribution and *L* represents the tap of the chosen channel (i.e. L-tap frequency selective channel) .It is assumed that a perfect channel state information (CSI) is available at the receiver but not at the transmitter. The total available power is also assumed to be allocated uniformly across all space-frequency sub-channels.

In MIMO-OFDM system Ergodic Capacity is define as this is the time-averaged capacity of a stochastic channel. It is found by taking the mean of the capacity values obtained from a number of independent channel realizations. And Outage Capacity is define as the *q*% outage capacity *Cout,q* is defined as the capacity that is guaranteed for (100 – *q*) % of the channel realizations. Ergodic Capacity is define by equation

$$C = E\left(\frac{1}{N_S}\sum_{i=0}^{N_S-1}\log\left(\left|I_{N_{Rx}} + \gamma . Q\right|\right)\right) \quad \text{………… (3)}$$

$$\gamma = \frac{\rho}{n_{Tx}} \quad \text{……………………………(4)}$$

$$Q = H_i H_i^H \quad \text{…………….. (5)}$$

In above equation E(.) denotes Ergodic Capacity $I_{N_{Rx}}$ is identity matrix of N_{Rx*} N_{Rx}.ρ is SNR per sub carrier,n_{Tx} no of transmit antenna.fig no 1 shows the block diagram of mimo ofdm system.

We use QAM (Quaderature Amplitude Modulation) for transmission. CP (Control Programming) is an operating system originally created for 8 bit processor. FFT is an efficient algorithm to compute the discrete Forier transform and its inverse.RF switch generally called Radio Frequency switch. PIN Diode is generally used to make it operate at very high frequency.

In this switch input signal is fed at one end then this signal is split in no of output signal by demux.

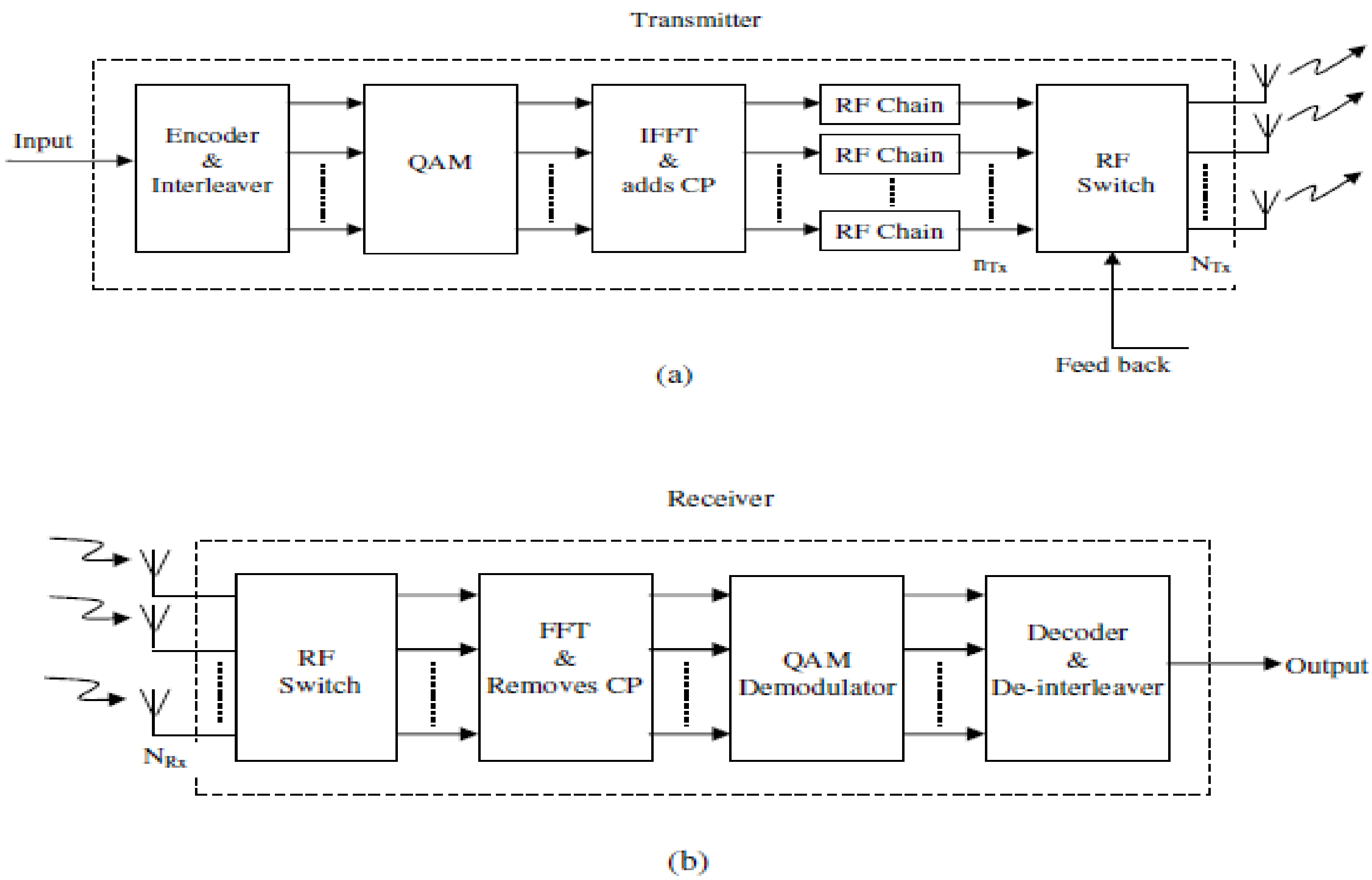

Fig1.Block Diagram of MIMO-OFDM system, (a) Transmitter and (b) Receiver

III. RESULT AND DISCUSSION

Table No 1. SNR and Ergodic Capacity ($n_{r=}30$)

SNR	Ergodic Capacity at n_t =1	Ergodic Capacity n_t =3	Ergodic Capacity n_t =5	Ergodic Capacity n_t =7	Ergodic Capacity n_t =9
1	4.9141	10.5412	14.3561	17.1753	19.5185
2	5.2428	11.4435	15.7827	19.0485	21.6816
3	5.5622	12.3961	17.2637	21.0353	24.0077
4	5.8974	13.3402	18.7704	22.9589	26.5246
5	6.203	14.2589	20.3132	25.0615	29.109
6	6.5339	15.2268	21.8322	27.1798	31.7573
7	6.8601	16.2632	23.456	29.3827	34.4004
8	7.1926	17.2053	24.9587	31.5893	37.1596
9	7.5135	18.1372	26.6475	33.8097	40.0087
10	7.8726	19.1608	28.1907	36.0127	42.796
11	8.1993	20.1556	29.9291	38.3173	45.6812
12	8.5444	21.1782	31.5437	40.5858	48.6058
13	8.8575	22.113	33.1979	42.8871	51.4745
14	9.1949	23.0783	34.8575	45.043	54.4744
15	9.5027	24.1185	36.383	47.3636	57.3149
16	9.8537	25.0964	38.1116	49.7351	60.4162
17	10.1903	26.0509	39.8034	52.102	63.3441
18	10.538	27.0836	41.45	54.3697	66.2991
19	10.8647	28.0583	43.0952	56.6751	69.2412
20	11.156	29.0562	44.6574	58.9058	72.2491

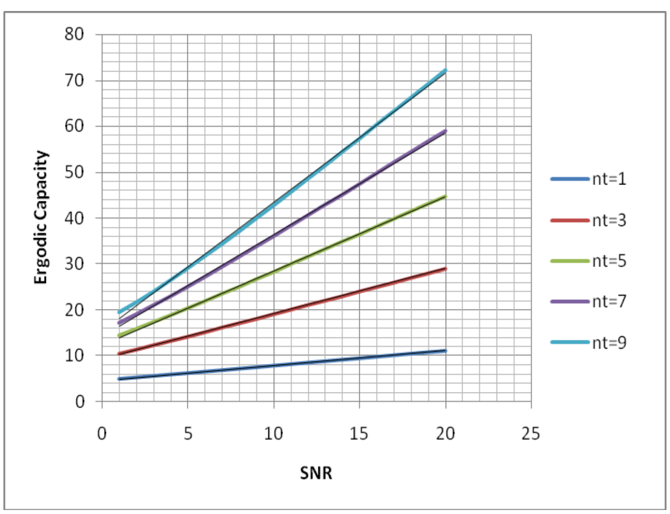

Fig 2: SNR vs Ergodic Capacity

Above fig show how ergodic capacity change with respect to SNR value where n_t is no of transmit antenna. We use MATLAB R2010 for calculating Ergodic and Outage Capacity. We see that when there is less no of transmit antenna then capacity is not increasing too much but when no of transmit antenna (n_t) increases then at very small value of SNR , Ergodic Capacity

Table No 2 .Ergodic and outage capacity (n_r=30)

No of transmit Antenna (n_t)	Ergodic Capacity	Outage Capacity
1	9.8707	9.5344
3	24.6982	24.0656
5	37.246	36.4236
7	48.3897	47.4389
9	58.4615	57.3587
11	67.6932	66.4502
13	76.1313	74.7882
15	83.7933	82.2818
17	90.746	89.1375
19	97.1604	95.3177
21	102.867	101.1306
23	108.1797	106.2103
25	113.133	111.2995
27	117.7546	115.8544
29	122.118	120.3211

increases rapidly. This indicate that ergodic capacity is function of no of transmit antenna and SNR. Fig no 2 shows the variation of SNR vs. Ergodic capacity(value of n_t are constant) .In fig no.2 we find limitation of ergodic capacity.We see that at n_t=1 although we increase SNR but Ergodic capacity not increases w.r.t SNR means it is nearly study state.So for improve Capacity or channel we should increase the no of transmit and receive antenna.Table no. 2 shows variation of ergodic and outage capacity w.r.t no of transmit antenna, and it give that there are 1% difference between them and this comparison also present in graph no 6.Fig no 3 an 5 show individual variation of Ergodic and Outage Capacity. Table 3 shows that if we increase SNR then BER is also reduces and fig 6 is semi logical plot between SNR and BER. It show that if SNR increases then BER decreses.

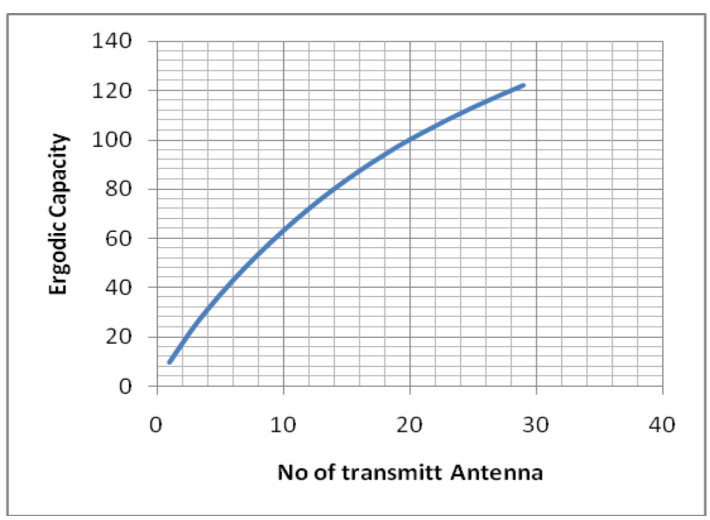

Figure: 3 Ergodic Capacity Vs no of transmit antenna

Table No 3: SNR vs BER

SNR	BER
1	0.1092
2	0.0867
3	0.0658
4	0.0471
5	0.0314
6	0.0192
7	0.0105
8	0.005
9	0.002
10	6.52E-04
11	1.62E-04
12	2.86E-05
13	3.31E-06
14	2.25E-07
15	7.80E-09
16	1.17E-10
17	6.03E-13
18	8.20E-16
19	2.08E-19
20	6.35E-24

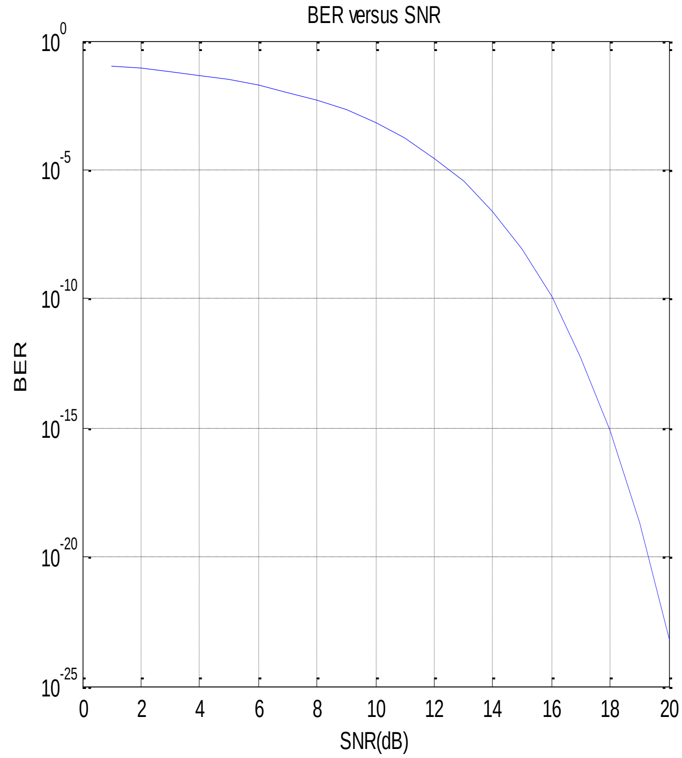

Fig no. 4 ber vs. SNR

Table no 3 shows variation of bit error rate w.r.t signal to noise ratio. We use AWGN as a noise singnal and QAM (Quadrature Amplitude Modulation) as a modulation. In fig no 4 when SNR is increase then the value of BER is almost zero at 20.

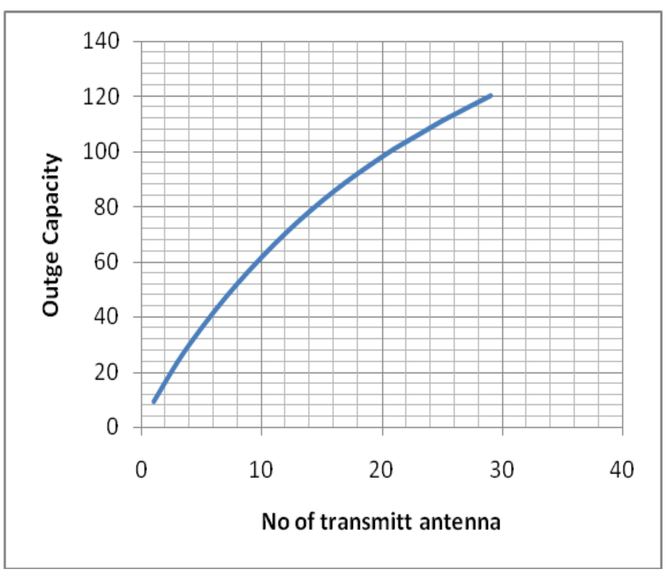

Fig. 5 Outage capacity vs. n_t

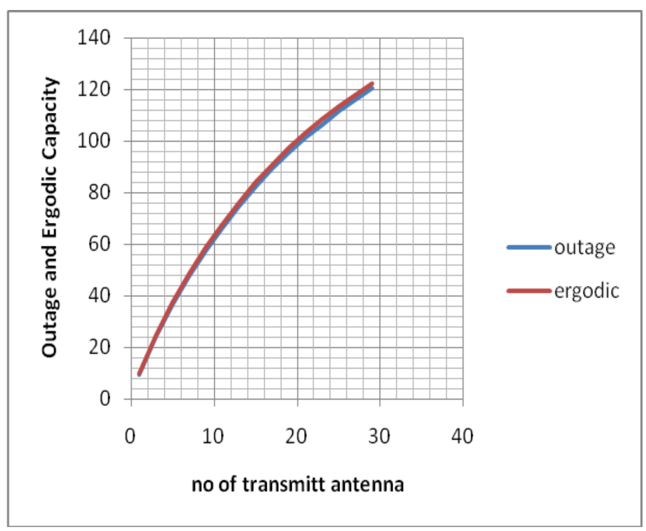

Fig: 6 Outage and Ergodic capacity vs n_t

IV. CONCLUSION

Ergodic channel capacity has some limitation in MIMO-OFDM system. So channel capacity optimization is necessary to improve the performance of MIMO-OFDM System. By above result we can analyze MIMO-OFDM system deeply and use various algorithms to optimize channel capacity.

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