A COMPARATIVE STUDY OF SPACE RECEIVE DIVERSITY TECHNIQUES FOR MASSIVE MIMO

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ABSTRACT

Mobile communication systems became an attractive technology, and nowadays there is a high demand for wireless communication. This paper focuses, to imp²rove the signal received by the receiver. A study comparative of space receive diversity combining techniques which are Selection Combining (SC), Maximum Ratio Combining (MRC) and Equal Gain Combining (ECG) for massive MIMO system over channel for massive MIMO system. The results indicate that the improvements of Signal to Noise Ratio and capacity is achieved by increasing number of receive antennas for tree combining techniques. The comparison made between tree techniques explains that MRC is a better performance than SC and ECG to combat multipath fading for next generation of cellular communications.

Keyword: *Massive Mimo, diversity, SNR, MRC, SC, ECG*

1. INTRODUCTION

The use of spatial diversity at the transmitter reduces the harmful effects of fading on the quality of the transmission link. Indeed, the diversity generates according to the technique used several replicas of the signal which will be used to improve the transmission. Thus, future wireless systems have to satisfy three main requirements: first of all having a high throughput secondly, simultaneously serving many users; and having less energy consumption systems. The space receive diversity combing techniques selection combining (SC), maximum ratio combining (MRC) and Equal Gain Combining (EGC) which applied for massive MIMO system to combine multiple copies of data streams by determine the two performance methods (signal to noise ratio and system capacity) with assumption of optimum transmitted signals over Rayleigh fading channel.

1.1 RELATED WORK

Consider a receive diversity system for massive MIMO system with large number of receive antennas Nr and user with a single transmit antenna. The channel matrix between transmitter and receiver is given by:

$$h = \left[h_1 h_2 \dots h_{N_r}\right]^T \quad (1)$$

Where h denotes to channel matrix, Nr represents the independent Rayleigh fading channels. Let x denotes the optimum transmitted signal with the unit variance in the channel. The received signal $y \in C^{N_r*1}$ as written by:

$$y = \sqrt{\frac{E_x}{N_0}}\, h\, x + z \quad (2)$$

Where:

y: is received signal.

x: is transmitted signal.

N_0 : is noise power.

Z: zero-mean circular symmetric complex Gaussian.

The method to quantify the system performance is given:

- ***Signal to Noise Ratio*** (SNR) (which is ratio between receive signal power to noise power) for the ith branch, which is given by:

$$SNR_i = |h_i|^2 \frac{E_x}{N_0}, \; i = 1, 2, 3 \ldots N_r \quad (3)$$

Other method to quantify the system performance is the capacity. The capacity follows the Shannon's theorem.

capacity at which the transmitter can transmit over the channel. From Shannon theorem, the channel capacity is given by [2]:

$$C = \log_2(1 + \mathrm{SNR}) \text{ (bits/s/Htz)} \quad (4)$$

The received signals in the different antennas can be combined by various combining techniques. These combining techniques include maximal ratio combining (MRC), selection combining (SC), and equal gain combing (EGC); to improve the system performance of cellular communication.

2. SYSTEM MODEL

Consider a receive diversity system for massive MIMO with large number of receive antennas and user with a single transmit antenna.

The concept consists in choosing this factor so that the quality of the recombined signal is improved. We put $u_l = h_l s + \eta_l$, then the combined signal becomes:

$$\gamma = \sum_{l=1}^{L} w_l u_l \quad (5)$$

The received signals in the different antennas can be combined by various combining techniques but the choice depending on the choice of w_l.

2.1 Maximal Ratio Combining Modeling

The weighting coefficient w_l is applied to each branch before all the signals are combined and substituted for the combination coefficient which is defined by [1]:

$$w_l = h_l^* \quad (6)$$

The combined signal γ is expressed by:

$$\gamma = \sum_{l=1}^{L} h_l^* h_l s + \sum_{l=1}^{L} h_l^* \eta_l \quad (7)$$

2.2 Selection Combining Modeling

The Selection Combining (SC) technique is a technique of selecting the signal having the maximum power or signal-to-noise ratio of all the independent signals arriving at the receivers [4]. For the SC technique, we denote γ_n the SNR of the branch then the SNR of the signal obtained after the SC technique is expressed by the following statement:

$$M_{\gamma sc}(s) = M_{\gamma max}(s) \quad (8)$$

2.3 Equal Gain Combining

In some cases, it is not convenient to provide for the variable weighting capability required for true maximal ratio combining. In such cases, the branch weights are all set unity, but the signals from each branch are cophased to provide equal gain combining diversity. In this technique; it assigned the equal weights to the receiver branches which amplify the signals equally [2].

3. SIMULATION RESULT

MATLAB tools have been used for the SNR, outage probability and capacity improvements simulation.

3.1 Maximal Ratio Combining technique

- SNR

For the MRC technique, if we consider γ_l the SNR of the branch then, the SNR of the combined signal is expressed by:

$$\gamma_{MRC} = \sum_{l=1}^{L} \gamma_l \quad (11)$$

- Outage probability

For MRC technical via a Rayleigh channel, the outage probability is expressed by:

$$P_{OUT_{MRC}} = \int_0^{\gamma_{th}} \frac{1}{2^L (L-1)! (\bar{\gamma})^L} \gamma_{MRC}^{L-1} e^{-\frac{\gamma_{MRC}}{2\bar{\gamma}}} d\gamma_{MRC} \quad (14)$$

- capacity

For a SISO channel the capacity is defined by [4] :

$$C_{SISO} = \log_2(1+\gamma) \quad (15)$$

The capacity of a channel using the recombination technique by MRC is expressed by:

$$C_{SISO} = log_2\left(1 + \frac{E_b}{N_0}|h_l|^2\right) \quad (16)$$

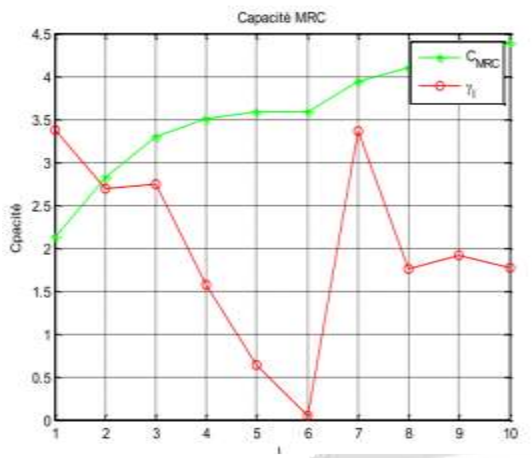

Figure 1: Performance for capacity improvement of MRC

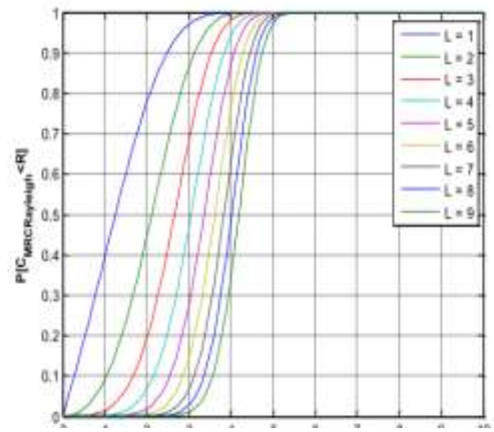

Figure 2: Capacity - Rayleigh improvement for MRC

3.2 Selection Combining SC

- Outage probability

Irrespective of the transmission channel, the SNR outage probability handset through the SC technique:

$$P_{OUTSC}=\left[F_{\gamma}(\gamma_{th})\right]^{L} \quad (17)$$

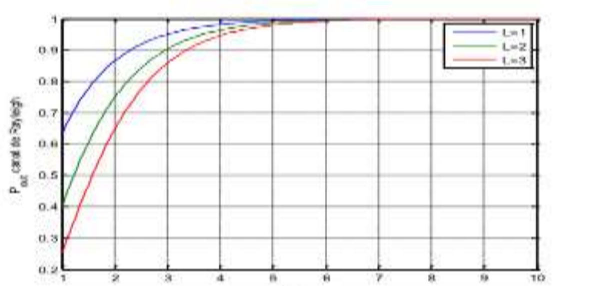

Figure 3**:** Outage probability - Rayleigh channel improvement for SC

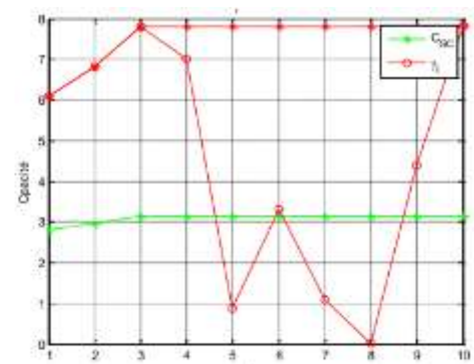

Figure 4**:** Outage probability - Rayleigh channel improvement for SC

3.3 Equal Gain Combining

- Capacity of a combined MIMO channel by EGC

The capacity of a channel using the EGC recombination technique is expressed by:

$$C_{ECG}=\log_2\left(1+\frac{E_b}{N_0}\frac{\left|\Sigma_{l=1}^{L}|h_l|\right|^2}{L}\right) \quad (18)$$

The figures (5 and 6) below show the comparaison of output cuves between Signal to Noise Ratio (SNR) and Numbers of receive antenna (Nr) [up to 128 and 256 respectively] of massive MIMO system for (SC), EGC and MRC ; while figures (7) represents the capacity and number of receive antenna (Nr) for massive MIMO system. By assume optimum transmitted signal (10^4 bits or symbols) with FBMC modulation techniques and the signal to noise ratio for digital communication (Eb/No (dB) =30).

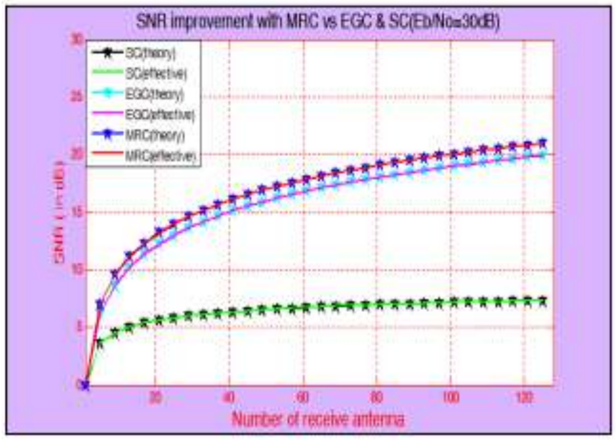

Figure 5: Performance comparison for SNR improvement of SC, EGC & MRC [up to 128 antennas].

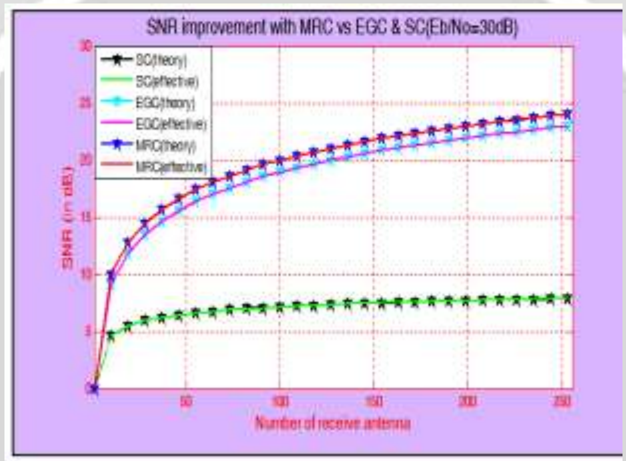

Figure 6: Performance comparison for SNR improvement of SC, EGC &MRC [up to 256 antennas].

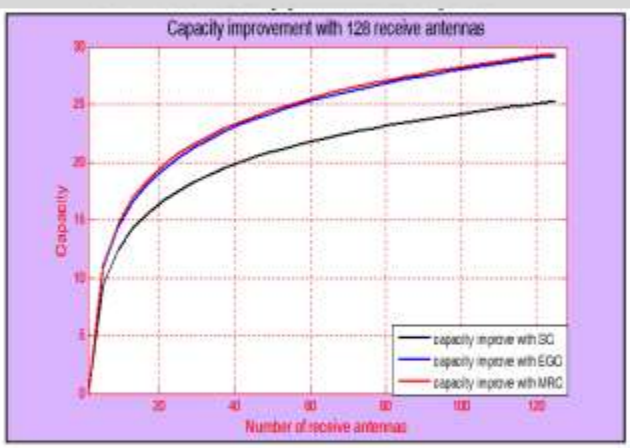

Figure 7: Performance comparison for capacity improvement of SC, EGC & MRC [up to 128 antennas].

4. CONCLUSIONS

This study focuses a comparison of space receive diversity combining techniques for massive MIMO system over Rayleigh fading channel to compact the effect of multipath problems and select the optimum combing techniques for massive MIMO system. The simulations and results explain that; increasing the number of receive antennas enhance the system performance for wireless communication (Noise Ratio and capacity) for three combining techniques. At 128 antennas; the SNR and capacity improvement for SC, EGC and MRC In the case of 256 antennas Maximum ratio combining technique and Equal gain combining technique give better performance than selection combining technique. In contrast; the Maximum ratio combining technique is better than SC and EGC (relative to priority of non-unity weighting and co-phasing) for receive diversity in next wireless communication.

5. REFERENCES

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