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Research paper

Ergodic Sum Rate of Transmitting Antenna Selection in Non-Orthogonal Multiple Access for Modern Systems

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Abstract

Wireless systems hiring multiple antennas at the transmitter side used for the transmission of the high capacity information through the channels making the system more complex and costlier. To overcome these problems, the multiple antennas at the transmitter side must be reduced and the performance should retained with reduced antennas as earlier. This can be achieved by using the algorithm Transmitting Antenna Selection (TAS) which is carried out by considering the transmission of the information through the channels using the Non-Orthogonal Multiple Access (NOMA). The NOMA algorithm is used to provide the high throughput using the heterogeneous demands in which there is no interference between the transmitted signals from the multiple antennas equipped in a single base station. TAS-NOMA algorithm is proposed in this paper for selecting the best transmitting antenna out of multiple antennas equipped in the base station by using the Ergodic sum rate which is measured at the transmitter side considering the average of the channels capacity.

Keywords: *TAS; NOMA; Ergodic Sum Rate; Channel Capacity.*

1. Introduction

The present technology used in wireless systems for the transmission of information through the channels using the modern transmission system using the (MIMO) i.e., multiple inputs and multiple outputs algorithm at the transmitter side. The complexity and the power consumption is more by using the MIMO. Different algorithms were proposed to reduce the complexity and the power consumption but they are not upto the extent. The system complexity can be reduced by using the single antenna for the transmission, instead of using multiple antennas.

The single antenna selection for the transmission of signals through the channels is carried by the process defined as TAS. It is based on the different parameters like complexity, power consumption and the cost of the system. TAS speculatively selects a single best antenna out of multiple

Antennas and uses a single radio frequency chain for transmission [1]. The antenna selection is based on the feedback from the receiver antennas and the receivers must receive the required signal so that system must be able to distinguish the received signal and there is less interference between the signals transmitted to other users.

NOMA have been regarded as the promising multiple access technology for 5G systems. NOMA assigns the same frequency band and time slots at different power levels to all users unlike conventional orthogonal multiple access to increase spectral efficiency and data rates. However, the transmitter allocates different power to each user based upon their channel quality. Successive interference cancellation (SIC) is applied to the users to decode their respective information. Less power is applied to the users with good quality and the more power is to be applied to the users with poor quality [2].

TAS-NOMA is a prominent technology to modern system which is used to select a best antenna based upon the sum rate, achieved by considering the user rate based on the channel conditions and the antenna selection is processed by the investigation of the sum rate of each transmitting antenna and then the best antenna is selected. The sum rate is the capacity of the transmitting antenna which is observed at the user and then based upon the received signal the sum rate is estimated. In order to measure the sum rate of an antenna, data must be transferred from the antenna to user and feedback is acknowledged to select the best antenna. [3].

The orthogonal principle states that the channel state information (CSI) at receiver sends the feedback to transmitter to select the best antenna and the feedback cannot be sent to the transmitter without channel state information [4]. The Non-orthogonal principle states that there is no channel state information at receiver and the partial channel state information available at transmitter side is used to select the best antenna.

Capacity is measured based on averaging the rate over all channel states or maintain a fixed rate for most channel states. More particularly, when channel state information is known perfectly both transmitter and receiver and transmitter can adapt its transmission strategy relative to the channel and therefore channel capacity is characterized by the ergodic [5].

In this paper, the sum rate measurement is carried out by a different process and the sum rate accomplished by the proposed method is defined as ergodic sum rate. The ergodic sum rate is obtained by calculating the probability density function of channel allocation coefficient (each user assigned a channel) and taking the average of the instantaneous capacity of each channel.

The remaining of this paper is as follows: section II gives a brief review about the related work regarding to TAS, NOMA and TAS-NOMA and Section III details the proposed work by step by step algorithm and results are presented in section IV to highlight the implementation of the proposed work. Finally, the work is concluded in section V.

2. Related Work

Shahab sanayei et.al proposed an algorithm based on two approaches, norm-based selection and successive selection in Which SNR is considered using feedback from the receivers if the feedback is correlated during acknowledgement it is not accurate for antenna selection [6].
Yang-seok et.al, proposed a fast antenna selection algorithm based on the correlation and mutual information between the signals at the different antenna elements. The computation of the correlation between the signals is time consuming and requires N2 computations where N is the number of transmitting antennas [7].
Ziad qais Al- Abhasi et.al, proposed an algorithm for the maximization of sum rate in the non-orthogonal multiple access using the division of spectrum into sub carrier it is mainly focused on two users, if the users more than two, the sum rate gain will be diminishes [8].
Xin Liu et.al, proposed an algorithm for the antenna selection in multiple input and multi output and non-orthogonal multiple access systems by considering the limited candidate antennas and it is not suitable for the multiple antennas at the base station [9].
Anish prasad Shrestha et.al, proposed an algorithm for the 5th generation systems to select a best antenna out of multiple antennas at the base station and they used to investigate each antenna at the user to obtain the maximum sum rate and did not considered PSNR for the transmission of the data through the channel under different conditions [10].
Andreas F. Molisch et.al, discussed the impact of system nonidealties, like noisy channel estimation, Correlations of the received signals, etc. to select the best antenna. But it is very lengthy process to define all the estimations to select the best antenna [11].
However, to overcome the problems raised in the existing works, a new approach is proposed. In this proposed work all these conditions are considered for addressing the problems in previous method. TAS-NOMA is existing algorithm but there is no consideration about the PSNR values. So, in this paper, presented work will describe about the increase in capacity of channel and also to reduce the time delay in the evolution of sum rate which is ergodic sum rate.

3. Proposed Work

In this proposed work, the transmitting base station is equipped with the N number of multiple antennas to transmit the information across the channel. The usage of the multiple antennas at the base station of transmitting side make it more complex to operate and also it requires more power to operate so the proposed work first uses the multiple antennas to find the best antenna and also the capacity of the channel is to be increased when the users are increased. Now the data to be transmitted to the users is given as input to the multiple antennas i.e., said to be as data input in the block diagram shown in the fig 1. To isolate the best antenna among the multiple antennas, the data rate of each antenna is calculated at the transmitter before the transmission of the data through the channels and the same operation is performed at the user side to measure the data rate and then the main purpose of the proposed work is achieved here that is instead of measuring the individual data rate of each antenna signal observed at the user, the average of the data rates of all the signals from the multiple antennas is considered in order to increase the capacity of the channel. The average of the data rates at the user side by considering the different effects on the channel during the transmission and other fading losses is said to be the Ergodic sum rate.

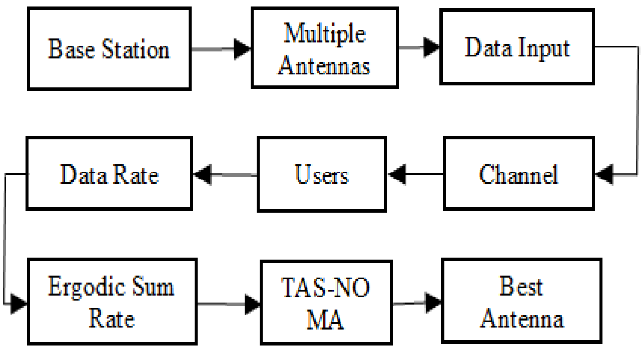

Fig. 1: Block Diagram for Selecting the Best Antenna.

The sum rate measurement for a base station equipped with 'n' number of antennas to transmit the data over the channel using the different powers. The channel assignment is based on the channel allocation coefficients h_m^n and the power allocation coefficient a_m^n to allocate the required power for the transmission and p^n is the transmit signal to noise ratio [12].

$$R_{n\times 1} = \sum_{m=1}^{M-1} \log\left(1 + \frac{p^n|h_m^n|^2 a_m^n}{p^n|h_m^n|^2 a_m^n+1}\right) + \log(1 + p^n|h_m^n|^2 a_m^n) \quad (1)$$

Where $a_m^n = \sum_{i=m+1}^{M} a_i^n$ (2)

This equation (1) represents the sum rate of the best antenna by considering the single receiving antenna. In this, method 'n' number of transmitting antennas are considered as transmitting antennas and out of which, a best antenna is selected by searching the maximum sum rate at the receiving antenna.
In the proposed work, 'n' number of transmitting antennas and receiving antennas are considered a new method is designed such that the best antenna is selected by averaging the instantaneous capacity at the receiving antennas. So the delay is reduced when compared to the existing method in which each antenna is examined for the maximum sum rate but in this paper, an average the instantaneous capacity is measured and the best antenna is selected based on the average sum rate. The average of the instantaneous capacity at the receiving side is given equation (3).

$$R_{avg}^n = \sum_{n=1}^{N-1}\left\{\sum_{m=1}^{M-1}\{\int_0^\infty \log\left(1 + \frac{xp^n a_m^n}{xp^n a_m^n+1}\right) f|h_m^n|^2(x)dx + \int_0^\infty \log(1 + p^n x a_m^n) f|\, h_m^n|^2(x)dx\}\right\} \quad (3)$$

Where $a_m^n = \sum_{i=m+1}^{M} a_i^n$ (4)

The data rate of each antenna is measure by the equation (1) and the average of the all antennas is calculated by the equation (3) and after getting the average data rate i.e. Ergodic sum rate the best antenna has to identified, for that the maximum sum rate achieved by which antenna has to be known, by using equation (5) the antenna with the maximum sum rate is identified.

$$R_{sum}^{n\times n^2} = \max_{1\le n\le N} R_{avg}^{n\times n} \quad (5)$$

4. Results and Implementations

The ergodic sum rate is measured by varying the total power to the base station and the value of N is changed i.e. the number of antennas are increased. The total transmission power available at the base station is depicted as a function from the noted ergodic sum rate for different values of N= 1, 2, 4, 8, 10 are shown in Fig 2, 3, 4, 5, 6 respectively. By using instantaneous capacity, the sum rate efficiency can be improved. For increasing in the number of transmitting antennas N, the ergodic sum rate can be calculated for each N individually. And it clearly states that the increase in total power available at the base station leads to increase in ergodic sum rate. The proposed work is implemented by using Matlab 2016a and achieved better results in terms of increment in the values of Ergodic sum rate when compared with the earlier work [10].

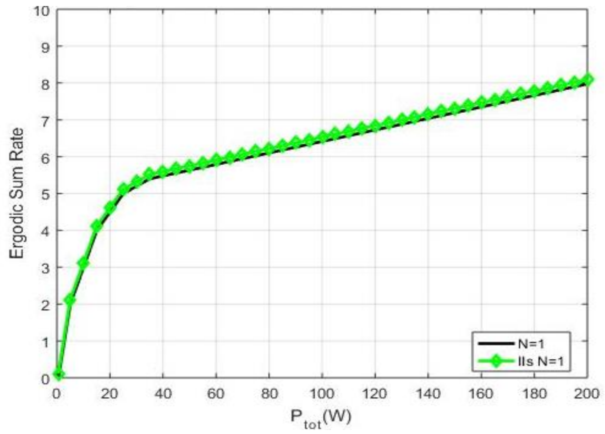

Fig. 2: Ergodic Sum Rate vs Ptot for N = [1].

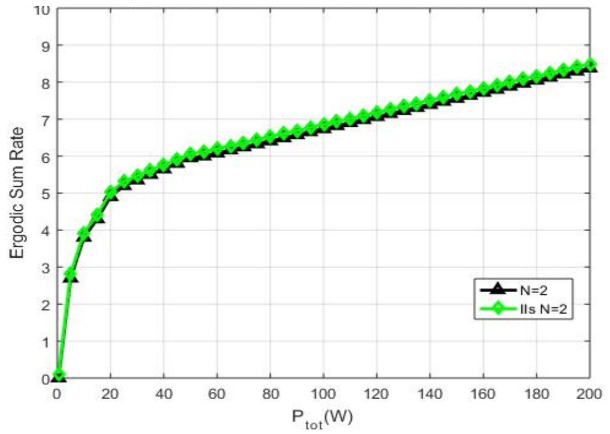

Fig. 3: Ergodic Sum Rate vs Ptot for N = [2].

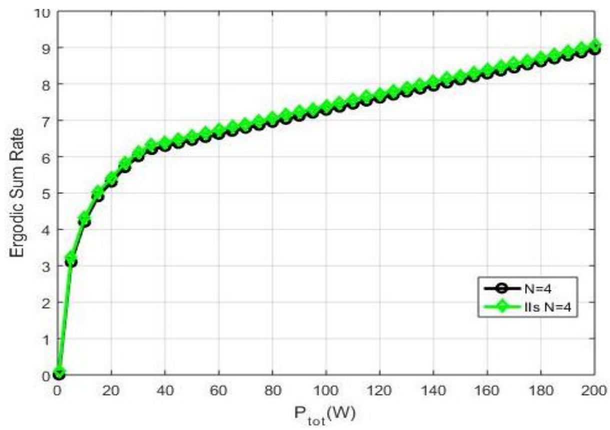

Fig. 4: Ergodic Sum Rate vs Ptot for N = [4].

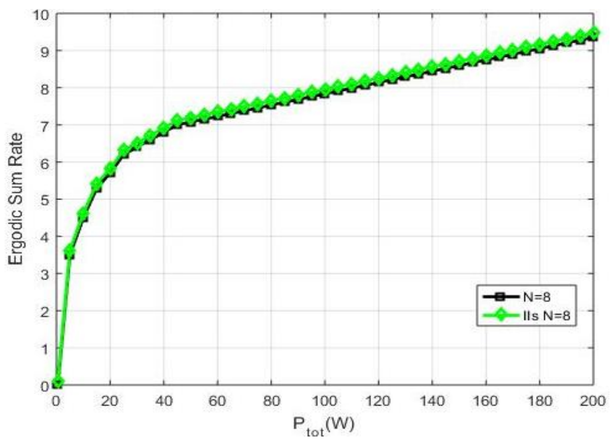

Fig. 5: Ergodic Sum Rate vs Ptot for N = [8].

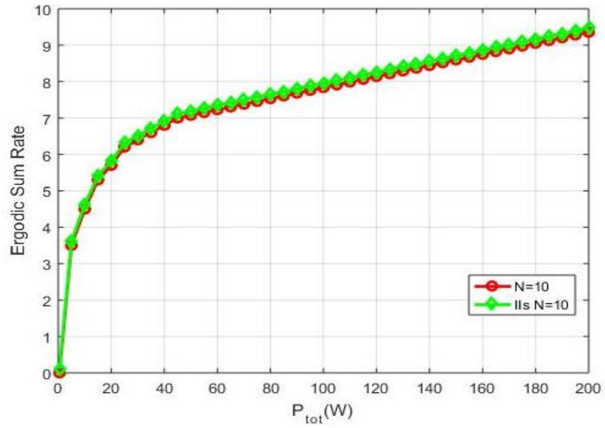

Fig. 6: Ergodic Sum Rate Vs Ptot for N=10.

The graphs shown in below are plotted by considering the number of users M. The Ergodic sum rate is measured by considering the different number of mobile users i.e. the graphs are plotted for M= [2], [4], [8]. It can be observed that the sum rate had increased for the increase in the value of M. The ergodic sum rate is represented as a function of total transmission power available at the base station for different values of M as shown in Fig 7, 8, 9 respectively. When the total power available at the base station is high and the number of mobile users are increased, then the ergodic sum rate increases.

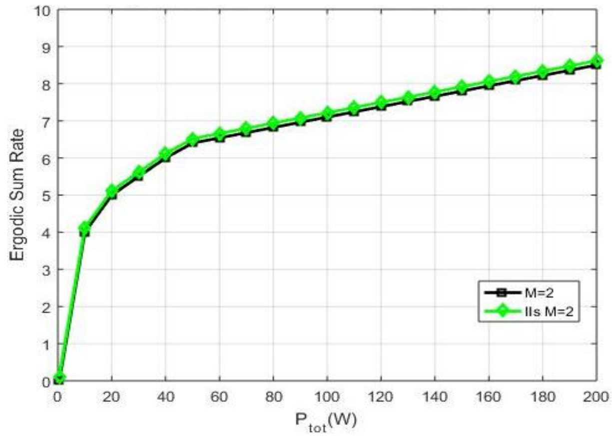

Fig. 7: Ergodic Sum Rate vs Ptot for M = [2].

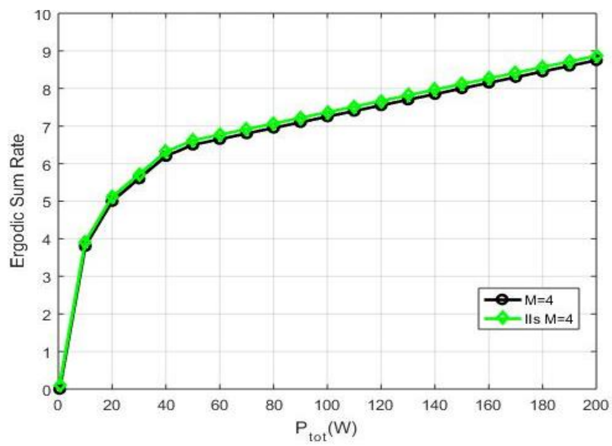

Fig. 8: Ergodic Sum Rate vs Ptot for M = [4].

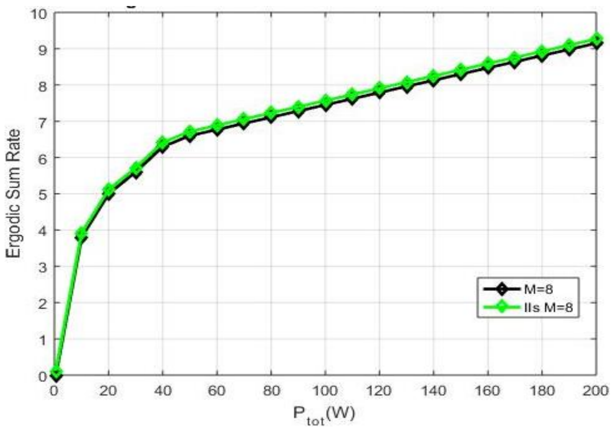

Fig. 9: Ergodic Sum Rate vs Ptot for M = [8].

The comparison of sum rate and ergodic sum rate for different values of transmitting antennas N are depicted in the table I. If we observe the table I sum rate and ergodic sum rate for transmitting antennas are increasing gradually whereas the sum rate and ergodic sum rate for different users are increasing gradually which is depicted in table II.

Table 1: Comparison of Sum Rate for Different Values of N

Number of Transmitting Antennas	Sum Rate	Ergodic Sum Rate
N=1	7.974	8.091
N=2	8.378	8.495
N=4	8.939	9.056
N=8	9.354	9.470
N=10	9.358	9.476

Table 2: Comparison of Sum Rate for Different Values of M

Number of Mobile Users	Sum Rate	Ergodic Sum Rate
M=2	8.5	8.617
M=4	8.75	8.867
M=8	9.15	9.267

5. Conclusion

The channel capacity increases in TAS-NOMA scheme by considering the ergodic sum rate and delay is reduced and considering the ‘n’ number of receiving antennas for ‘n’ number of transmitting antennas to measure the average of the instantaneous capacity at each receiving antenna and the best antenna is selected based upon the maximum ergodic sum rate and the capacity also increased. In future, this work can be extended for massive mimo systems to increase the channel capacity.

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