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Application of Multiple Antenna Non-Orthogonal Multiple Access (Noma) Technique in Wireless Communication

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Abstract- A multiple antenna Non-Orthogonal Multiple Access (NOMA) model has been applied to wireless communication system. A trans-user downlink wireless communication system performance analysis was extensively performed by matlab simulation. The simulations were evaluated in terms of three performance metrics namely, Bit error rate (BER) against transmit power (dBm), achievable sum rates and outage probability. The results from the simulations conducted in terms of BER against transmit power in dBm, revealed that the near user equipment (UE-1) has better performance (BER of 2.0e-6) than the far user equipment (UE-2) (of BER =2.4e-5) at 40dBm with distance of UE-2 from the base station (BS) equal to 500m. Further simulation by reducing the distance of the UE-2 to 300m showed that the BER of both users improves such that UE-1 has 0, while for UE-2, it was 3e-6 at transmit power of 40dBm. The achievable sum rate curve of multiple-input multiple-output-NOMA system revealed that it increases exponentially as the transmit power increases such that the outcome was a value of 20.75 bps/Hz at transmit power of 40dBm. Further simulation of achievable sum rates of UE-1 and UE-2 indicated that the near user has a value of 18.75 bps/Hz as against 1.999 bps/Hz for the far user. This performance was achieved when the distance of the UE-2 equal to 500m. With the distance of UE-2 equal to 300m, the achievable sum rates of UE-1 and UE-2 were 18.75 bps/Hz and 2 bps/Hz respectively. Hence, with these results for different distances of UE-2 from the BS revealed that distance of user does not significantly influence achievable sum rate performance. In terms of outage probability, UE-1 has 8e-6 while that of UE-2 was 2.3e-5 at transmit power of 40dBm respectively. Since the outage probability is used as a measure of the quality of service (QoS) of user, it means UE-1 has better QoS. In addition, performance of the MIMO-NOMA was compared with MIMO-orthogonal multiple access. Results revealed that the MIMO-NOMA downlink system outperformed the MIMO-OMA in terms of achievable sum rate and outage probability as the system can be used for 5G network application.

Keywords: Non-Orthogonal Multiple Access, Multiple Antennas, Achievable Sum Rate, MIMO-NOMA, Outage Probability

I. INTRODUCTION

New technology solutions are being sought after for the fifth generation (5G) and future cellular networks to ensure that mobile communication services are sustained in the next decades (Ali, 2017). Considering the perceived exponential growth in cellular traffic, it is envisaged that these new technologies will provide significant improvement in spectral efficiency as well as system capacity enhancing the experience of users. Several approaches to enhance wireless communication have been studied. For instance, massive Multiple Input Multiple Output (massive MIMO) techniques have been presented. With massive MIMO technique, a near optimal sum rate was achieved, channel capacity was increased, and Bit-to-Error Rate (BER) was enhanced (Muoghalu *et al*., 2021a, 2021b, and 2021c), respectively. The use of MIMO combined with Orthogonal Frequency Division Multiplexing (OFDM) technique has been shown to improve wireless communication system performance (Muoghalu & Achebe, 2023). The application of adaptive equalization technique was shown to reduce multipath effect so as to improve signal quality (Osuagwu *et al*., 2024 and 2025). The evaluation of system capacity using multiple antennas with different array and channel configurations revealed promising performance (Achebe & Muoghalu, 2025). The performance of correlated channel for large scale MIMO system was evaluated by Nnaji *et al*. (2023). Scheduling and zero forcing techniques were used to improve channel allocation performance in wireless communication (Ezejiofor *et al*., 2024). BER optimization technique has been used to improve handoff in mobile communication system (Nwabueze *et al.*, 2016).

In wireless communication system, to provide communication service between multiple transmitters and receivers simultaneously over a single channel by using channelization techniques based on time, frequency or code is known as multiple access. The channels are created by dividing the resources orthogonally or semi-orthogonally. The transmitting power of each transmitter may be different, but the receiver's bandwidth is divided among the users. The principle of multiple access technology is utilizing the available resources like bandwidth and power in an efficient manner while creating minimum or no interference. Generally, when dedicated channel allocation is done to the users, it is called multiple access. It is commonly used in the telephone systems as they use dedicated channel allocation for voice signals. The sharing of bandwidth which require burst transmissions by using random channel allocation and which does not assure channel access is called random multiple access. The choice of random access or multiple access and channelization type to be used will depend on the characteristics and compatibility of the system. By sharing the bandwidth, overall channel capacity is increased (Tanuja *et al,* 2022). Multiple Access is categorized into two which are the NOMA and the OMA (Islam *et al.,* 2016).

In order to provide communication service among multiple users over a single channel, multiple access technique has been implemented. In contrast to conventional multiple access schemes such as orthogonal multiple access (OMA), NOMA is considered a promising scheme to address lapses for 5G and next generation wireless network because it offers improved user fairness, limited number of connected users, latency, and robustness. However, the main problem with NOMA is inter-user interference (IUI), and this has attracted significant.

In this work, the binary phase shift keying (BPSK) is used as a substitute for QPSK modulation method used in Son and Le Khoa (2021) for MIMO-NOMA over Rayleigh channel. Also, while Son and Le Khoa studied on performance of the system in terms of BER only for two users' scenarios, this work considered the performance of MIMO-NOMA in terms of BER, average sum rates (data transmission capacity), and outage probability using BPSK modulation scheme for two users' scenario. Furthermore, the work carried out by Son and Le Khoa (2021) did not implement successive interference cancellation (SIC) via superposition code at the transmitter. This work carried out superposition coding at the transmitter to achieve SIC at the receiver.

II. METHODS

2.1 System Model

Figure 1 is a description of the multiuser multiple antenna NOMA system model considered in this work. It represents a downlink MU MIMO-NOMA network that comprises a base station (BS) that transmits desired signal and at different power allocation coefficients β_1 and β_2, to number of users (UE-1 and UE-2).Let the distances of UE-1 and UE-2 from the BS be d_1 and d_2. It is assumed that distance of UE-2 from the BS is longer than that of UE-1 such that $d_2 > d_1$. Hence, UE-1 is regarded as strong user while UE-2 is considered the weak user based on their nearness to the base station. In this work, the MIMO antenna is used to achieve diversity gain so as to decrease BER. The block diagram of the system is shown in figure 2. The expressions δ_1 and δ_2 are the channel noise.

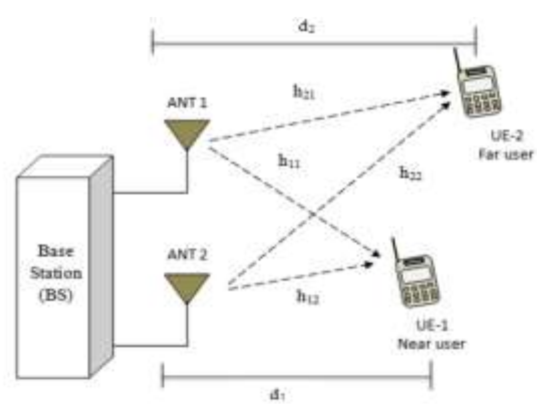

Figure 1: Multiuser MIMO-NOMA Downlink System Model

As shown in Figure 1, a block diagram description of the proposed multiple-antenna NOMA system with multiple users (user UE-1 and user UE-2) communicating with a base station from the different distance locations.

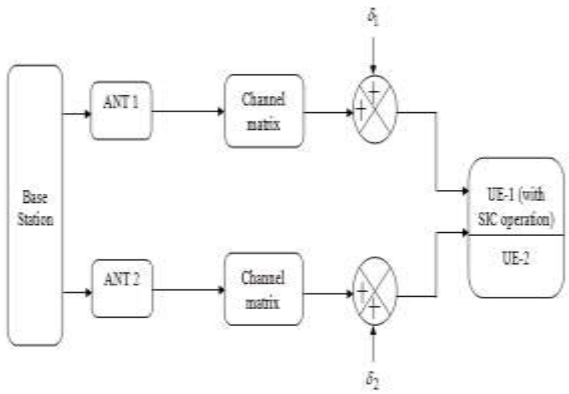

Figure 2: Developed Block Diagram Model

Now, let s_1 and s_2 represent the transmitted signals from the BS antennas to UE-1 and UE-2. Maintaining the convention of MIMO system, h_{ij}represents the multipath fading channel between ith transmit antenna andjth receive antenna as shown in figure 1. It should be noted that the far user is allocated more power, while the near user is assigned less power. Successive interference cancellation (SIC) is performed by the nearest user (this is achieved by the process of superposition coding at transmitter), but not with the far user.

Figure 3 shows a typical conventional MIMO system. The mathematical description of the process is presented in equations (1) and (2).

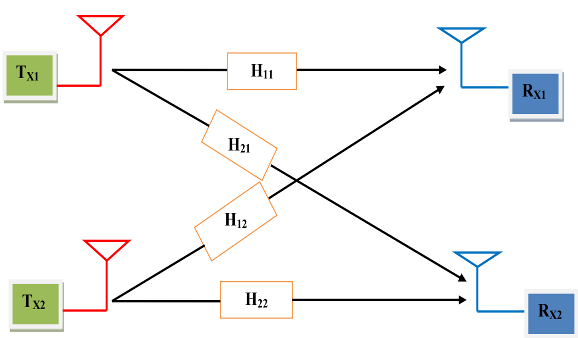

Figure 3: 2×2 Channel Conventional MIMO Model

Given that signal is sent from the transmitting end with two transmit antennas to the receiving with two receive antenna, the mathematical definition of the process is defined by:

$$r_1 = H_{11}s_1 + H_{21}s_2 + \delta_1$$
$$r_2 = H_{12}s_1 + H_{22}s_2 + \delta_2 \qquad (1)$$

s_1 and s_2 are the transmitted signals from the transmit antenna $T_{X1}$and T_{X2} respectively. r_1 andr_2 are the received pilot signals on the receive antenna R_{X1} and R_{X2}. δ_1 andδ_2 are the noise components on receive antenna $R_{X1}$and R_{X2} respectively.

Given the channel H_{ij} from i^{th}transmit antenna T_{Xi} to jth receive antenna R_{Xj}withi and j $\varepsilon\{1,2\}$. The channel matrix is expressed by:

$$H = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix} \qquad (2)$$

2.3 Mathematical Description of Signal Model

In this work, considering the system model as shown in figure 1, the BS is assumed to be transmitting signals from two M transmit antennas ANT 1 and ANT 2 to two single-cell users at distance d_1 and d_2 using NOMA technique over Rayleigh fading channels technique. With power allocation factors β_1 and β_2, assigned to the respective jth user equipment, the signal transmitted is given as:

$$s = \sqrt{P_s}\left(\sqrt{\beta_1}s_1 + \sqrt{\beta_2}s_2\right)$$

Or simplified further as:

$$s = \sqrt{P_s}\sqrt{\beta_1}s_1 + \sqrt{P_s}\sqrt{\beta_2}s_2 \qquad (3)$$

where P_s is the transmission power from the base station (that is the total average energy available at the BS in one symbol period). It should be noted that$\beta_1 < \beta_2$because UE-2 is the weaker user.

Now, at the receiver, the transmitted $s$received by the various users as a complex signal vector influenced by the channel characteristics and noise and since it is transmitted by the transmit antennas at the same time to the users, it is expressed as follows with respect to each user.

For first user (UE-1):

$$r_1 = sh_{11} + sh_{12} + \delta_1 = s\,(h_{11} + h_{12}) + \delta_1 \quad (4)$$

For second user (UE-2):

$$r_2 = sh_{21} + sh_{22} + \delta_2 = s\,(h_{21} + h_{22}) + \delta_2 \quad (5)$$

where δ_1 and δ_2 are additive white Gaussian noise (AWGN) with zero mean and variance,σ^2. The next approach is to describe the mathematical expression for the decoding operations at the UE-1 and UE-2,

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which represents the performance metrics for the system.

2.4 Performance Metrics

In this section, the various performance metrics considered in evaluating the developed system are briefly discussed. These are achievable rate, outage capacity, BER, and power allocation.

Achievable Rate

The first user equipment, UE-1 must decode s_1 from r_1. Since UE-1 is the near user, its signal s_1 is assigned less power. Thus, in r_1, s_2 will be dominating (that is s_2 will over shadow or dominate s_1 since it is allocated more power coefficient). Hence, UE-1 has to carry out direct decoding on r_1 to determine s_2. This requires SIC to be performed in order to eliminate s_2 and afterward, s_1 is decoded. In order to carry out SIC, BPSK modulation is first performed on both s_1 and s_2. Then a superposition coded signal is obtained as in Equation (3). The entire process for achieving SIC via superposition coding is described as follows:

Step 1: At this stage, the transmitted signal s is directly decoded to obtain the signal s_2, which is weighed with high power.

Step 2: Here, the directly decoded signal s_2 in step 1 is multiplied by its corresponding weight β_2 and then minus the transmitted signal s.

Step 3: This stage involves decoding the signal resulting from step 2 to obtain the other signal, s_1 which weighed (or multiplexed) with low power.

Considering the SIC process described, the expression for the achievable sum rate for UE-1 is determined as follows. Substituting equation (3.3) for s into equation (3.4) gives:

$$r_1 = (\sqrt{P_s}\sqrt{\beta_1}s_1 + \sqrt{P_s}\sqrt{\beta_2}s_2)\ (h_{11} + h_{12}) + \delta_1 \qquad (6)$$

Expanding equation (3.6) gives:

$$r_1 = \underbrace{\sqrt{P_s}\sqrt{\beta_1}s_1(h_{11} + h_{12})}_{\text{desired}} + \underbrace{\sqrt{P_s}\sqrt{\beta_2}s_2(h_{11} + h_{12})}_{\text{undesired (dominating signal)}} + \delta_1 \qquad (7)$$

Since more power is allocated to UE-2 by the BS, that is, $\beta_1 < \beta_2$, the UE-1 cannot decode its own signal directly. It must first decode the strong signal s_2. The signal interference to noise ratio (SINR) at UE-1 on decoding of s_2 is given by:

$$SINR_{12} = \frac{\left|\sqrt{P_s}\sqrt{\beta_2}s_2(h_{11}+h_{12})\right|^2}{\left|\sqrt{P_s}\sqrt{\beta_1}s_1(h_{11}+h_{12})+\delta_1\right|^2} \qquad (8)$$

Simplifying equation (3.8) gives:

$$SINR_{12} = \frac{P_s\beta_2|h_{11}+h_{12}|^2}{P_s\beta_1|h_{11}+h_{12}|^2+\sigma^2} \qquad (9)$$

Hence, after SIC process, the undesired signal in equation (3.7) is removed since UE-1 knows the exact interference term from the signal s_2. Therefore, the resultant received signal at UE-1 after the SIC process is given by:

$$r_1' = \sqrt{P_s}\sqrt{\beta_1}s_1(h_{11} + h_{12}) + \delta_1 \qquad (10)$$

At this point, the UE-1 can now decode its signal given in equation (10). The resulting SINR (or signal to noise ratio) at UE-1 is given by:

$$SINR_{11} = \frac{\left|\sqrt{P_s}\sqrt{\beta_1}s_1(h_{11}+h_{12})\right|^2}{\sigma^2} = \frac{P_s\beta_1|(h_{11}+h_{12})|^2}{\sigma^2} \qquad (11)$$

Thus the achievable sum rates at UE-1 for decoding s_1 and s_2 are expressed as:

$$R_1 = log_2(1 + SINR_{11}) \qquad (12)$$

$$R_2 = log_2(1 + SINR_{12}) \qquad (13)$$

On the other hand, the UE-2 can directly decode its own signal since it considers the s_1 as a low noise signal (i.e., a weak signal) (Suprith & Ahmed, 2022). Thus, UE-2 can directly decode s_2 from r_2, while treating s_1 as interference (Poojala&Vedavalli, 2021). Substituting s in equation (3) into equation (5) gives:

$$r_2 = (\sqrt{P_s}\sqrt{\beta_1}s_1 + \sqrt{P_s}\sqrt{\beta_2}s_2)\ (h_{21} + h_{22}) + \delta_2 \qquad (14)$$

Expanding equation (14) gives:

$$r_1 = \underbrace{\sqrt{P_s}\sqrt{\beta_1}s_1(h_{21} + h_{22})}_{\text{desired}} + \underbrace{\sqrt{P_s}\sqrt{\beta_2}s_2(h_{21} + h_{22})}_{\text{interference}} + \delta_1 \qquad (15)$$

Now, the SINR for the process of decoding signal s_2 at UE-2 is given by:

$$SINR_{22} = \frac{P_s\beta_2|h_{21}+h_{22}|^2}{P_s\beta_1|h_{21}+h_{22}|^2+\sigma^2} \qquad (16)$$

The achievable sum rate at UE-2 is expressed as:

$$R_3 = log_2(1 + SINR_{22}) \qquad (17)$$

Outage Probability

When the instantaneous signal to noise ratios of each UE reduces below the specified value, outage occurs. The scope or capacity of the system can be known from the outage probability, which measures the quality of service (QoS) of the user (Suprith & Ahmed,

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2022). The outage probability of users, UE-1 and UE-2, can be defined by (Li et al., 2019):

$$P_1^{out} = P(log(1 + r_{1\rightarrow 2}) < R_2 or\ log(1 + r_1) < R_1) = 1 - P(log(1 + r_{1\rightarrow 2}) \geq R_2) P(log(1 + r_1) \geq R_1) \quad (18)$$

$$P_2^{out} = P(log(1 + r_2) < R_2) \quad (19)$$

where $r_{1\rightarrow 2}$ is the information intended for UE-2 obtained by UE-1, and R_1, R_2 are the target rates of UE-1 and UE-2.

Bit Error Rate and Signal to Noise Ratio

Bit error rate (BER) is defined as the ratio of the number of received bits containing errors to the sum of transmitted bits of data stream for a given time (Abood and Hburi, 2022). The BER equation is mathematically expressed as in Panwar and Kumar (2012):

$$\text{BER} = \frac{\text{Received erroneous bits}}{\text{Total number of bits}} \quad (20)$$

On the other hand, signal to noise ratio (SNR) describes the power of signal to the power of noise in a wave, and represents the metric for comparing the desired signal strength to the background noise strength (Abood and Hburi, 2022). It is defined mathematically as:

$$\text{SNR} = \frac{\text{Signal power}}{\text{Noise power}} = \frac{P_S}{\sigma^2} \quad (21)$$

2.5 Simulation Parameters

In order to carry out the analysis of the performance of the multiple antenna NOMA system with multiple users' scenario, this section presents the simulation parameters taken from related work carried out by Son and Le Khoa (2021) with modification to include distances of users from the base station, path loss gain, and number of symbol. The definition and values of the parameters are shown in Table 1.

Table 1 Simulation parameters

Definition	Value
Average channel gain of UE-1	$g_1 = 1$
Average channel gain of UE-2	$g_2 = 0.5$
Power allocation coefficients	$\beta_1 = 0.25,\ \beta_2 = 0.75$
Transmission power of single antenna	$P_s = 1$
Channel state information (CSI)	Perfectly known at receiver (assumed)
Channel	Rayleigh fading
Distance of users from BS (meter)	$d_1 = 200$, $d_2 = 500$
Path loss exponent	$P_l = 4$
Number of symbol	10^6

III. RESULTS AND DISCUSSION

3.1 Signal Interference Cancellation Evaluation

Simulations were carried out first for MIMO-NOMA and then compared with MIMO-OMA using BPSK modulation scheme. Generally, the performance evaluation of the multiuser system was done using different data in a typical downlink MIMO-NOMA wireless communication. The simulation process was considered assuming the channel state information (CSI) of the Rayleigh fading channel is known at the receiver. Signal Interference Cancellation (SIC) evaluation for the users was first performed to ascertain the effective of this method to eliminate interference of the users' signals. The simulation was carried out assuming two users with data r_1 and r_2 respectively. The resulting graphs are shown in figure 4.

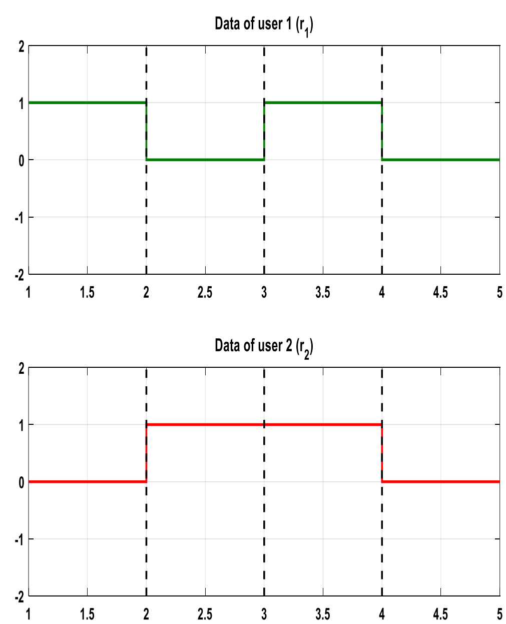

Figure 4a: Data of User 1 and User 2

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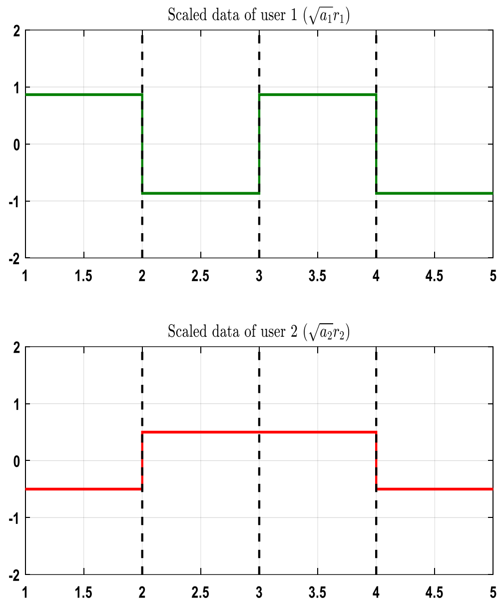

Figure 4b: Scale Data of User 1 and User 2

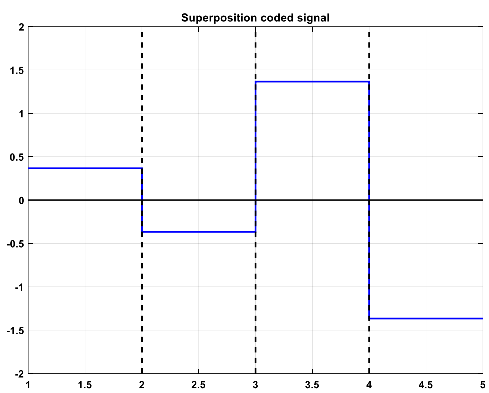

Figure 4c: Coded Signal Superposition

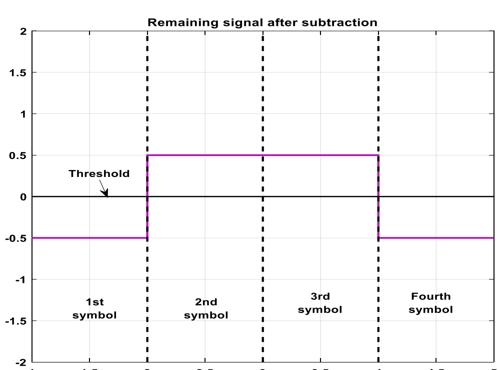

Figure 4d: Remaining Signal after subtraction

Figure 4a show the simulation curves of both users' signals r_1 and r_2 first modulated with BPSK modulation scheme. For the purpose of simulation in this work, r_1 and r_2 were assigned data set of 1010 and 0110, respectively. The resulting modulated signals were scaled by factor $\sqrt{\beta_1}r_1$ and $\sqrt{\beta_2}r_2$ as shown in figure 4b such that the amplitude of the modulated signal or symbol drops. The combination of both users' data resulted in a superposition coded signal as shown in figure 4c, which will then be multiplied by transmitting signal power P_s as in equation (3). With r_1 multiply by its corresponding power weight and subtracted from superposition coded signal. Thus, the resulting graph in figure 4d looks similar to that of scaled data of user 2 in figure 4b. Hence, by this approach, any interference from user 1 signal is cancelled by user 2 equipment. The same process holds for user 1 and vice versa.

3.2 MIMO-NOMA System

Simulation results are presented for multiuser MIMO-NOMA downlink system assuming two users UE-1 and UE-2 communicating with a base station (BS) simultaneously. The system was evaluated in this case for BER, achievable sum rates and outage probability.

BER Analysis

The simulation results obtained for MIMO-NOMA system considering two users such that UE-1 is a near user and UE-2 is taken as the far user is shown in figure 5 in terms of BER performance curves assuming the distances of the users to be 200m and 500m. Further simulation was conducted by varying distance of UE-2 from 500 to 300m and the BER performance is shown in figure 6.

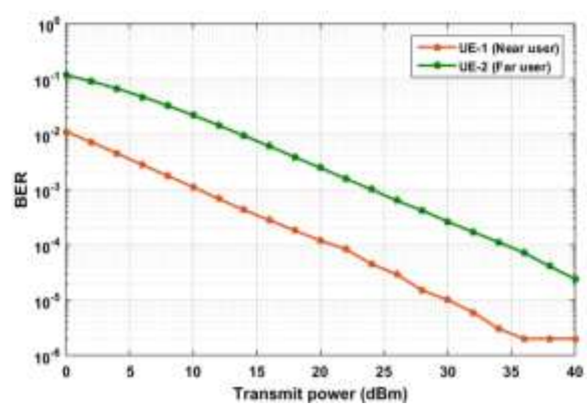

Figure 5: BER Performance of Two Users in MIMO-NOMA System (d_2 = 500m)

The BER simulation curves of the multiuser MIMO-NOMA system assuming two users communicating to a (BS) at different distances d_1 = 200m and d_2 = 500m presented in figure 5.

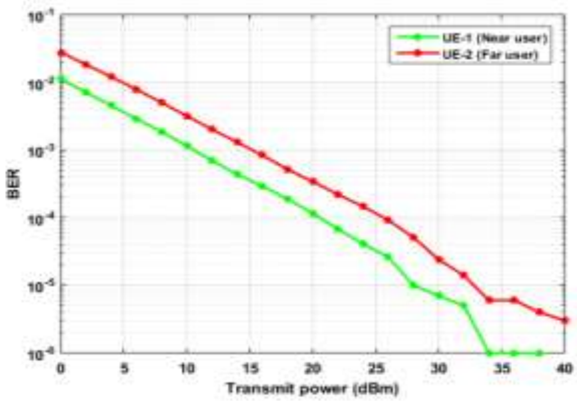

Figure 6: BER Performance of Two Users in MIMO-NOMA System (d_2 = 300m)

The numerical analysis of each simulation curve of BER against transmit power for UE-1 and UE-2 shows that the near user has better performance than the far user even though user 2 was assigned the higher power allocation. This is because the UE-2 signal (or symbol) depends on UE-1 decoding. Further analysis carried out on the BER performance of the system by reducing the distance of the far user (UE-2) to 300m revealed that the BER performances of the users are improved. The reason for the change in the distance of UE-2 affecting the BER of both users can be attributed to the fact that the information intended for UE-2 is obtained by UE-1 as established in equation (17). That means that the information (Bits) sent to UE-2 is influenced by UE-1. It should be noted that the power allocation coefficients for the users remain the same.

Achievable Sum Rates

The simulation result of MIMO-NOMA downlink system is presented with respite to the achievable sum rates performance metric as shown in figure 7. Also, the resulting curves in terms of achievable sum rates for multiuser MIMO-NOMA downlink system assuming two users UE-1 and UE-2 communicating with BS at different distance, but the individual power allocation factor remains the same as shown in figures 8 and 9 for d_2 = 500m and d_2 = 300m respectively.

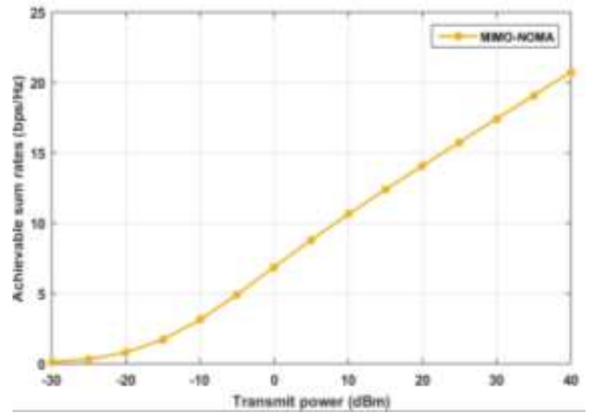

Figure 7: Achievable Sum Rate Plots of MIMO-NOMA Downlink System

Figure 7 is the achievable sum rate of MIMO-NOMA system, but not individual achievable sum rate. The simulation curve shows that the achievable sum rate increases as the transmit power (in dBm) increases. Thus, the achievable sum rate of the multiuser MIMO-NOMA downlink system is 20.75 bps/Hz at transmit power of 40dBm.

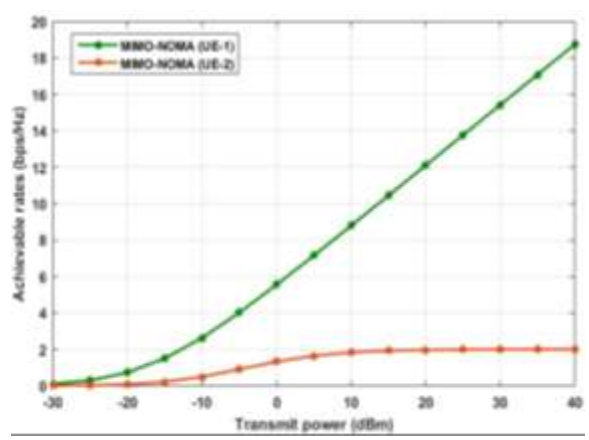

Figure 8: Achievable Sum Rate Plots of Individual User (d_2 = 500m)

Figure 8 shows the individual achievable sum rates of the carriers in the network when d_2 = 500m. Similar to the achievable sum rates of the MIMO-NOMA system, the curves for the users increases as the transmit power increases. It can be seen that the near user (UE-1) has better achievable sum rate than the far user (UE-2). Simulation results indicated that each of UE-1 and UE-2 has achievable sum rates of 18.75 bps/Hz and 1.999 bps/Hz at transmit power of 40 dBm respectively.

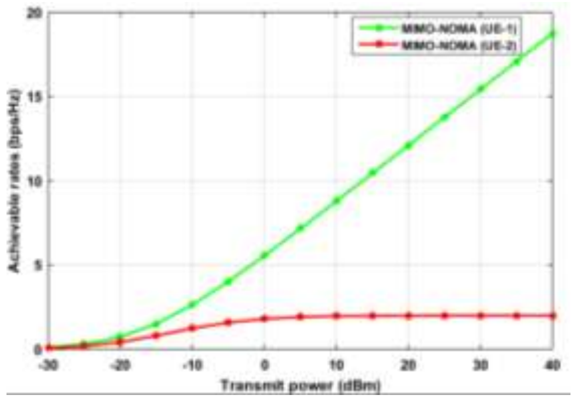

Figure 9: Achievable Sum Rate Plots of Individual User (d_2 = 300m)

The achievable sum rates for d_2 = 300m is represented in figure 9. In this case, the simulation result indicated the achievable sum rate for UE-1 is 18.75 bps/Hz and 2 bps/Hz at transmit power of 40dBm respectively. Thus, from the achievable sum rate performances represented in figures 8 and 9, it is obvious making the distance of far user closer to the first user did not cause any significant increase or change in the achievable sum rate of UE-2. This shows that distance of user does not influence achievable sum rate performance.

Outage Probability

The performance of the multiuser MIMO-NOMA downlink system is presented in terms of outage probability as can be seen in figure 10. In this case, UE-1 and UE-2 are taken to be communicating with BS at different distance.

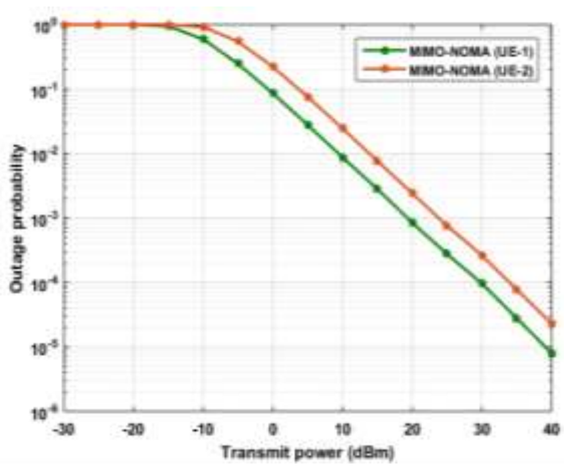

Figure 10: Outage Probability of Individual User

The simulation curves shown in figure 10 are the outage probability performances of two different users in MIMO-NOMA downlink system. The results showed that the UE-1 has an outage probability of 8e-6 while that of UE-2 is 2.3e-5 at transmit power of 40dBm respectively. Since the outage probability is used as a measure of the quality of service (QoS) of service of user, it means UE-1 has better QoS.

3.3 Performance Comparison

This subsection covers the results obtained from the simulation analyses carried out to examine the performance of the multiuser MIMO-NOMA downlink system developed against conventional multiuser MIMO-OMA downlink system. The comparison was done for achievable sum rate for MIMO-NOMA and MIMO-OMA downlink systems shown in figure 11. Further comparison was done for individual achievable Sum rate and the Outage probability between two near users in MIMO-NOMA and MIMO-OMA as shown in figures 11 and 12, respectively.

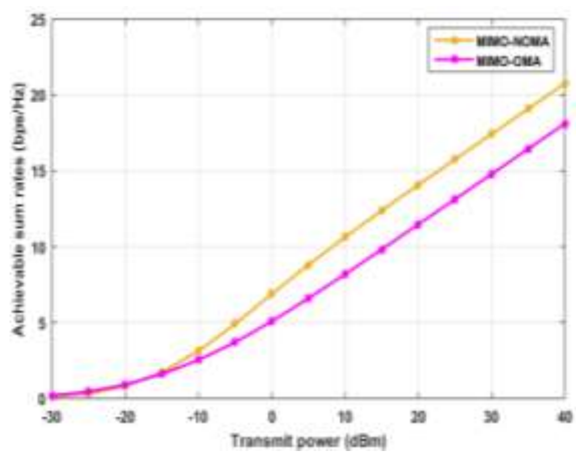

Figure 11: Comparison of Achievable Sum Rates

The achievable sum rates are compared as shown figure 11. From the simulation curves, it was observed that the MIMO-NOMA downlink system offered an Achievable Sum Rate of 20.75 bps/Hz while the MIMO-OMA downlink system yielded 18.11 bps/Hz.

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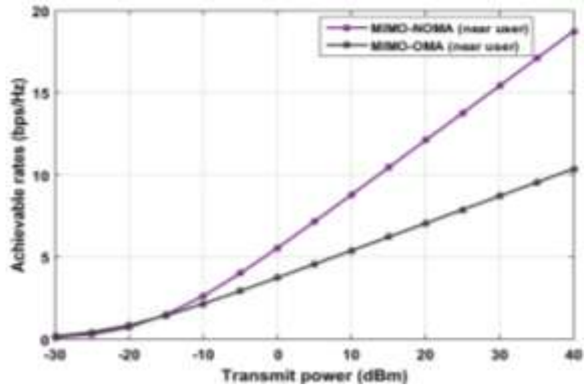

Figure 12: Individual Achievable Sum Rates of MIMO-NOMA and MIMO-OMA

The achievable sum rates simulation curves shown in figure 13 are for two near users in MIMO-NOMA and MIMO-OMA downlink systems. The results revealed that the near user in MIMO-NOMA has an achievable sum rate of 18.75 bps/Hz while that of the near user in MIMO-OMA is 10.37 bps/Hz.

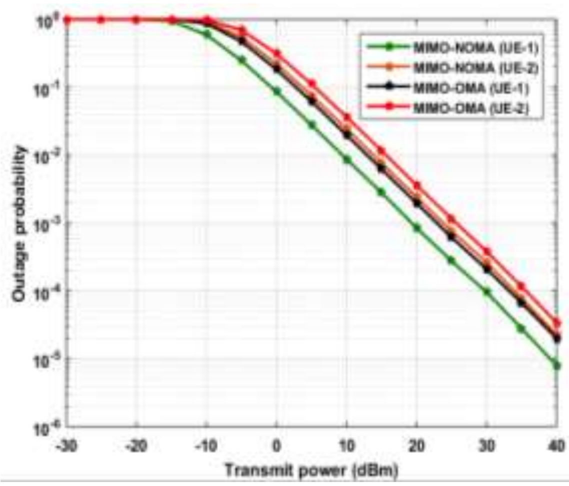

Figure 13: Individual Outage Probabilities of MIMO-NOMA and MIMO-OMA Users

The outage probability curves of multiuser MIMO-NOMA and MIMO-OMA downlink systems are shown in figure 13. The essence of this comparison considering both near user (UE-1) and far user (UE-2) is because the QoS of NOMA is a measure of outage probability. Thus as can be seen in figure 4.10, the near user (UE-1) in MIMO-NOMA outperformed the near user in MIMO-OMA with outage probability of 8e-6 against 2e-5. On the other hand, the far user (UE-2) in MIMO-NOMA yielded better performance than far user in MIMO-OMA with outage probability of 2.3e-5 against 3.4e-5 for far user (UE-2) in MIMO-OMA.

IV. CONCLUSION

The performance analysis of multiple antenna non-orthogonal multiple access (NOMA) system in multiuser scenario has been carried out via simulations in MATLAB. The simulations were evaluated with respite to three performance metrics namely, BER against transmit power (dBm), achievable sum rates and outage probability. The results from the simulations conducted as shown in figure 4.2, revealed that the near user (UE-1) has better performance than the far user (UE-2). Further simulation by reducing the distance of the UE-2 showed that the BER of both users increase as the distance between them decreases. This should be expected because the information (Bits) sent to UE-2 is influenced by UE-1. The achievable sum rate of MIMO-NOMA system revealed that achievable sum rate increases exponentially as the transmit power increases such that the outcome was a value of 20.75 bps/Hz at transmit power of 40dBm. Further simulation of achievable sum rates of UE-1 and UE-2 indicated that the near user has a value of 18.75 bps/Hz as against 1.999 bps/Hz for the far user. This performance was achieved when the distance of the UE-2 equal to 500m. With the distance of UE-2 equal to 300m, the achievable sum rates of UE-1 and UE-2 were 18.75 bps/Hz and 2 bps/Hz respectively. Hence, with these results for different distances of UE-2 from the BS revealed that distance of user does not significantly influence achievable sum rate performance. For the outage probability, UE-1 has 8e-6 while that of UE-2 was 2.3e-5 at transmit power of 40dBm respectively. Since the outage probability is used as a measure of the quality of service (QoS) of user, it means UE-1 has better QoS. In addition, performance of the MIMO-NOMA was compared with MIMO-OMA. Simulation results revealed that the MIMO-NOMA downlink system outperformed the MIMO-OMA in terms of achievable sum rate. In the case of comparison of users in both MIMO-NOMA and MIMO-OMA, the result of the analysis revealed that the user in MIMO-NOMA yielded better achievable sum rate than the user in MIMO-OMA. For outage probability, the results showed that the users in MIMO-NOMA have better performances than their corresponding users in MIMO-OMA.

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