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| RESEARCH ARTICLE

Implementation of SIC Algorithms in the 5G DL

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| ABSTRACT
In this paper, we have implemented successive interference cancellation algorithms in the 5G downlink. We have calculated the maximum throughput in Frequency Division Duplex (FDD) mode in the downlink, where we have obtained a value equal to 836932 b/ms. The transmitter is of type Multiple Input Multiple Output (MIMO) with eight transmitting and receiving antennas. Each antenna among eight transmits simultaneously a data rate of 104616 b/ms that contains the binary messages of the three users. In this case, the cyclic redundancy check CRC is negligible, the Block error rate BLER is null, the MIMO category is the spatial diversity. The technology used for this is called Non-Orthogonal Multiple Access (NOMA) with a Quadrature Phase Shift Keying (QPSK) modulation. The transmission is done in a Rayleigh fading channel with the presence of obstacles. The MIMO Successive Interference Cancellation (SIC) receiver with two transmitting and receiving antennas recovers its binary message without errors for certain values of transmission power such as 50 dBm, with 0.054485% errors when the transmitted power is 20 dBm and with 0.00286763% errors for a transmitted power of 32 dBm(in the case of user 1) as well as with 0.0114705% errors when the transmitted power is 20 dBm also with 0.00286763% errors for a power of 24 dBm(in the case of user2) by applying the steps involved in SIC.

| KEYWORDS

5G, NOMA, QPSK, TBS, LDPC, SIC, capacity

| ARTICLE INFORMATION

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1. Introduction

The 5G is a technology that offers high throughput through Increased bandwidth numerology compared to 4G and also carrier aggregation technology. The duration of a subframe is 1ms[1]; the 4G site can transmit the pdsch without CRC bits and with zero BLER (uncoded transmission)[2], even the experts who implemented these SIC algorithms have not used the precoding[3]. The rayleigh fading channel is a channel model where there is no direct path between the transmitter and the receiver[4]. The transmission of the same signal is simultaneous on different antennas. The signals received on each of the reception antennas are then phased back and summed in a coherent way. A version uses the signal from only one antenna, the one that receives the best signal at a given moment[5]. According to IMT International Mobile Telecommunications for 2020 and beyond, 5G technology requires three main scenarios such as enhanced mobile broadband(eMBB), massive machine type communication(mMTC), ultra-reliable and low latency communication(URLLC). Non-orthogonal Multiple Access(NOMA)is an emerging technology for the fifth generation(5G)wireless networks which can address the requirements of 5G set in IMT 2020 as follows: NOMA offers higher spectral efficiency due to the use of multiple users on the same frequency resource. It provides massive connectivity by serving more uses at the same time. It provides lower latency(1 ms)due to simultaneous transmission all the time rather than a dedicated scheduled time slot.

The problem to solve is to find successive interference cancellation algorithms in the 5G downlink that will be used in reception at the level of both users with lower power in order to cancel the inter-user interference in order to recover the binary message with a zero or low BER and an algorithm at the level of far user with greater power that will be used to decode the estimated signal. Let us take a look at the SIC algorithm. SIC is an iterative algorithm where data is decoded in the order of decreasing power levels. That is, data corresponding to the user who is given the highest power is decoded first, then the data of the user who is given the next highest power is decoded. This process repeats till we have decoded all user's data[6]. For our simple case of 3 users NOMA system, we set a_1,a_2 and a_3 the power allocation coefficients of users U1, U2 and U3, respectively, of sum equal to 1, the power allocation coefficients must be ordered as: a_1 greater than a_2 greater than a_3, the steps that will be involved in SIC are described as follows[7]: At U1: the estimated signal eq_1 will be decoded directly to get the estimate of U1's data. At U2: The estimated signal eq_2 will be decoded directly to get the estimate of U1's data. The estimate of U1's data will be remodulated and will be multiplied by its corresponding weight a_1 and will be substracted from eq_2. The resulting signal rem_2 will be decoded as before to get the estimate of U2's data. At U3: The estimated signal eq_3 will be decoded directly to get the estimate of U1's data. The estimate of U1's data will be remodulated and will be multiplied by its corresponding weight a_1 and will be substracted from eq_3. The resulting signal rem_{31} will be decoded to get the estimate of U2's data. The estimate of U2's data will be remodulated and will be multiplied by its corresponding weight. a_2 and will be subtracted from the resulting signal m_{31} . The resulting signal rem_3 will be decoded to get the estimate of U3's data. In this article entitled BER of 3 user Non-orthogonal multiple access (NOMA) with QPSK modulation[3], the author has studied a SISO system. We have studied an 8×2 system. In our case, the MIMO category is the spatial diversity that will maximizes the SINR in reception, so the average capacity for individual users will be better than that calculated in SISO. The rest of the paper is organized as follows: Section 2 gives the throughput calculation formula in 5G DL and the concept of 5G channel coding, plus an example of throughput calculation; in section 3, we focus on the power allocation method in NOMA and on SIC algorithms, in section 4, we discuss the results of our MATLAB programming, In section 5, we conclude with a summary.

2. 5G New Radio (NR) throughput and Power allocation in NOMA

According to 3GPP TS 38.306, the approximate maximum data transfer rate is calculated in Mbps using the following equation[8].

$$T = 10^{-6} \times \sum_{j=1}^{J} \left\{ \begin{array}{l} \left(v_{Layers}^{(j)} \times Q_m^{(j)} \times f^{(j)} \times R_{maxim} \right) \\ \times \left(\frac{N_{PRB}^{BW(j),u} \times 12}{T_s^u} \times \left(1 - OH^{(j)}\right) \right) \end{array} \right\} \quad (1)$$

This equation has different parameters, and the details of each one are as below: J is the number of aggregated components carriers in a band or band combination. In 5G NR, the maximum number of CC is 16 components carriers, $v_L^{(j)}$ represents the maximum number of MIMO layers. In MIMO, the number of layers is very similar to the term stream and also, the number of the layer can't be more than the antennas number. $v_L^{(j)}$ (maximum value) = 8 in DL and 4 in UL, $f^{(j)}$ The scaling factor is used for Medium and High mobility and should be configured per Carrier. It can take the following values: 0.4, 0.75, 0.8 and 1, $N_{PRB}^{BW(j),u}$ represents the number of resource block pairs allocated PRBs per bandwidth per subcarrier spacing SCS, the maximum number of allocated PRBs per BW per SCS is specified in the table1:

TABLE 1
MAXIMUM TRANSMISSION BANDWIDTH CONFIGURATION

SCS, KHZ	5 MHZ	20 MHZ	25 MHZ	80 MHZ	100 MHZ
15	25	106	133	N/A	N/A
30	11	51	65	217	273
60	N/A	24	31	107	135

$Q_m^{(j)}$represents the maximum modulation order per Modulation Coding Scheme MCS. 5G supports different modulation types QPSK(2 bits per symbol), 16 Quadrature Amplitude Modulation QAM(4 bits per symbol), 64QAM(6 bits per symbol) and 256QAM(8 bits per symbol), R_{maxim} Value depends on the type of coding, and for LDPC code maximum number is 948/1024 = 0.92578128(from 3GPP MCS index table), T_s^u represents the average Orthogonal Frequency Division Multiplexing (OFDM) symbol duration in a subframe for u(i) value for normal cyclic prefix, $u(i) = 0{,}1{,}2{,}3{,}4{,}5$. $OH^{(j)}$ represents the overhead for control channels. It can take the following values: Its value is 0.14 for FR1(FR1) for downlink, Its value is 0.18 for FR2(FR2) for downlink, Its value is 0.08 for FR1(FR1) for uplink, Its value is 0.10 for FR2(FR2) for uplink.

Let's assume that a network operator does have 100 MHz of spectrum in the 3.5 GHz range for 5G NR. In this case, the DL maximum throughput FDD will be calculated as below $j = 1$ as we have here one carrier component, $v_L^{(j)} = 8$ assuming 8 layer in DL, according to 38.214-Table 5.1.3.1-1, $MCS = 9$, $Q_m^{(j)} = 2$, $R_{maxim} = 0.6630859375$, $f^{(j)} = 1$ for FDD, BW: 100MHz FR1, $u = 1$ for subcarrier spacing 30 KHz, $N_{PRB}^{BW(j),u} = 273$, $T_s^u = \frac{10^{-3}}{14\times 2^u}$, $OH^{(j)} = 0.14$ for FR1 DL. DL Data Rate is equal to 836.932005 Mb/s.

Let us consider a wireless network consisting of three NOMA users, numbered U1, U2 and U3. Let a_1,a_2 and a_3 denote their respective power allocation coefficients such that:

$$a_1 + a_2 + a_3 = 1 \tag{2}$$

The power allocation coefficients must be ordered as follows: a_1 greater than a_2 greater than a_3. For simplicity, in our case, we are using fixed power allocation[3]. That is, we fixed the values of a_1,a_2 and a_3 irrespective of the channel conditions. There are better ways to optimize the power allocation coefficients dynamically based on the values of channel state information(CSI). There are a few different dynamic power allocation schemes, each trying to accomplish a specific goal. The goal could be maximizing the sum rate, maximizing the energy efficiency, etc., for example, a fair power allocation scheme whose goal is to provide user fairness. Our fair PA gives priority to the weak/far user. That is, the power allocation coefficients are calculated such that the far user's target rate is met. Only after meeting the target rate of the far user all the remaining available power is allocated to the near user. The capacity equations for NOMA far user and near user can be written as follows:

$$R_f = log_2\left(1 + \frac{a_f \times P \times |h_f|^2}{P \times a_n \times |hf|^2 + \sigma^2}\right) \tag{3}$$

$$R_n = log_2\left(1 + \frac{a_n \times P \times |h_n|^2}{\sigma^2}\right) \tag{4}$$

Where a_n is the power allocation coefficient for near users, a_f is the power allocation coefficient for far users, h_n is the Rayleigh fading coefficient for near users, h_f is the Rayleigh fading coefficient for the far user, P is the Total transmit power, σ^2 is the noise power.

$$a_n + a_f = 1 \tag{5}$$

Where $a_f > a_n$. Let R^* denote the target rate of far users. Our goal is to choose a_n and a_f such that R^f is greater than or equal to R^*. Let's set $R^f = R^*$. Let's denote[9]:

$$\xi = 2^{R^*} - 1 \tag{6}$$

ξ is the target SINR for the far user who has target rate R^*. We get:

$$a_f = \frac{\xi \times \left(|h_f|^2 \times P + \sigma^2\right)}{|h_f|^2 \times P \times (1 + \xi)} \tag{7}$$

We don't want the power allocation coefficient for far user a_f to exceed 1. So, let's set a limit as

$$a_f = min\left(1, \frac{\xi \times \left(|h_f|^2 \times P + \sigma^2\right)}{|h_f|^2 \times P \times (1 + \xi)}\right) \tag{8}$$

We can easily calculate the power allocation coefficient for the near user a_n as,

$$a_n = 1 - a_f \tag{9}$$

3. Methodology

For our case, the 5G site is of type 8×8(8 receiving transmitting antenna), and the mobile user is of type 2×2(2 receiving transmitting antenna). Assuming we have a 3 users NOMA system with QPSK modulation. Let d_1,d_2 and d_3 denote their respective distances from the 5G site. Let a_1,a_2 and a_3 denote their respective power allocation coefficients. The power allocation coefficients must be ordered as follows: a_1 greater than a_2 greater than a_3. SIC algorithms are given in the form of mathematical equations that are presented below:

$$\begin{Bmatrix} h_{1k_{BSU1}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_1^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (10)$$

$$\begin{Bmatrix} h_{2k_{BSU1}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_1^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (11)$$

$$\begin{Bmatrix} h_{1k_{BSU2}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_2^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (12)$$

$$\begin{Bmatrix} h_{2k_{BSU2}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_2^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (13)$$

$$\begin{Bmatrix} h_{1k_{BSU3}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_3^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (14)$$

$$\begin{Bmatrix} h_{2k_{BSU3}} = \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right) \\ \times \sqrt{d_3^{-eta}} \times \frac{1}{\sqrt{2}} \end{Bmatrix} \quad (15)$$

Where $k = 1,2,3,4,5,6,7,8$. eta is the path loss exponent N is the number of bits to transmit. $h_{1k_{BSU1}}, h_{2k_{BSU1}}, h_{1k_{BSU2}}, h_{2k_{BSU2}}, h_{1k_{BSU3}}, h_{2k_{BSU3}}$ denote the Rayleigh fading coefficient between the user receiver antenna and base station transmitter antenna k.

$$No = -174 + 10log_{10}(BW) \quad (16)$$

Where No represents the noise power in dBm, BW represents the bandwidth in Hz. np represents the noise power in linear scale.

$$np = 10^{-3} \times 10^{\frac{No}{10}} \quad (17)$$

$$n_{uk} = \frac{\sqrt{np} \times \left(randn\left(\frac{N}{2},1\right) + 1i \times randn\left(\frac{N}{2},1\right)\right)}{\sqrt{2}} \quad (18)$$

n_{uk} represents the Additive White Gaussian Noise (AWGN) noise samples for the user, $uk = 11,12,21,22,31,32$. n_{11},n_{12},n_{21},n_{22},n_{31} and n_{32} have mean zero and variance np. x_u represents the message bits for user u, $u = 1,2,3$.

$$x_u = randi([0\ 1], N, 1) \quad (19)$$

We have to create the QPSKModulator and QPSKDemodulator objects as follows:

$$\begin{Bmatrix} QPSKmod = comm.QPSKModulator \\ ('BitInput', true) \end{Bmatrix} \quad (20)$$

$$\begin{Bmatrix} QPSKdemod = comm.QPSKDemodulator \\ ('BitOutput', true) \end{Bmatrix} \quad (21)$$

$$xmod_u = step(QPSKmod, x_u) \quad (22)$$

Where $xmod_u$ represents the result of modulating of binary bit stream x_u. x represents the NOMA transmit signal.

$$x = \sqrt{a_1} \times xmod_1 + \sqrt{a_2} \times xmod_2 + \sqrt{a_3} \times xmod_3 \quad (23)$$

$$h_{s(1)_{BSU1}} = \sum_{k=1}^{8} h_{1k_{BSU1}} \quad (24)$$

$$h_{s(2)_{BSU1}} = \sum_{k=1}^{8} h_{2k_{BSU1}} \quad (25)$$

$$h_{s(1)_{BSU2}} = \sum_{k=1}^{8} h_{1k_{BSU2}} \quad (26)$$

$$h_{s(2)_{BSU2}} = \sum_{k=1}^{8} h_{2k_{BSU2}} \quad (27)$$

$$h_{s(1)_{BSU3}} = \sum_{k=1}^{8} h_{1k_{BSU3}} \quad (28)$$

$$h_{s(2)_{BSU3}} = \sum_{k=1}^{8} h_{2k_{BSU3}} \quad (29)$$

The received signal for all three users U1, U2 and U3, is given by:

$$y_1 r_i = \sqrt{pt} \times x \times h_{s(i)_{BSU1}} + n_{1i} \quad (30)$$

$$y_2 r_i = \sqrt{pt} \times x \times h_{s(i)_{BSU2}} + n_{2i} \quad (31)$$

$$y_3 r_i = \sqrt{pt} \times x \times h_{s(i)_{BSU3}} + n_{3i} \quad (32)$$

Where pt represents the transmit power in watt, $i = 1,2$. SINR(Signal to interference and noise ratio) measures signal quality: the strength of the wanted signal quality: the strength of the wanted signal compared to the unwanted interference and noise. We calculate the SINR and the average SINR to determine the best received signal on the user's receiving antenna. the SINR formula is given below:

$$SINR_i = \frac{pt \times a_1 \times \left|h_{s(i)_{BSU1}}\right|^2}{\left(pt \times (a_2 + a_3) \times \left|h_{s(i)_{BSU1}}\right|^2 + np\right)} \quad (33)$$

$$SINR_k = \frac{pt \times a_1 \times \left|h_{s(k-2)_{BSU2}}\right|^2}{\left(pt \times (a_2 + a_3) \times \left|h_{s(k-2)_{BSU2}}\right|^2 + np\right)} \quad (34)$$

$$SINR_m = \frac{pt \times a_1 \times \left|h_{s(m-4)_{BSU3}}\right|^2}{\left(pt \times (a_2 + a_3) \times \left|h_{s(m-4)_{BSU3}}\right|^2 + np\right)} \quad (35)$$

$$SINR_j = \frac{pt \times a_2 \times \left|h_{s(j-6)_{BSU2}}\right|^2}{\left(pt \times a_3 \times \left|h_{s(j-6)_{BSU2}}\right|^2 + np\right)} \quad (36)$$

$$SNR_z = \frac{pt \times a_3 \times \left|h_{s(z-8)_{BSU3}}\right|^2}{np} \quad (37)$$

Where $i = 1,2$. $k = 3,4$. $m = 5,6$. $j = 7,8$, and the last index $z = 9,10$.

$$avgSINR_l = mean(SINR_l) \quad (38)$$

$$avgSNR_n = mean(SNR_n) \quad (39)$$

Where $l = 1,2,3,4,5,6,7,8$. $n = 9,10$. If we will obtain $avgSINR_1 > avgSINR_2$, $y_1 r_1$ will be the best received signal. If $avgSINR_8 > avgSINR_7$, $y_2 r_2$ will be the best received signal. If $avgSNR_9 > avgSNR_{10}$, $y_3 r_1$ will be the best received signal. suppose that $y_1 r_1$,$y_2 r_2$ and $y_3 r_1$ are the best signals received. The estimated signals are given by:

$$eq_i = \frac{y_i r_i}{h_{s(i)_{BSUi}}} \quad (40)$$
$$eq_k = \frac{y_k r_1}{h_{s(k-2)_{BSUk}}} \quad (41)$$

Where $i = 1,2$. $k = 3$. Lets do the processing at the receiver side of user1[3]: Directly demodulate eq_1 to get an estimate of x_1.

$$dec_1 = step(QPSKdemod, eq_1) \quad (42)$$

Moving on to user 2: Directly demodulate eq_2 to get the estimate of x_1.

$$dec_{12} = step(QPSKdemod, eq_2) \quad (43)$$

Remodulate the estimate of x_1 to convert it to the same form as in eq_2. So let's do that.

$$dec_{12_{remod}} = step(QPSKmod, dec_{12}) \quad (44)$$

Multiply $dec_{12_{remod}}$ by its corresponding weight and subtract it from the estimated signal.

$$rem_2 = eq_2 - \sqrt{pt \times a_1} \times dec_{12_{remod}} \quad (45)$$

rem_2 contains U2 and U3's data. Demodulate rem_2 to get an estimate of x_2.

$$dec_2 = step(QPSKdemod, rem_2) \quad (46)$$

Moving on to user 3: Directly demodulate eq_3 to get the estimate of x_1.

$$dec_{13} = step(QPSKdemod, eq_3) \quad (47)$$

Remodulate the estimate of x_1 to convert it to the same form as in eq_3. So let's do that.

$$dec_{13_{remod}} = step(QPSKmod, dec_{13}) \quad (48)$$

Multiply $dec_{13_{remod}}$ by its corresponding weight and subtract it from the estimated signal.

$$rem_{31} = eq_3 - \sqrt{pt \times a_1} \times dec_{13_{remod}} \quad (49)$$
$$dec_{23} = step(QPSKdemod, rem_{31}) \quad (50)$$
$$dec_{23_{remod}} = step(QPSKmod, dec_{23}) \quad (51)$$
$$rem_3 = rem_{31} - \sqrt{pt \times a_2} \times dec_{23_{remod}} \quad (52)$$
$$dec_3 = step(QPSKdemod, rem3) \quad (53)$$

The achievable capacity and the average achievable capacity for individual user are given by:

$$R_1 = log_2(1 + SINR_1) \quad (54)$$
$$R_2 = log_2(1 + SINR_8) \quad (55)$$
$$R_3 = log_2(1 + SNR_9) \quad (56)$$
$$R_{i_{avg}} = mean(R_i) \quad (57)$$

Where $i = 1,2,3$. The bit error rate BER is the ratio between the number of bits incorrectly received and the total number of bits transmitted through a communication channel. BER1, BER2 and BER3 are given by the following expressions:

$$BER_i = \frac{biterr(dec_i, x_i)}{N} \quad (58)$$

Where $i = 1,2,3$. Figure1 shows the successive interference cancellation decoding procedure.

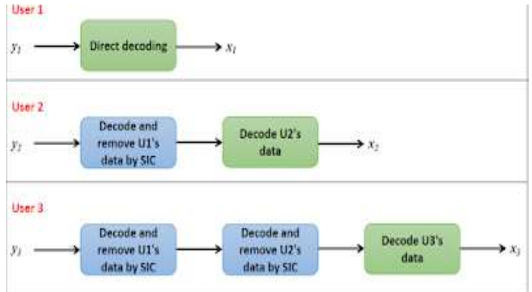

Fig. 1 SIC Decoding procedure

Table 2 compares NOMA with orthogonal multiple access OMA. TDMA stands for Time-Division Multiple Access.

TABLE 2
COMPARISON OF OMA AND NOMA

NOMA	OMA
Increased complexity of receivers	Simpler receiver detection
Higher spectral efficiency	Lower spectral efficiency
Higher connection density	Limited number of users
Enhanced user fairness	Unfairness for users
Lower Latency: 1ms	Latency: 1.73 ms for TDMA for serve 3 users
Latency reduction: 42.23 %	-

4. Results and Discussion

For a MIMO 8×8 5G site and three MIMO 2×2 users, U1, U2 and U3. For $BW = 10^6 Hz$, $eta = 4$. For $a_1 = 0.8$, $a_2 = 0.15$ and $a_3 = 0.05$. For $d_1 = 500\ m$, $d_2 = 200\ m$ and $d_3 = 70\ m$. The transmission in DL of a throughput equal to 836932 b/ms for a number of MIMO layers equal to 8 is done as follows: each antenna among eight antennas transmits a TBS equal to 104616 b/ms (CRC is negligible), where the number of bits allocated to each user is equal to 34872 bits. The results are obtained for different transmission powers using MATLAB. These values are 20 dBm:2 dBm:50 dBm.

Figure 2 shows that user 1 has received its binary message with a BER estimated by 0.054485% when the transmission power is 20 dBm. That is to say; there are 19 bits that were received erroneously among 34872 bits sent to this user, with a BER of 0.00286763% (0.9999999336 erroneous bits) when the transmission power is 32 dBm and has recovered its binary message with a zero BER when the transmission power exceeds 32 dBm. It also shows that user 2 has received its binary message with a BER equal to 0.0114705% when the transmission power equal to 20 dBm; therefore, 3.99999276 erroneous bits in reception for transmission power of 24 dBm; User 2 has received its data of 34872 bits with 0.9999999336 erroneous bits, beyond 24 dBm, the latter has received the same message that was allocated to him without errors. User 3 has received the same message that was assigned to him whatever the value of the transmitted power. These good results are obtained because the QPSK is a more robust modulation, there is no interference between symbols, and the received signal by user3 (for example) will be multiplied by $1/\left(h_{11_{BSU_3}} + h_{12_{BSU_3}} + h_{13_{BSU_3}} + h_{14_{BSU_3}} + h_{15_{BSU_3}} + h_{16_{BSU_3}} + h_{17_{BSU_3}} + h_{18_{BSU_3}}\right)$.

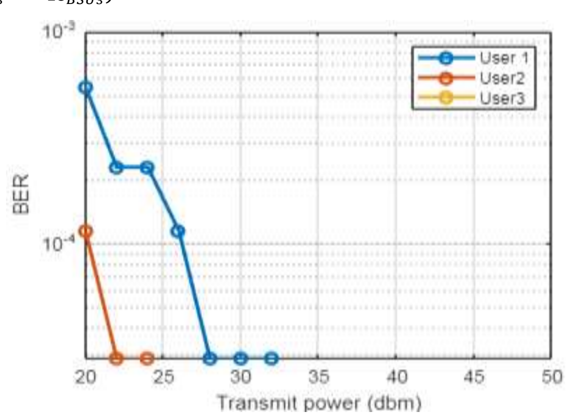

Fig. 2 Bit Error Rate

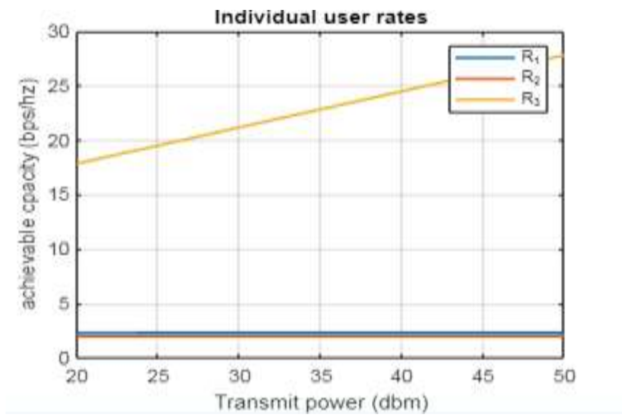

Fig. 3 Average Capacity

Figure 3 shows the average capacity achieved in b/s/Hz for each user for different transmission power values. The average capacity for user 1 and user 2 is almost constant; it will increase very slowly with the increase of the transmitted power due to interference experienced by these both users. The average capacity for user 3 will increase for different transmission powers until reaching the maximum value of 27.8045 b/s/Hz for a transmission power equal to 50 dBm.

5. Conclusion

The allocation of PRBs in 5G DL is done every 1 ms. The 5G MIMO site emits a throughput in b/ms; each site antenna emits symbols. The spatial diversity allows an increase in the SINR and SNR. As the SINR increases, the capacity at the receiver in b/s/Hz increases. In our work, we have studied NOMA for the case of three users, but generally, there are more than three users in the cell who are connected to the site. NOMA uses power domain multiplexing of users sharing the same time and frequency resources. The rayleigh fading channel is a model of the transmission channel with an existence of obstacles between the transmitter and the receiver. The BER results show that the three users have received their binary messages sometimes without errors and others with low BER because the QPSK is very robust. In addition, the factor multiplied by the received signal will lead to very positive results. For a given transmission power, the achieved rate(spectral efficiency) in b/s/Hz at user 3 is greater than the achieved rate at user 1 and at user 2 because the average of SNR_9 is greater than the average of $SINR_1$ as well as greater than the average of $SINR_8$. The proposed SIC algorithms will make it possible to cancel the interference and to decode the data of each user. Therefore, it will be necessary to have user equipment with a SIC receiver.

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