Research Article

A New Cooperative and Distributed Antenna Structure in Massive MIMO-NOMA Based on mmWave Transmission Scheme

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In this paper, we propose a new massive multiple-input multiple-output (MIMO) nonorthogonal multiple access (NOMA) system with a cooperative and distributed antenna structure based on a millimeter-wave (mmWave) transmission system. We proposed this method to obtain high energy efficiency (EE) and spectrum efficiency (SE) by using the mmWave transmission scheme. In the proposed system, the user selects a few nearby base stations (BS) to create a virtual cell to own the serving BS antenna set. We concentrate on the mmWave massive MIMO-NOMA scheme. In this scheme, a large number of BS antennas and users by uniform distributions (UD) are considered in a specific area. Also, we combine our proposed method by interleaving division multiple access (IDMA) and utilize the IDMA benefits for high-rate applications. The proposed transmission scheme significantly improves the performance output in terms of SE, EE, sum rate, and log sum rate, according to our simulation results.

1. Introduction

1.1. A. Motivation. The next or fifth-generation (5G) mobile telecommunications system will interpenetrate all aspects of future life and connect everything through a wireless communication network. Researchers are proposed several serious challenges to 5G such as low latency, massive connectivity, high data rate, and more security [1–3]. These connected devices will form a 5G-Internet of Things (IoT) network, which is referred to as the internet of everything and everyone. Mass-connected equipment and even faster transmission rates are the driving forces of 5G in industry and academia. 5G devices in IoT can operate efficiently by meeting the following conditions: massive connectivity and low latency [4].

Countless technologies have been presented in recent years to meet these challenges. Recently, non-orthogonal multiple access (NOMA) techniques have been introduced to satisfy massive connectivity requirement of the 5G of wireless communication systems [5, 6], where is a method of serving multiple users from a single resource, such as power, code, or other domains [7].

At the receiver, multiuser successive interference cancellation (SIC), and at the transmitter, a superposition coding is

used in NOMA technologies. So, the receiver can detect their own desired signal from the multiplexed signals. NOMA can embed more users on the same frequency bands compared to orthogonal multiple access (OMA) and so outperformed in terms of massive connectivity, energy efficiency (EE), and spectrum efficiency (SE).

1.2. B. Related Works. NOMA is achievable by interleaving division multiple access (IDMA) [8], and direct-sequence code division multiple access (DS-CDMA) [9] techniques. For multiple access, DC-CDMA used the specific spreading sequences. Spreading sequences afford rate loss, which is inconvenient for high-rate applications. IDMA solves this issue by using complex interleaving in multiple access, that prevents rate loss [10]. So, IDMA is appropriate for high-rate applications. Another technology offered for use in the 5G is MIMO technology. Combining MIMO and NOMA technology in the 5G can improve system capacity, where the system capacity is one of the most proposed challenges in 5G. Also, this combination can improve SE in the system [11, 12]. Authors in [13] extended MIMO and NOMA combining for multicell systems. Extending NOMA to multicellularity causes intercellular interference at the border of cellular networks, that reduces the quality of service (QoS)

for user placed in the edge of the cells. Reducing QoS in edge cell destroys user fairness in the system. To provide abundant spectral diversity, massive MIMO is proposed in [14].

In massive MIMO technology, the number of antennas involved at the BS and users is very large. One of the important practical challenges in massive MIMO is the best utilization of this diversity at a low cost. Also, one of the most important parts in the implementation of massive MIMO is having channel status information (CSI) in the BS [15, 16]. So, the CSI error can have a very important effect on the massive MIMO performance. Factors affecting CSI included radio frequency (RF) calibration error, channel variation, and channel estimation error.

The millimeter-wave (mmWave) technology is also another emerging technology in the 5G of wireless communications, which, because of its high bandwidth, can improve SE, and hence increase the achievable capacity and the rate of the system. The mmWave refers to the 30~300 GHz frequency band. High frequency and short propagation distance cause different propagation characteristics to be between mmWave and existing macrowaves. Therefore, many studies have been done on propagation characteristics and channel models in a mmWave transmission scheme [17–21].

In recent years, the mmWave-NOMA has been received much attention. The system performance analysis of the mmWave-NOMA transmission scheme is introduced in [22, 23]. To improve the system performance, the authors suggested a cooperative mmWave-NOMA multicast scheme in [24–26].

Also, by considering the high directionality of the mmWave transmission scheme, the transmission scheme performance of mmWave-NOMA has been analyzed in [27]. In research carried out at [28] of the total sum rate, the capacity of the system and bit error rate (BER) in the systems integrated with two MIMO and NOMA technologies are measured, analyzed, and shown in the Rayleigh and the log-normal channel fading.

In [29], cooperative NOMA for mmWave vehicular networks at intersection roads is proposed. In this paper, the authors derived closed form outage probability expressions for cooperative NOMA and compared them with cooperative OMA. The coverage probability of mmWave cooperative NOMA relay selection schemes is proposed in [25] and is showed that closest-to-source and closest-to-destination relay selection perform closely and both outperform OMA. Also, in [27], the authors proposed a mmWave MIMO-NOMA transmission system and utilize one dominant path for the mmWave channel.

1.3. C. Contributions. In this paper, we present a novel mmWave transmission scheme with two massive MIMO and NOMA technologies to improve the EE and SE. We assume that the distance between our transmitters and receivers is relatively less than compared with the research carried out in [28]. In this method, we utilize a cooperative and distributed antenna structure. In the cooperative and distributed antenna, a few neighboring BS to create a virtual cell are chosen by the user. To reduce the system complexity, cellular networks are divided into several cells. In this

method, the users in each cell are served using a BS that is placed at the cell center. In the proposed distributed antennas method, the efficient utilization of space resources is provided compared to antenna arrays. Also, for high-rate applications, we utilize IDMA in the proposed cooperative and distributed massive MIMO-NOMA system based on the mmWave transmission system.

We can summarize the contribution of the paper as follows:

- (i) We utilize the virtual cooperative and distributed antenna downlink system in the massive MIMO-NOMA system based on the mmWave transmission structure
- (ii) Our proposed cooperative and distributed massive MIMO-NOMA based on the mmWave transmission scheme improves the performance of the system in terms of SE and EE as compared to previous works, according to simulation results
- (iii) We evaluate our proposed method in terms of sum rate and log sum rate. Also, show that the proposed cooperative and distributed massive MIMO-NOMA system based on mmWave transmission scheme improves system performance compared to other previous works
- (iv) We use IDMA in the massive MIMO-NOMA system according to the mmWave transmission scheme to improve system performance. Also, we apply IDMA in cooperative and distributed structures and analyze the system performance in terms of BER. Based on our simulation results, the proposed IDMA cooperative and distributed approach improve the performance of the system

2. System Model

In this section, a downlink virtual cell-based distributed antenna system (DAS) in the mmWave transmission scheme is considered. In our model, a BS with M number of omnidirectional antennas with unit radius in a circular area is considered, where the BS serves K users. Suppose each user is served independently of others using their own virtual cell, where multiple users are grouped jointly and together served using their virtual cells. The received signal is given in downlink by the user as

$$y = HWP_s + n, \quad (1)$$

where $s = [s_1, s_2, \dots, s_K]^T$ is the vector of the sent signal with dimensions $K \times 1$ for all K users, the power sent to all K users shows by $P = \text{diag}(p)$, where $p = [\sqrt{p_1}, \sqrt{p_2}, \dots, \sqrt{p_K}]$, $W = [w_1, w_2, \dots, w_K]$ is the precoding matrix with dimensions $N \times K$ for $k = 1, 2, \dots, K$, and $n \sim \text{CN}(0, 1)$ is the vector of complex additive white Gaussian noise (AWGN).

Considering the channel matrix $H = [h_1, h_2, \dots, h_K]^T$ with dimensions $K \times N$, where h_k with dimensions $N \times 1$ represents the vector of the space channel between the user

k and the BS, based on mmWave, h_k can be modeled as follows [30]:

$$h_k = \sqrt{M} \frac{\alpha_{k,L} a(\theta_{K,L})}{\sqrt{1 + d^{\alpha_L}}} + \sqrt{M}, \quad (2)$$

where a line-of-sight (LoS) path and a set of few non-LoS (NLoS) paths are combined to create the proposed mmWave channel. In [4], the complex path gain of the NLoS paths for user k is denoted by $\alpha_{K,NL}$ that follows the complex Gaussian distribution; the normalized direction of the NLoS paths for user k is denoted by $\theta_{k,NL}$. $\theta_{k,NL}$ follows the uniform distributions (UD) in $[-1, 1]$.

$\alpha_{k,L}$ shows the complex gain of the LoS path for user k and follows the complex Gaussian distribution. The normalized direction of the LoS path for user k is denoted $\theta_{K,L}$. $\theta_{K,L}$ follows the UD in $[-1, 1]$. The path loss exponents for the NLoS and LoS paths are represented by α_{NL} and α_L , respectively. The distances from the BS to user k and the number of NLoS paths are denoted by d_k and L , respectively.

The array steering vector $a(\theta) \in \mathbb{C}^{N \times 1}$ for the uniform linear array (ULA) antenna [31] can be interpreted as follows:

$$a(\theta) = \frac{1}{\sqrt{M}} \left[e^{-j2\pi n\theta} \right]_{n \in J(M)}, \quad (3)$$

where $J(M) = \{i - (M-1)/2, \text{ for } i = 0, 1, 2, \dots, M-1\}$ is a symmetric set of indexes located around zero. The $a(\theta)$ in equation (4) has unit norm; therefore, the normalization factor $\sqrt{M}$ is contained in equation (2). The $\theta = d/\lambda$ represented the spatial direction, where the signal wavelength, the physical direction satisfying, and the antenna spacing are represented via λ , $\theta(-\pi/2 \leq \theta \leq \pi/2)$, and d ($d = \lambda/2$), respectively.

2.1. Cooperative and Distributive. We use the cooperative and distributive structure to connect users to multiple antennas in our coverage area, where each user may be covered by distributed antennas in their coverage area. Figure 1 illustrates our proposed cooperative and distributive structure. Figure 1 represents each mobile user to form its virtual cell selects some BS antennas based on the largest fading coefficients on a large scale. After creating virtual cells for each user, first, we assume each user is served using its virtual cell, which is independent of the others. Then, we expand our model and assume multiple users are clustered jointly and together represented by their virtual cells. By applying this structure in our work and using the user's subscription from other available antennas in the coverage area, our channel model is defined as $H_r = H(i, :)$ with dimension $M \times K$ which is $M \leq N$.

In the new channel model, with the proposed structure, the dimension of our channel matrix is reduced due to the use of some common antenna by users, improving SE and improving our system capacity. In this model, by decreasing the dimensions of the channel matrix, the number of radio frequencies used in the system decreases.

FIGURE 1: Cooperative and distributive structure.

By using the cooperative and distributed structure in our paper, the received signal by the user in a downlink can be written as follows:

$$y = H_r W P s + n, \quad (4)$$

where $H_r = [h_{r,1}, h_{r,2}, \dots, h_{r,K}]$ with dimension $M \times K$. Conversely, if the number of K user's increases, the size of virtual cell V needs to be decreased in order to prevent overlapping of various virtual cells. It should be noticed that the size of every virtual cell needs to be an integer and not smaller than 1. Hence, the size of optimal virtual cell V^* should be further refined as [32]

$$V^* = \left\lceil 0.2 \frac{L}{K} \right\rceil. \quad (5)$$

According to equation (5), the optimal virtual cell size V^* must be increased, when the number of L BS antennas compared to the number of K users is increased.

3. Performance Analysis

In this section, we analyze our proposed system model. The user rates are calculated as

$$r_k = \log_2 \left(1 + (N_0)^{-1} h_k h_k^H w_k p_k \right), \quad (6)$$

where $N_0 = 2\sigma^2$ and p_k are the transmission power of user k . The sum power and rate transmission of all users can be interpretation as follows:

$$P_{\text{sum}} = \sum_{k=1}^K p_k \text{ and } R_{\text{sum}} = \sum_{k=1}^K r_k. \quad (7)$$

In accordance with the abovementioned equation, the sum signal-to-noise ratio (SNR) is calculated as

$$\text{SNR}_{\text{sum}} = \frac{P_{\text{sum}}}{N_0}, \quad (8)$$

and we consider the two constraints for system design based on [28] as follows:

- (i) Sum power constraint (SPC): optimize r_k and p_k jointly to reach maximum R_{sum}
- (ii) Equal power constraint (EPC): we consider $p_k = P_{\text{sum}}/N_0$ for all users and optimize r_k to reach maximum R_{sum} . Also, we maximize the sum log rate ($\sum \log(r_k)$) to evaluate our proposed method under SPC

We optimize sum rate with the constraints on transmit power based on [33] and Algorithm 1 in [34], and based on [33, 34], the proposed method to solve the optimization problem in these references is optimal solution.

3.1. Zero Forcing. Zero forcing (ZF) attempts to invert the channel on the received sequence by approximating the inverse of the channel with a linear filter. The ZF is a method of precoding that is used in MIMO, and the multiple antenna transmitter can null multiuser interference signals. This method only considers the effect of the channel and eliminates the noise added to the data. If the transmitter knows the CSI perfectly and the number of users is large, the system capacity can be achieved by ZF-precoding. A ZF estimator is given by

$$\hat{s} = (H_r^H H_r)^{-1} H_r y. \quad (9)$$

Substituting equation (6) into equation (9), we have

$$\hat{s} = s + \zeta, \quad (10)$$

where $\zeta = (H_r^H H_r)^{-1} H_r n$. Now, $\hat{s}$ can be used to estimate s in the system. ZF prevents interference and provides angle gain in the system by dividing different users into different orthogonal subspaces.

3.2. Maximum Ratio Combining. Maximum ratio combining (MRC) is an estimation method. This method does not consider the effect of user interference, and its purpose is to maximize the ratio of transmitted signal power to noise power. The main advantage of this method is its simplicity, and its main disadvantage is not considering the effect of interference between users. MRC technology combines the signals of multiple antennas so that stronger signals are amplified, and weaker signals are attenuated, and in the symbol-by-symbol form, it can be defined as follow:

$$\hat{s}_k(j) = h_{r,k}^H \omega_k^{-1} p_k^H y(j), \quad (11)$$

where $h_{r,k}$ and $y(j)$ are the channel vector of j -th receiver in time j and the received signal, respectively. Substituting equation (6) into equation (11) in the symbol-by-symbol form,

$$\hat{s}_k(j) = \lambda_k s_k(j) + \zeta_k(j), \quad (12)$$

where $\lambda_k = p_k h_{r,k}^H h_{r,k}^H p_k = p_k \|h_{r,k}\|^2$ is a scalar, and $\zeta_k(j)$ can be defined by

$$\zeta_k(j) = \sum_{k' \neq k} h_{r,k}^H h_{r,k'}^H p_{k'}^H \omega_k^{-1} \omega_{k'} s_{k'}(j) + h_{r,k}^H \omega_k^{-1} p_k^H n_j(j), \quad (13)$$

and it is a noise plus interference ($s_{k'}(j)$) term. The cost of MRC is lower than ZF because MRC does not involve the matrix inversion. However, when K is large, interference is an especially problem for MRC.

3.3. MRC-SIC. MRC with successive interference cancellation (MRC-SIC) is a practical and appealing reception technique that retains the low cost of MRC and is utilized for the NOMA system owing to its low computational complexity. In the NOMA technique, users divided into two groups, and one user of each group pairs together. So, MRC-SIC utilized to detect the received signal in each user. User 1 decodes the signal of user 2, using SIC at the receiver, so that the estimated signal in user 1 can be presented as follows:

$$\hat{s}_1(j) = \lambda_k s_1(j) + \zeta_1(j), \quad (14)$$

$$\zeta_1(j) = h_{r,1}^H h_{r,2} s_2(j) + h_{r,1}^H n_1(j). \quad (15)$$

The achievable rate of user 1 according to equation (15) is

$$r_1 = \log_2 \left(1 + \frac{p_1 \|h_{r,1}\|^2}{p_2 \|h_{r,1}^H h_{r,2}\|^2 / \|h_{r,1}\|^2 + N_0} \right). \quad (16)$$

After successfully decoding $s_1(j)$, user 2 decodes its own signal using signal treatment of user 1 as noise. So, achievable rate of user 2 is as follows:

$$r_2 = \log_2 \left(1 + \frac{p_2 \|h_{r,2}\|^2}{N_0} \right). \quad (17)$$

Based on equations (16) and (17), the sum rate is

$$R_{\text{sum}} = r_1 + r_2. \quad (18)$$

In the equation (16), the correlation term $\|h_{r,1}^H h_{r,2}\|^2$ is the Angle gain which represents interference and when N_{BS} increases so its impact reduces. In this paper, we adjust p_1 and p_2 to minimize P_{sum} when r_1 and r_2 are fixed based on [33]. Also, we maximize R_{sum} when r_1 and r_2 are adjustable, and for better fairness, we maximize sum log rate based on Algorithm 1 in [34].

4. Simulation Result

In this section, our suggested model according to mmWave transmission scheme and cooperative structure is validated

by simulations. We consider the mmWave channel model in downlink and uplink. In this channel model, λ is equal to 0.0107 due to work at the frequency of 28 GHz. In this paper, the working frequency of 28 GHz from the frequency range of the mmWave is considered for better performance, including in environmental conditions such as rainfall and atmospheric air conditions in this study. For all users' channels, one LoS component and $L = 2$ NLoS components are considered. Table 1 shows the parameters related to the simulation that is under the coverage of our assumed system model.

To simulate Figure 2, we consider 64 antennas in the BS and included both fast and slow fading factors. In Figure 2, for a single-cell system, the sum rate capacity gain in the two states EPC and SPC is shown. In this figure, the high efficiency of sum power constraint is shown with increase the number of users L , whereas the number of users increases, and this has demonstrated its optimal performance, which demonstrates the significance of the power allocation technique in the system with a high user number. Comparing the simulation of the [28] with the simulation of the proposed method, these sum rates have been reduced for different users due to the use of a mmWave channel and the high path loss in mmWave frequencies. In the initial, the difference between SPC and EPC is small, but when K is very large, it becomes noticeable. This shows the significance of resource allocation when K is large.

In Figure 3, TDMA with equal length (TDMAEL) is utilized as reference. Also, we consider $N_{MT} = 1$ and $N_{BS} = 1$, and the other of the system configurations are the same as in Figure 2. In Figure 3, the NOMA and OMA technology for both EPC and SPC in a mmWave channel is shown. In this figure, for both EPC and SPC in the NOMA due to the use of the SIC, the average of sum rate increased using increasing the number of users in our model. In each cluster with multiple users, the near user uses of the SIC and first decodes the far users signal and then decodes his signal after eliminates the far user's signals of his received signal. By comparing the [28] with our proposed model in the mmWave channel model and cooperative structure, the achievable sum rates, along with SE and EE, have increased for both NOMA and OMA technologies.

In our simulation, we adopt OMA under resource allocation. We consider time division multiple access with flexible length (TDMA-FL) [35], to maximize sum rate in this mode. In TDMA-FL, the time slot lengths are optimized for different users. In Figure 4, the compression performance of the NOMA with different types of OMA has been shown in various SNR. This figure shows the system performance improvement in a mmWave channel with a cooperative structure. Also, it indicates that PC-SIC is slightly better than TDMA-EL and TDMA-FL. The curves of sum log rate are shown in Figure 5 and illustrate the same fairness in the OMA and NOMA schemes. Figure 6 illustrates the simulations of the system performance for both SPC and EPC for a variety of cases, including ZF, MRC, capacity, and MRC-SIC.

As Figure 2 shows, the sum rate has increased with increasing the number of users. From Figure 6, we can deduce the following results:

TABLE 1: Simulation parameters.

Parameters	Value
Working frequency	28 GHz
LoS component	1
$\alpha_{K,L}$	$CN(0, 1)$
$\theta_{K,L}$	Uniformly distributed $[-1/2, 1/2]$
NLoS component (L)	2
$\alpha_{K,NL}$	$CN(0, 10^{-1})$ for all $1 \leq NL \leq L$
$\theta_{K,NL}$	Uniformly distributed $[-1/2, 1/2]$
λ	0.0107
Loss factor	-3.76 dB
Log-normal fading deviation	8 dB

FIGURE 2: Sum rate capacity with SPC and EPC.

- (i) The MRC will work fine when the number of users under network coverage is small
- (ii) When the number of network users is small, ZF works close to capacity, but when increases the number of users, in SPC mode, ZF works well under capacity, but for the ZF under EPC mode, it loses its effectiveness
- (iii) MRC-SIC has a good performance for all K under both SPC and EPC
- (iv) MRC-SIC can potentially provide good fairness by optimizing the sum rate and power

4.1. Spectrum Efficiency. Figure 7 illustrates the SE in various SNR of the proposed mmWave and cooperative scheme. For this simulation, we consider the number of users is $K = 32$, and the number of iterations is set as 20 to solve the power

FIGURE 3: Near far gain using OMA and NOMA in SISO MAC under EEC. OMA is based on TDMA-FL and NOMA on SIC.

FIGURE 4: Average sum rate under SEC. The parameters of simulation are similar to Figure 2.

allocation optimization problem. As observed in the figure, our proposed mmWave cooperative method is better than the mmWave method, as well as the results of the proposed method in [28]. With the precision in Figure 7, it can be concluded that by increasing the SNR, the SE in the proposed mmWave cooperative scheme increases. In Figure 8, a comparison of performance in terms of SE in various numbers of users is illustrated.

FIGURE 5: Average sum log rate for OMA and NOMA. The parameters of simulation are selected similar to Figure 2.

FIGURE 6: Achievable sum rate of various approaches. The perfect CSIR is considered in the simulation. The parameters of simulation are selected similar to Figure 2. $SNR_{sum} = 5dB$.

The results of this simulation show that as the number of user's K increases, the performance gap between the mmWave scheme and the suggested mmWave and cooperative becomes larger. Also, the performance gap between the suggested scheme in [28] and the suggested mmWave and cooperative becomes larger too. Due to the number of users

FIGURE 7: Performance of SE for various SNR (the number of users is considered $K=32$).

FIGURE 8: Performance of SE for various the number of users (SNR=10 dB).

that has increased, the probability of choosing the same beam increases for different users.

4.2. Energy Efficiency. The ratio between power consumption and the achievable sum rate R_{sum} is defined as the EE and can be calculated as follows:

$$\epsilon = \frac{R_{sum}}{P + N_{RF}(P_{RF} + P_{SW}) + P_{BB}}, \quad (19)$$

where ϵ is the EE, and P_{BB} , P_{SW} , and P_{RF} are the baseband

FIGURE 9: Performance of EE for various SNR (the number of users is considered $K=32$).

power consumption, the power consumption of switch, and the power consumed by each RF chain, respectively. In our simulations, we consider $P_{BB} = 200mW$, $P_{RF} = 300mW$, and $P_{SW} = 5mW$.

Figure 9 shows the EE against SNR. In this figure, we use 32 users in our simulation. As can be shown, the suggested massive MIMO-NOMA based DAS in the mmWave transmission scheme can obtain higher EE than other schemes. Exclusively, the suggested method has about 17% EE improvement compared to an existing massive MIMO-NOMA in the mmWave transmission scheme, which benefits from the use of the cooperative and distributed structure. In addition, the proposed method improves the performance of the system in terms of EE compared to the massive MIMO-NOMA proposed in [36].

In Figure 10 presented the performance of EE in various methods. In this figure, SNR is given as 10 dB, and EE for the number of users is shown. We find that the suggested massive MIMO-NOMA based on DAS in the mmWave transmission scheme is higher than the massive MIMO-NOMA in the mmWave transmission scheme and massive MIMO-NOMA scheme in terms of EE.

4.3. IDMA. Now, we analyze our proposed cooperative and distributed mmWave massive MIMO-NOMA system based on IDMA. In this paper, we used the IDMA structure presented in reference [28]. Figure 11 presents the BER of the proposed method for versus SNR. In this figure, we consider IDMA with power allocation, Quadrature Phase Shift Keying (QPSK), and rate-1/2 repetition coding ratios 0.5:0.7:1.0. As see, the BER of the cooperative and distributed mmWave massive MIMO-NOMA system based on IDMA is better than the cooperative and distributed mmWave massive MIMO-NOMA system without IDMA. In Figure 12, we evaluated our proposed method for the

FIGURE 10: Performance of EE for various numbers of users (SNR = 10 dB).

FIGURE 11: IDMA systems with mmWave channels. MRC detection for $K=3$. Rate-1/3 turbo coding followed using rate half repetition coding is utilized for each user and QPSK modulation.

different number of users. We simulated the mmWave massive MIMO-NOMA by considering cooperative IDMA and noncooperative IDMA. The BER of the cooperative and distributed mmWave massive MIMO-NOMA system based on IDMA is better than the mmWave massive MIMO-NOMA system. As we expected, by increasing the number of users, the system performance is decreased.

FIGURE 12: Performance of BER for various numbers of users (SNR = 10 dB) in IDMA systems with mmWave channels.

5. Conclusions

In this paper, we investigated a novel massive MIMO-NOMA system based on DAS in the mmWave transmission scheme. In our proposed method, a few neighboring BS antennas were selected by each user. Also, we focused on a massive MIMO-MOMA on the mmWave transmission scheme which a large number of BS antennas and users distributed in a certain area uniformly. We evaluated our proposed method in sum rate and log sum rate and showed that the established performance analysis is confirmed by our simulation results. We showed that the suggested method could effectively improve EE and SE in the mmWave transmission scheme. Also, we utilized IDMA in the proposed cooperated and distributed mmWave massive MIMO-NOMA transmission system and analyzed the system performance in terms of BER.

Data Availability

There is no data availability.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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