A BIA-NOMA Scheme for Downlink of Two-Cell SISO Network

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Abstract. This paper studies a transmission problem based on a two-cell downlink SISO network. We propose a blind interference alignment transmission scheme based on TDMA by using interference alignment technology, which can improve the DoF of users. In order to improve the average achievable sum-rate of the system, we propose the BIA-NOMA scheme by combining NOMA with BIA technology. Theoretical analysis shows that the BIA-NOMA scheme can effectively improve the achievable rate of the center users, and its sum-rate is higher than that of the BIA-TDMA scheme. At the end of this paper, we give the simulation results to verify the performance of the scheme.

1. Introduction

Interference alignment (IA) is a signal multiplexing technology designed to allow users to share limited bandwidth resources. The difficulty of IA lies in its requirement of global and perfect channel state information. IA may not be achieved without channel state information at the transmitter (CSIT). But Jafar S. A. in 2010 [1] has shown that Blind Interference Alignment (BIA) could be implemented by constructing interference alignment blocks. He proposed in literature [2] that BIA can be realized by reconstructing antenna switching technology by using artificial antenna manipulation. He explained in detail how to realize reconfigurable antenna switching technology under the MISO broadcast channel based on K user M×1, and deduced the achievable rate of each user in the system [3].

Non-Orthogonal Multiple Access (NOMA) has been recognized as the spectrum efficient multiple access technologies for the next generation mobile communication network [4] and is also considered as one of the key technologies to improve the capacity of the system and reduce the latency of the fifth-generation mobile network [5]. The core idea of NOMA is to use power allocation to achieve multiple access, which means multiple users can code in the same time domain and frequency domain. The application of MIMO to NOMA can further improve the capacity of the system. In [6] and [7], the achievable rate of each user for MIMO-NOMA and MIMO-OMA are compared, which prove that MIMO-NOMA can improve the sum rate of the system. In [8], a multi-antenna base station uses NOMA to serve two multi-antenna users at the same time and propose the throughput maximization problem and two algorithms to solve the optimization problem.
BIA can increase the Degree of Freedom (DoF) of users, and NOMA can increase the capacity of the system. Another advantage of NOMA is that it does not require the accurate channel state information, which can be combined with BIA to improve system performance. At present, the literature about NOMA has always focused on SISO and MIMO system models of single-cell, MIMO network of multi-cell, etc., and combines with beamforming to achieve interference management. They study how to conduct power distribution and user pairing proves NOMA’s superiority in channel capacity, interrupt probability and other aspects. Therefore, based on the literature [3] and [6], this paper proposes a hybrid BIA-NOMA interference management scheme. This scheme combines the reconfigurable antenna switching technology with NOMA in a two-cell SISO downlink network system model. We divide the two users with a large difference in channel gain into a cluster, which explains how to use BIA and NOMA to implement the process of interference management. And we derive the achievable rate of each user and the average achievable sum-rate of this system.

The chapter arrangement of this article is as follows: the second section briefly introduces the whole system model constitution. The third section describes the signal modulation and demodulation scheme in detail. In the fourth section, we deduce the achievable rate of each user and the average achievable sum rate of the system and present the simulation results and analysis. The fifth section is the conclusion.

2. System model
We consider a two-cell SISO downlink network system, where each base station (BS) is configured with a transmission antenna to broadcast to multiple user equipment (UE). We have a reconfigurable antenna for marginal users and a normal antenna for center users. The center user with good channel gain and the edge user with poor channel gain in the cells are divided into a cluster. The following full text assumes that the marginal users of the cells are interfered with by two base stations at the same time, but the center users of the cell are not interfered with by the base stations. The whole system model is shown in Fig. 1 below. Square represents the cell edge user, randomly distributed in inner circle D1 with radius d1. The triangle represents the center user, which is randomly distributed in the outer ring D2 of radius (d3-d2), and the base station is also distributed in the outer ring D2.

![Fig. 1 System model of the two-cell downlink NOMA SISO network.](image)

In this article, i ∈ J = {1,2,...,I} means cell index, k ∈ K = {1,2,...,K} represents the cluster index of a cell, j ∈ J = {1,2,...,J} represents the user index, that is, j = 1 and j = 2 represents the marginal user and the center user of the cell, respectively. For simplicity, this paper assumes that i ={1,2}, k={1,2}, j={1,2}, and UE_{k,1} and UE_{k,2} represents the marginal users and the center users of the cell, and the signal x_{i,kj} represents the signal sent by the BS i to the user j of cell k.

Where y_{k,j}(t) represents the signal received by user UE_{k,j} in the time slot t, channel coefficient h_{k,j}(m(t)) represents the channel coefficient sent by base station n(n = 1,2) to user UE_{k,j} in mode m(t), x_{i,kj} represents the signal that the base station i sends to the user UE_{k,j}, and ρ is the power allocation.
coefficient, $1 - \rho \gg \rho, \xi$ represent the total transmitted power of the whole system, $z_{k,j}(t)$ stands for white Gaussian noise per unit, $z_{k,j}(t) \sim \mathcal{CN}(0,1)$.

3. Implementation scheme

3.1. BIA-TDMA Scheme

According to the above model, when we adopted the traditional BIA scheme[2], the base station was unable to send the signal to the center user. Traditional Time division multiple access technology (TDMA) can only be sent to one user in one time slot, which is inefficient. Therefore, we propose a BIA transmission scheme based on TDMA by using IA, which can improve the DoF of users. The signal transmission and demodulation process of the BIA-TDMA scheme is shown in Table 1.

Table 1. A hybrid BIA-TDMA scheme of the two cell SISO networks.

| Time slot | $Tx_1$ | $Tx_2$ | UE$_{1,1}$ | UE$_{1,2}$ | UE$_{2,1}$ | UE$_{2,2}$ |
|-----------|--------|--------|------------|------------|------------|------------|
| 1         | $x_{1,1,1} + x_{1,2,1}$ | $x_{2,1,1} + x_{2,2,1}$ | 1          | 1          |            |            |
| 2         | $x_{1,1,1}$       | $x_{2,1,1}$       | 2          | 1          |            |            |
| 3         | $x_{1,2,1}$       | $x_{2,2,1}$       | 1          | 2          |            |            |
| 4         | $x^{(1)}_{1,1,2}$ | $x^{(1)}_{2,2,2}$ |            |            |            |            |
| 5         | $x^{(2)}_{1,1,2}$ | $x^{(2)}_{2,2,2}$ |            |            |            |            |
| 6         | $x^{(3)}_{1,1,2}$ | $x^{(3)}_{2,2,2}$ |            |            |            |            |

According to the scenario described in the table, it can be divided into parts. The first three slots are BIA for interference management of edge users. The edge user uses the reconfigurable antenna switching technology to carry on the signal demodulation. The center user is equipped with a normal antenna, so there is no need to switch modes. In the remaining time slot, the base station uses TDMA to send data to the center user and each base station transmits data to its intended center user. We adopted three time slots to send the data to the center user in order to facilitate the comparison with the BIA-NOMA scheme in the case of the same desired data stream.

The detailed signal demodulation process of this scheme is a simple subtraction operation in section III of the reference [2], so it will not be repeated.

3.2. BIA-NOMA Scheme

Since NOMA can enhance the system capacity, we proposed to combine NOMA with BIA. The signal transmission and demodulation process of the BIA-NOMA scheme is shown in Table 2.

Table 2. A hybrid BIA-NOMA scheme of the two cell SISO networks

| Time slot | $Tx_1$ | $Tx_2$ | UE$_{1,1}$ | UE$_{1,2}$ | UE$_{2,1}$ | UE$_{2,2}$ |
|-----------|--------|--------|------------|------------|------------|------------|
| 1         | $\sqrt{(1-\rho)x_{1,1,1}} + \sqrt{\rho x^{(1)}_{1,1,2}}$ | $\sqrt{(1-\rho)x_{2,1,1}} + \sqrt{\rho x^{(1)}_{2,2,2}}$ | 1          | 1          | 1          |            |
| 2         | $\sqrt{(1-\rho)x_{1,1,1}} + \sqrt{\rho x^{(2)}_{1,1,2}}$ | $\sqrt{(1-\rho)x_{2,1,1}} + \sqrt{\rho x^{(2)}_{2,2,2}}$ | 2          | 1          | 1          | 1          |
| 3         | $\sqrt{(1-\rho)x_{1,2,1}} + \sqrt{\rho x^{(3)}_{1,1,2}}$ | $\sqrt{(1-\rho)x_{2,2,1}} + \sqrt{\rho x^{(3)}_{2,2,2}}$ | 1          | 1          | 2          | 1          |

Taking the edge user UE$_{1,1}$ as an example, the received signal can be expressed as:
\[
\begin{bmatrix}
    y_{1,1}(1) \\
    y_{1,1}(2) \\
    y_{1,1}(3)
\end{bmatrix} = \begin{bmatrix}
    h_{1,1}^1(1) & h_{1,1}^2(1) \\
    h_{1,1}^1(2) & h_{1,1}^2(2) \\
    0 & 0
\end{bmatrix} \begin{bmatrix}
    \sqrt{(1-\rho)x_{1,1,1}} \\
    \sqrt{(1-\rho)x_{2,1,1}}
\end{bmatrix} + \begin{bmatrix}
    h_{1,1}^1(1) & h_{1,1}^2(1) \\
    h_{1,1}^1(2) & h_{1,1}^2(2) \\
    0 & 0
\end{bmatrix} \begin{bmatrix}
    \sqrt{\rho x_{1,1,2}} \\
    \sqrt{\rho x_{2,1,2}}
\end{bmatrix} \\
+ \begin{bmatrix}
    h_{1,1}^1(1) & h_{1,1}^2(1) \\
    h_{1,1}^1(2) & h_{1,1}^2(2) \\
    0 & 0
\end{bmatrix} \begin{bmatrix}
    \sqrt{\rho x_{1,2,1}} \\
    \sqrt{\rho x_{2,2,1}}
\end{bmatrix} + \begin{bmatrix}
    z_{1,1}(1) \\
    z_{1,1}(2) \\
    z_{1,1}(3)
\end{bmatrix} \\
\]

(1)

3.3. Signal demodulation

The expected signals of marginal users are demodulated by BIA, and finally, the expected signals of center users are demodulated according to the power allocation coefficient. The first step is to demodulate the signal of edge user UE_{k,1}. The demodulation process of UE_{1,1} is as follows:

\[
\begin{bmatrix}
    y_{1,1}(1) - y_{1,1}(3) \\
    y_{1,1}(2)
\end{bmatrix} = \begin{bmatrix}
    h_{1,1}^1(1) & h_{1,1}^2(1) \\
    h_{1,1}^1(2) & h_{1,1}^2(2)
\end{bmatrix} \begin{bmatrix}
    \sqrt{(1-\rho)x_{1,1,1}} \\
    \sqrt{(1-\rho)x_{2,1,1}}
\end{bmatrix} + \begin{bmatrix}
    h_{1,1}^1(1) & h_{1,1}^2(1) \\
    h_{1,1}^1(2) & h_{1,1}^2(2) \\
    0 & 0
\end{bmatrix} \begin{bmatrix}
    \sqrt{\rho x_{1,1,2}} \\
    \sqrt{\rho x_{2,1,2}}
\end{bmatrix} \\
+ \begin{bmatrix}
    0 & 0 \\
    h_{1,1}(2) & h_{1,1}(2)
\end{bmatrix} \begin{bmatrix}
    \sqrt{\rho x_{1,1,2}} \\
    \sqrt{\rho x_{2,2,2}}
\end{bmatrix} + \begin{bmatrix}
    -h_{1,1}^1(1) \\
    -h_{1,1}^2(1) \\
    0
\end{bmatrix} \begin{bmatrix}
    \sqrt{\rho x_{1,2,1}} \\
    \sqrt{\rho x_{2,2,2}}
\end{bmatrix} \\
+ \begin{bmatrix}
    z_{1,1}(1) - z_{1,1}(3) \\
    z_{1,1}(2)
\end{bmatrix} \\
\]

(2)

Because NOMA send signals by using power distribution, the power distribution coefficient \(\rho\) is very small, so we can take the signal \(\sqrt{\rho x_{1,1,2}}\) as noise. The channel coefficients \(h_{1,1}^n(m(t))\) follow an independent identical distribution, so the channel coefficient matrix of symbol vector \(x_{1,1,1}\) is full rank, and then signals \(x_{1,1,1}\) and \(x_{2,1,1}\) can be demodulated. Similarly, we can demodulate the signals \(x_{1,2,1}, x_{2,2,1}\) of UE_{2,1}. Next, we will demodulate the signal of the center user UE_{k,2}. Since the center users only receives the signal sent by the base station, the desired signal can be demodulated by SIC after receiving the signal of a certain time slot.

Therefore, taking UE_{1,2} as an example, so the signal received by UE_{1,2} are as follows:

\[
y_{1,2}(2) = h_{1,2}^1(1) \left(\sqrt{(1-\rho)x_{1,1,1}} + \sqrt{\rho x_{1,1,2}}\right) + z_{1,2}(2) \\
\]

(3)

According to the signal received by each user, we can get six pairs of mixed signals, that are \(\sqrt{(1-\rho)x_{1,1,1}} + \sqrt{\rho x_{1,1,2}}\), \(\sqrt{(1-\rho)x_{2,1,1}} + \sqrt{\rho x_{2,2,2}}\), \(t=1,2,3\). Next, we will use NOMA to demodulate a single signal. Since \(|h_{k,2}^1(m(t))|^2 > |h_{k,1}^1(m(t))|^2\), take the mixed-signal \(\sqrt{(1-\rho)x_{1,1,1}} + \sqrt{\rho x_{1,1,2}}\) as an example, we first consider the expected signal \(x_{1,1,2}^{(2)}\) of UE_{1,2} as noise, and then decode the expected signal \(x_{1,1,1}\) of UE_{1,1}. Then UE_{1,2} will regard the signal \(x_{1,1}^{(2)}\) as interference, and decode the estimated signal \(\tilde{x}_{1,1,1}\) of UE_{1,1}, and finally subtract the estimated signal \(\tilde{x}_{1,1,1}\) from the superimposed signal, thereby obtaining its own desired signal \(x_{1,1,2}^{(2)}\). Similarly, we can demodulate the signal \(x_{2,2,2}^{(2)}\).
4. Analysis of sum-rate

4.1. Expected value of BIA-TDMA sum-rate
According to the Table 1 and section 4 in reference [3], the achievable rate of the edge user UE$_{k,1}$ can be calculated as follows:

$$R_{k,1}^{BT} = \frac{1}{6} \cdot E \left[ \log \det \left( I_M + \frac{3\zeta}{8} H_{k,1} H_{k,1}^+ \right) \right]$$

where $H_{k,1} = \begin{bmatrix} \frac{1}{\sqrt{2}} h_{k,1}^1(1) & \frac{1}{\sqrt{2}} h_{k,1}^2(1) \\ \sqrt{\frac{1}{2}} h_{k,1}^1(2) & \sqrt{\frac{1}{2}} h_{k,1}^2(2) \end{bmatrix}$. UE$_{k,2}$ is able to achieve

$$R_{k,2}^{BT} = \frac{1}{2} E \left[ \log(1 + \frac{1}{2} \zeta \cdot | h_{k,2}^n(m(t)) |^2) \right]$$

The sum rate of the entire system is:

$$S^{BT} = \sum_{k=1}^{2} (R_{k,1}^{BT} + R_{k,2}^{BT})$$

The derivation of the above formula is similar to section 4.2, so it will not be repeated.

4.2. Expected value of BIA-NOMA sum-rate

**Theorem 1.** Suppose $| h_{k,2}^n(m(t)) |^2 > | h_{k,1}^n(m(t)) |^2$, $1 - \rho > \rho$, according to the scheme, the achievable rate of the edge user UE$_{k,1}$ can be calculated as follows:

$$R_{k,1}^{BN}(\rho) = \frac{1}{3} E \left[ \log \det \left( I_M + \frac{3(1-\rho)}{8-2\rho} \frac{3\zeta}{8-2\rho} H_{k,1} H_{k,1}^+ + 1 \right) \right]$$

where

$$H_{k,1} = \begin{bmatrix} \frac{1}{\sqrt{2}} h_{k,1}^1(1) & \frac{1}{\sqrt{2}} h_{k,1}^2(1) \\ \sqrt{\frac{1}{2}} h_{k,1}^1(2) & \sqrt{\frac{1}{2}} h_{k,1}^2(2) \end{bmatrix}, H_{k,1}^{(1)} = \begin{bmatrix} \frac{1}{\sqrt{2}} h_{k,1}^1(1) & \frac{1}{\sqrt{2}} h_{k,1}^2(1) \\ 0 & 0 \end{bmatrix}, H_{k,1}^{(2)} = \begin{bmatrix} 0 & 0 \\ h_{k,1}^1(2) & h_{k,1}^2(2) \end{bmatrix},$$

$$H_{k,1}^{(3)} = \begin{bmatrix} -\frac{1}{\sqrt{2}} h_{k,1}^1(1) & -\frac{1}{\sqrt{2}} h_{k,1}^2(1) \\ 0 & 0 \end{bmatrix}.$$  

**Proof:** The edge user UE$_{1,1}$ is taken as an example to illustrate the derivation process of the edge user’s achievable rate. According to the solution, the signals received by the edge user UE$_{1,1}$ is shown in formula (1). So interference signals are aligned at $[1 \ 0 \ 1]^T$. In order to eliminate interference, we need to project the received signal onto a 2-dimensional subspace orthogonal to $[1 \ 0 \ 1]^T$. We can see that the rows of the following matrix form the standard orthogonal basis of the subspace.

$$P_{k,1} = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & -\frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \end{bmatrix}$$

After projection, the received signal is expressed as:

$$P_{k,1} Y_{k,1} = \begin{bmatrix} \frac{1}{\sqrt{2}} h_{1,1}^1(1) & \frac{1}{\sqrt{2}} h_{1,1}^2(1) \\ h_{1,1}^1(2) & h_{1,1}^2(2) \end{bmatrix} \begin{bmatrix} \sqrt{(1-\rho) x_{1,1,1}} \\ 0 \end{bmatrix} + \begin{bmatrix} \frac{1}{\sqrt{2}} h_{1,1}^1(1) & \frac{1}{\sqrt{2}} h_{1,1}^2(1) \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \sqrt{\rho x_{1,1,2}} \\ \sqrt{\rho x_{2,2,2}} \end{bmatrix}.$$
\[
\begin{align*}
&+ \begin{bmatrix}
0 & 0 \\
h_{1,1}^1(2) & h_{2,1}^2(2)
\end{bmatrix}
\begin{bmatrix}
\sqrt{p_{h_{1,1},2}}(2) \\
\sqrt{p_{h_{2,2},2}}(2)
\end{bmatrix}
+ \begin{bmatrix}
-\frac{1}{\sqrt{2}} h_{1,1}^1(1) \\
0
\end{bmatrix}
\begin{bmatrix}
\sqrt{p_{h_{1,1},2}}(3) \\
0
\end{bmatrix}
= H_{1,1} X_{1,1} + H_{1,1}^1 X_{1,1}^1 + H_{1,1}^2 X_{1,1}^2 + H_{1,1}^3 X_{1,1}^3 + P_{1,1} Z_{1,1}
= H_{1,1} X_{1,1} + \sum_{t=1}^3 \bar{H}_{1,1}^t X_{1,1}^t + P_{1,1} Z_{1,1}
\end{align*}
\]

Since \(z_{k,t}(t) \sim CN(0,1)\), \(E[zz^\dagger] = 1\). Assuming that the total emission energy is limited to \(\xi\) and the energy of each signal is \(\bar{P}\), the energy of each time slot is obtained according to the scheme as shown in the following formula:

\[
2(2(1 - \rho) + \rho) + 2 + 2) \bar{P} = 3\xi,\text{then } \bar{P} = \frac{3\xi}{8 - 2\rho}.\]

Since there is no CSIT, we allocate average power to each signal, the channel input is subject to the average power constraint \(E[\|x\|^2] \leq \frac{3\xi}{8 - 2\rho}\). According to the definition of the Signal to Interference plus Noise Ratio (SINR):

\[
\text{SINR} = \frac{P_d}{P_n + N}
\]

Where \(P_d\) represent the power of the desired signal, \(P_n\) represent the power of the interference signal, and \(N\) represent the noise power, and the SINR of the edge user \(UE_{1,1}\) can be obtained as:

\[
\text{SINR}_{1,1} = \frac{P_d}{P_n + N} = \frac{E[H_{1,1} X_{1,1}^t X_{1,1}^t H_{1,1}^t]}{\sum_{t=1}^3 E[H_{1,1}^t X_{1,1}^t X_{1,1}^t H_{1,1}^t] + E[P_{1,1} Z_{1,1} Z_{1,1}^t P_{1,1}^t]}
= \frac{H_{1,1} (1 - \rho) \frac{3}{8 - 2\rho} \xi \cdot I}{\sum_{t=1}^3 H_{1,1}^t \cdot \frac{3}{8 - 2\rho} \rho\xi \cdot I \cdot H_{1,1}^t + P_{1,1} P_{1,1}^t}
= \frac{(1 - \rho) \frac{3}{8 - 2\rho} \xi \cdot I \cdot H_{1,1}^t}{\frac{3}{8 - 2\rho} \rho\xi \cdot I \cdot \sum_{t=1}^3 H_{1,1}^t H_{1,1}^t + I}
\]

According to the Shannon formula \(C = \log (1 + \text{SNR})\), we can get the user’s achievable rate as follows:

\[
R_{1,1}^{BN}(\rho) = E[\log \det(1 + \text{SINR}_{1,1})] = E \left[ \log \det \left( I_M + \frac{(1 - \rho) \frac{3}{8 - 2\rho} \xi \cdot I \cdot H_{1,1}^t}{\sum_{t=1}^3 H_{1,1}^t H_{1,1}^t + I} \right) \right]
\]

Since the entire system occupy 3 time slots for signal modulation and demodulation, the achievable rate for the edge user \(UE_{1,1}\) per time slot is:

\[
R_{1,1}^{BN}(\rho) = \frac{1}{3} R_{1,1}^{BN'}(\rho) = \frac{1}{3} E \left[ \log \det \left( I_M + \frac{(1 - \rho) \frac{3}{8 - 2\rho} \xi \cdot I \cdot H_{1,1}^t}{\sum_{t=1}^3 H_{1,1}^t H_{1,1}^t + I} \right) \right]
\]
Due to symmetry, the edge users $\text{UE}_k$, are able to achieve

$$
R^{\text{BN}}_{k,1}(\rho) = \frac{1}{3} \mathbb{E} \left[ \log \left( 1 + \frac{3}{8 - 2\rho} \xi \cdot \left| \mathbf{h}_{k,1} \right|^2 \right) \right]
$$

\begin{equation}
\text{Theorem 2.} \quad \text{The achievable rate of the center users } \text{UE}_{k,2} \text{ are calculated as follows:}
\end{equation}

$$
R^{\text{BN}}_{k,2}(\rho) = \mathbb{E} \left[ \log \left( 1 + \frac{3}{8 - 2\rho} \xi \cdot \left| \mathbf{h}_{k,2}^n(m(t)) \right|^2 \right) \right]
$$

The sum rate of the entire system is:

$$
S^{\text{BN}}(\rho) = \sum_{k=1}^{K} \left( R^{\text{BN}}_{k,1}(\rho) + R^{\text{BN}}_{k,2}(\rho) \right)
$$

\textbf{proof:} Since the center users only receives the signal of the base station of the local cell, it does not need to participate in the signal transmission and reception process of the BIA, and only needs to demodulate the desired signal in the received mixed signal. We take the user UE$_{1,2}$ as an example to calculate the achievable rate of the center user. The signals received by UE$_{1,2}$ are as follow:

$$
y_{1,2}(2) = h_{1,2}^1(1) \left( \sqrt{1 - \rho} x_{1,1,1} + \sqrt{\rho} x_{1,1,2}^{(2)} \right) + z_{1,2}(2)
$$

Then the SINR can be expressed as:

$$
\text{SINR}_{1,2} = \mathbb{E} \left[ \left| h_{1,2}^1(1) \sqrt{\rho} x_{1,1,2}^{(2)} \right| \right] = \frac{3}{8 - 2\rho} \xi \cdot \left| h_{1,2}^1(1) \right|^2
$$

Therefore, according to the scheme in the table, the achievable rate of the center user UE$_{1,2}$ in each time slot is:

$$
R^{\text{BN}}_{1,2}(\rho) = \frac{3}{3} \mathbb{E} \left[ \log \left( 1 + \text{SINR}_{1,2} \right) \right] = \mathbb{E} \left[ \log \left( 1 + \frac{3}{8 - 2\rho} \xi \cdot \left| h_{1,2}^1(1) \right|^2 \right) \right]
$$

Due to symmetry, the center users $\text{UE}_k$, are able to achieve

$$
R^{\text{BN}}_{k,2}(\rho) = \mathbb{E} \left[ \log \left( 1 + \frac{3}{8 - 2\rho} \xi \cdot \left| h_{k,2}^n(m(t)) \right|^2 \right) \right]
$$

The sum rate of the entire system is:

$$
S^{\text{BN}}(\rho) = \sum_{k=1}^{K} \left( R^{\text{BN}}_{k,1}(\rho) + R^{\text{BN}}_{k,2}(\rho) \right)
$$

\textbf{4.3. Comparison of BIA-TDMA Capacity and Simulation Results}

In this paper, we construct a two-cell SISO non-broadcast channel model that satisfies d1, d2, d3 and consider the average achievable sum-rate of the system as the performance evaluation standard, by comparing BIA-TDMA scheme under the same model to prove the performance improvement of the BIA-NOMA scheme. We assume that the channel coefficient obeys the Rayleigh distribution, and the power distribution coefficient is set to $\eta = 0.1$. Considering the urban environment factor, the path fading coefficient is set to $\eta = 3$. It can conclude that the achievable rate of the edge user and the center user, the average achievable sum-rate curve of the system for the two schemes are shown in Fig 2 and 3.

It can be clearly seen from the figure that the achievable rate of center users for the BIA-NOMA scheme are higher than all users of the BIA-TDMA scheme, and the average achievable sum rate of
the system is also larger than that of the BIA-TDMA scheme, at any SNR value, always maintain superiority.

![Figure 2. Achievable Rate of the User.](image1)

![Figure 3. Average Achievable Sum-Rate.](image2)

5. Conclusion
This paper has proposed a BIA-NOMA scheme based on the two-cell SISO downlink network system. It combines BIA with NOMA to achieve interference management, and uses different methods to deal with cluster interference and cluster interference. The performance of the BIA-NOMA scheme is better than that of BIA-TDMA by deriving the achievable rate of users and the average achievable sum-rate formula of the system. Since CSIT is not required, the achievable rate of the center users and the average achievable sum-rate of the system are improved while reducing system overhead.

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