

Non-Orthogonal Multiple Access Assisted Device-to-Device Communication: Best Helping Base Station Approach

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ABSTRACT

It can be studied in this paper that a cooperative non-orthogonal multiple access (NOMA) helps device-to-device (D2D) communication system through base station (BS). In particular, we investigate BS selection scheme as a best channel condition for dedicated devices where a different data transmission demand on each device is resolved. The analysis on amplifying-and forward (AF) relay is proposed to evaluate system performance of the conventional cooperative NOMA scheme. Under the realistic assumption of perfect channel estimation, the achievable outage probability of both devices is investigated, and several impacts on system performance are presented. The mathematical formula in closed form related to probability has also been found. By implementing Monte-Carlo simulation, the simulation results confirm the accuracy of the derived analytical results. Also, the proposed D2D cooperative NOMA system introduces expected performance on reasonable selected parameters in the moderate signal to noise ratio (SNR) regime.

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1. INTRODUCTION

In recent times, non-orthogonal multiple access and device-to-device have attracted a lot of attention as interesting candidate for 5th generation (5G) networks. It is considered as one of the modern technologies applied in mobile networks for the purpose of solving the problem of network congestion as well as to offload traffic for the cellular networks and enhance the spectral efficiency (SE) that caused by massive growth in connected mobile devices. NOMA can be used in a wide variety of areas, especially in the Internet of Things (IoT) applications or wireless sensor networks, where wireless signal processing techniques are required. One of the biggest advantages of NOMA is that it allows multiple devices concurrently served with the same bandwidth resources, e.g., time slots, frequency or spreading codes, but the power of the devices in the NOMA system must be different.

With a specific goal to enhance the system capacity and improve the dependability of NOMA, cooperative NOMA (C-NOMA) systems have drawn in a few considerations, such as the authors in [1] considered the average normal rate for C-NOMA networks. In order to improve the performance of the system, the authors in [2] have studied the technique of combining NOMA with multiple antenna network. In [3], the spectral efficiency is enhanced by the application of NOMA technology to the relay transmission and coordinated directed. In [4], the C-NOMA network was recommended as a new detection scheme. Besides, the value of optimal and near optimal power division parameters was also proposed.

There are a number of studies to improve the transmission power in relaying communication networks, which indicated in [5]-[7], due to the diversity of radio channels that the devices or expanding coverage of relaying schemes can be exploited. In fact, the LTE system or other systems are indispensable modern techniques such as device selection techniques, relay selection techniques and scheduling techniques. Therefore, the authors in [8] have done research on relay selection techniques that based on the NOMA principle. Results demonstrate that the blending scheme of helpful cooperative relay and NOMA can incredibly enhance the system's performance. Furthermore, the outage probability in closed-form equation was also found by the authors in [8], and they also proposed a decode-and-forward (DF) relay selection in the two-stage scheme. Also related to the relay selection associated with NOMA, the research works in [9] have achieved good results in finding the asymptotic and approximation equation of the average sum rate in AF mode. In addition, another relay selection method has been applied in [10], which relies on partial channel state information (CSI). The results of the study are shown by the analysis of the outage probability and its asymptotic form. In this way, it is possible to evaluate the influence of the partial relay selection technique on the system's performance.

It can be seen as a modern technique to make the mobile data offloading for wireless networks, device-to-device (D2D) scheme is proposed to proximity communication. D2D devices deploy in the same frequency band with cellular devices (CUs) under control of the base station (BS) in the cellular network and hence effectively success transmission probability can be seen and the spectral efficiency can be improved [11], [12]. Due to limited resource of the battery lifetime budget of devices, it can be affected to the system throughput in D2D underlaying networks. Fortunately, to prolong the lifetime of networks, D2D underlaying networks can be used energy harvesting via radio frequency as in works [13], [14]. Other trends in relaying networks can be seen in recent works, such as [15], [17]-[19]. While performance of energy harvesting-based relaying can be shown in [20], [21].

Motivated by advantage of D2D and NOMA [15], in this paper, we propose a D2D NOMA scheme in specific mode, where device transfer signal to other device via base station, with relay selection and the influence of Rayleigh fading channels is determined. For the main purpose of research is to solve the problem of increasing spectrum efficiency, the primary contributions of this paper are summarized as follows:

1. We analyze and evaluate the performance of the system which incorporate with NOMA together with BS selection to enhance network performance and spectral efficiency.
2. Exact expressions for the outage probability are obtained in closed-form. Also, it can be used as a theoretical basis for the actual NOMA system design.
3. These derived expressions are checked via simulation to corroborate the exactness of analysis in NOMA

2. SYSTEM MODEL

The basic model of a downlink cooperative NOMA system is shown in Figure. 1, which includes one mobile device (D_0), two far devices (D_1 and D_2) and K AF relays node that acts as a base station (BS) (R_1, R_2, \dots, R_K with $K > 1$), in which D_0 would like to send its data to D_1 and D_2 with the assistance of a relay that it belongs to the set of K AF relays because there is no immediate way among the D_0 with two devices D_1 and D_2 , because of they are covered or in a very distant position. We considered all the devices that are equipped with only one antenna, this means that they work in half-duplex (HD) mode. The scheme of cooperative NOMA comprises of two successive equivalent length time slots. As previously mentioned, the selected relay can be resolved through some selection criteria. In this paper, we denote the fading channel coefficient and the additive white Gaussian noise (AWGN) between D_0 and R_k are $h_{D_0 R_k} \sim CN(0, \lambda_{D_0 R_k})$ and $\varpi_{R_k} \sim CN(0, N_0)$, respectively, the fading channel coefficient and the AWGN between R_k and D_i , $i=1,2$ are indicated by $g_{R_k D_i} \sim CN(0, \lambda_{R_k D_i})$ and $\varpi_{R_k D_i} \sim CN(0, N_0)$, respectively. D_1 and D_2 are combined together to perform NOMA cooperative system.

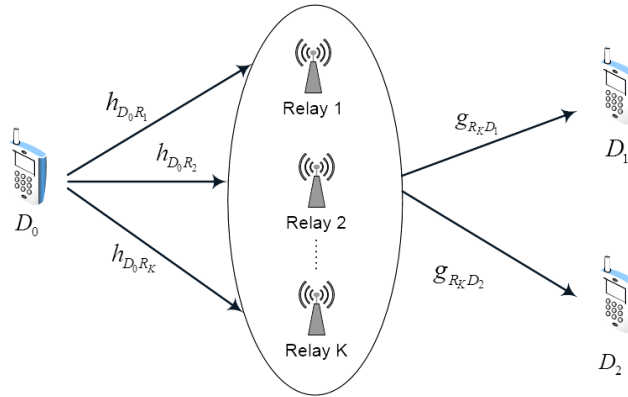


Figure 1. System model of non-orthogonal multiple access schemes with bs selection

In the first timeslot, D_0 will send its data to all relays node, which is given by as follows:

$$x_{D_0} = \sqrt{\beta_1 P_{D_0}} x_{D_{01}} + \sqrt{\beta_2 P_{D_0}} x_{D_{02}} \tag{1}$$

in which β_1 and β_2 are the power allocation coefficients, and $x_{D_{01}}$ and $x_{D_{02}}$ are the data for D_1 and D_2 , respectively, P_{D_0} denote the transmit power at D_0 . Based on the working fundamental of NOMA, it can be assumed that $\beta_1 > \beta_2$ with $\beta_1 + \beta_2 = 1$. The received signal at R_k is given by:

$$\begin{aligned} y_{R_k} &= h_{D_0,R_k} x_{D_0} + \varpi_{R_k} \\ &= h_{D_0,R_k} \left(\sqrt{\beta_1 P_{D_0}} x_{D_{01}} + \sqrt{\beta_2 P_{D_0}} x_{D_{02}} \right) + \varpi_{R_k} \end{aligned} \tag{2}$$

It can be assumed that the transmit power of D_0 and all relay devices is the same, i.e., $P_{R_1} = P_{R_2} = \dots = P_{R_K} = P_{D_0} = P$. Furthermore, we defined that the average transmit SNR $\rho_{D_0} = \frac{P}{N_0}$, and the random variables $H_k = \rho_{D_0} |h_{D_0,R_k}|^2$ and $Q_{ik} = \rho_{D_0} |g_{R_k,D_i}|^2$ stand for the SNRs of the links $D_0 \rightarrow R_k$ and $R_k \rightarrow D_i$, in which $i = 1, 2$ and $k = 1, 2, \dots, K$, respectively.

In the second stage, the signal to interference and noise ratio (SINR) at R_k of the chosen link for detecting signal $x_{D_{01}}$ can be communicated as:

$$\gamma_{D_0,R_k,x_{D_{01}}} = \frac{\beta_1 H_k}{\beta_2 H_k + 1} \tag{3}$$

Likewise, the SINR at R_k for detecting signal $x_{D_{02}}$ can be computed by applying successive interference cancellation (SIC) and it can be expressed as:

$$\gamma_{D_0,R_k,x_{D_{02}}} = \beta_2 H_k \tag{4}$$

After receiving the signal from D_0 , the relay transmits the signal $x_{R_k} = G_k y_{R_k}$ to D_1 and D_2 , in the second stage, where G_k is the gain factor of the AF relay mode, it can be expressed as:

$$G_k^2 = \frac{P_{R_k}}{P_{D_0} |h_{D_0 R_k}|^2 + N_0} \quad (5)$$

Without loss of generality, the received signals at D_1 and D_2 which forwarded by R_k as follows:

$$\begin{aligned} y_{R_k D_1} &= g_{R_k D_1} x_{R_k} + \varpi_{R_k D_1} \\ &= G g_{R_k D_1} h_{D_0 R_k} \sqrt{\beta_1 P_{D_0}} x_{D_{01}} \\ &\quad + G g_{R_k D_1} h_{D_0 R_k} \sqrt{\beta_2 P_{D_0}} x_{D_{02}} + G g_{R_k D_1} \varpi_{R_k} + \varpi_{R_k D_1} \end{aligned} \quad (6)$$

$$\begin{aligned} y_{R_k D_2} &= g_{R_k D_2} x_{R_k} + \varpi_{R_k D_2} \\ &= G g_{R_k D_2} h_{D_0 R_k} \sqrt{\beta_1 P_{D_0}} x_{D_{01}} \\ &\quad + G g_{R_k D_2} h_{D_0 R_k} \sqrt{\beta_2 P_{D_0}} x_{D_{02}} + G g_{R_k D_2} \varpi_{R_k} + \varpi_{R_k D_2} \end{aligned} \quad (7)$$

It is similar to the first time slot, the SINR at D_1 of the link $R_k \rightarrow D_1$ can be shown as

$$\gamma_{R_k D_1, x_{D_{01}}} = \frac{\beta_1 H_k Q_{1k}}{\beta_2 H_k Q_{1k} + H_k + Q_{1k} + 1} \quad (8)$$

Considering on the link $R_k \rightarrow D_2$, the instantaneous SINR at D_2 to remove $x_{D_{01}}$ and the SINR at D_2 to get its own data, respectively, are given by

$$\gamma_{R_k D_2, x_{D_{01-02}}} = \frac{\beta_1 H_k Q_{2k}}{\beta_2 H_k Q_{2k} + H_k + Q_{2k} + 1} \quad (9)$$

$$\gamma_{R_k D_2, x_{D_{02}}} = \frac{\beta_2 H_k Q_{2k}}{H_k + Q_{2k} + 1} \quad (10)$$

3. OUTAGE PERFORMANCE CONSIDERATION

Because it must be satisfied quality-of-service (QoS) requirements, it require consideration on outage performance. So, the devices in the system will be provided a separated SNR threshold, γ_{th_i} , $i=1,2$. Remembering this, next it will be derived the outage probabilities for the two paired devices D_1 and D_2 . For straightforwardness, it can be assumed that all the SINRs threshold of D_1 and D_2 are the same, i.e., $\gamma_{th_1} = \gamma_{th_2} = \gamma_{th}$.

3.1. Outage Probability At D_1 For Detecting Signal $x_{D_{01}}$

It can be initially determined the outage probability at the chosen relaying node R_k , related the signal $x_{D_{01}}$ and $x_{D_{02}}$, respectively.

The cumulative distribution functions (CDFs) of the random variables H_k^* and Q_{ik}^* are, respectively, given by [10]

$$\begin{aligned}
 F_{H_{k^*}}(\gamma_{th}) &= \left(1 - \exp\left(-\frac{\gamma_{th}}{\mathcal{X}_{D_0R_{k^*}}^0}\right) \right)^K \\
 &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \exp\left(-\frac{\gamma_{th}}{\mathcal{X}_{D_0R_{k^*}}^0}\right)^k
 \end{aligned}
 \tag{11}$$

$$F_{Q_{k^*}}(\gamma_{th}) = 1 - \exp\left(-\frac{\gamma_{th}}{\mathcal{X}_{R_{k^*}D_1}^0}\right)
 \tag{12}$$

where $\mathcal{X}_{D_0R_{k^*}}^0 = \rho_{D_0} \lambda_{D_0R_{k^*}}$ and $\mathcal{X}_{R_{k^*}D_1}^0 = \rho_{D_0} \lambda_{R_{k^*}D_1}$ stand for the average SNRs of the links $D_0 \rightarrow R_{k^*}$ and $R_{k^*} \rightarrow D_1$, respectively.

In principle of the NOMA scheme, an outage event occurs if the relaying transmission succeeds. Therefore, the outage probability (OP) at D_1 can be expressed as

$$OP_1 = Pr(\gamma_{R_{k^*}D_1 \rightarrow D_1} < \gamma_{th}) = F_{\gamma_{R_{k^*}D_1 \rightarrow D_1}}(\gamma_{th})
 \tag{13}$$

where,

$$\begin{aligned}
 F_{\gamma_{R_{k^*}D_1 \rightarrow D_1}}(\gamma_{th}) &= Pr\left(\frac{\beta_1 H_{k^*} Q_{1k^*}}{\beta_2 H_{k^*} Q_{1k^*} + H_{k^*} + Q_{1k^*} + 1} < \gamma_{th}\right) \\
 &= Pr\left(H_{k^*} (Q_{1k^*} (\beta_1 - \beta_2 \gamma_{th}) - \gamma_{th}) < Q_{1k^*} \gamma_{th} + \gamma_{th}\right)
 \end{aligned}
 \tag{14}$$

From (14), it can be also seen that if $Q_{1k^*} (\beta_1 - \beta_2 \gamma_{th}) - \gamma_{th} \leq 0$ the outage always happens, whereas if $Q_{1k^*} (\beta_1 - \beta_2 \gamma_{th}) - \gamma_{th} > 0$ or $Q_{1k^*} > \frac{\gamma_{th}}{\beta_1 - \gamma_{th} \beta_2} = \mathcal{X}_{th}^0$ then the outage may occur or not. Accordingly, it can be shown that

$$\begin{aligned}
 F_{\gamma_{R_{k^*}D_1 \rightarrow D_1}}(\gamma_{th}) &= F_{Q_{1k^*}}(\mathcal{X}_{th}^0) \\
 &+ \int_{\mathcal{X}_{th}^0}^{+\infty} F_{H_{k^*}}\left(\frac{z\gamma_{th} + \gamma_{th}}{z(\beta_1 - \beta_2 \gamma_{th}) - \gamma_{th}}\right) f_{Q_{1k^*}}(z) dz \\
 &= F_{Q_{1k^*}}(\mathcal{X}_{th}^0) + \int_{\mathcal{X}_{th}^0}^{+\infty} F_{H_{k^*}}\left(\frac{z+1}{\frac{z}{\mathcal{X}_{th}^0} - 1}\right) f_{Q_{1k^*}}(z) dz \\
 &= F_{Q_{1k^*}}(\mathcal{X}_{th}^0) + \int_{\mathcal{X}_{th}^0}^{+\infty} F_{H_{k^*}}\left(\frac{\mathcal{X}_{th}^0(z+1)}{z - \mathcal{X}_{th}^0}\right) f_{Q_{1k^*}}(z) dz
 \end{aligned}
 \tag{15}$$

Note that f_X denotes as the probability density functions (PDF) of the channel X , i.e., $f_X(x) = \frac{1}{\lambda_X} e^{-\frac{x}{\lambda_X}}$.

By displacing (11) and (12) into (15), $F_{\gamma_{R_{k^*}D_1 \rightarrow D_1}}(\gamma_{th})$ can be got as in (16) where $K_1(\cdot)$ indicates the first order modified Bessel function of the second kind [16, eq. (9.6.22)]

$$\begin{aligned}
 F_{\gamma_{R_k D_1}, \gamma_{D_{01}}}(\gamma_{th}) &= F_{Q_{1k}^*}(\gamma_{th}^0) \\
 &+ \int_{\gamma_{th}^0}^{+\infty} \left[1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \right. \\
 &\times \exp \left(-\frac{k}{\gamma_{D_0 R_k}^0} \left(\frac{\gamma_{th}^0(z+1)}{z - \gamma_{th}^0} \right) \right) \Big] f_{Q_{1k}^*}(z) dz \\
 &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \frac{1}{\gamma_{R_k D_1}^0} \\
 &\times \int_{\gamma_{th}^0}^{+\infty} \exp \left(-\frac{k}{\gamma_{D_0 R_k}^0} \left(\frac{\gamma_{th}^0(z+1)}{z - \gamma_{th}^0} \right) \right) \exp \left(-\frac{z}{\gamma_{R_k D_1}^0} \right) dz \\
 &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \\
 &\times \exp \left[-\gamma_{th}^0 \left(\frac{k}{\gamma_{D_0 R_k}^0} + \frac{1}{\gamma_{R_k D_1}^0} \right) \right] 2\sqrt{\theta} K_1(2\sqrt{\theta})
 \end{aligned} \tag{16}$$

where $\theta = \frac{k\gamma_{th}^0 + \gamma_{th}^0\gamma_{th}^0}{\gamma_{D_0 R_k}^0 \gamma_{R_k D_1}^0}$

At the end, the outage probability at D_1 for detecting signal $x_{D_{01}}$ can be achieved as

$$\begin{aligned}
 OP_1 &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \\
 &\times \exp \left[-\gamma_{th}^0 \left(\frac{k}{\gamma_{D_0 R_k}^0} + \frac{1}{\gamma_{R_k D_1}^0} \right) \right] 2\sqrt{\theta} K_1(2\sqrt{\theta})
 \end{aligned} \tag{17}$$

3.2. Outage Probability At D_2 For Detecting Signal $x_{D_{02}}$

Since D_2 requires to get and then remove the signal of D_1 first, the outage probability at D_2 will be occur if the outage probability of the first state and the second state occurred. In this manner, the outage probability at D_2 can be shown as

$$OP_2 = \Pr(\underbrace{\gamma_{R_k D_2, x_{D_{01-02}}} < \gamma_{th}}_{I_1}) \Pr(\underbrace{\gamma_{R_k D_2, x_{D_{02}}} < \gamma_{th}}_{I_2}) \tag{18}$$

From the outage probability of D_1 for detecting signal $x_{D_{01}}$, it can be computed that the outage probability for D_2 for detecting signal $x_{D_{02}}$ as follows [10]

$$\begin{aligned}
 I_1 &= Pr(\gamma_{R_k D_2, x_{D_{01-02}}} < \gamma_{th}) \\
 &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \\
 &\times \exp \left[-\gamma_{th}^0 \left(\frac{k}{\gamma_{D_0 R_k}^0} + \frac{1}{\gamma_{R_k D_2}^0} \right) \right] 2\sqrt{\phi_1} K_1(2\sqrt{\phi_1})
 \end{aligned} \tag{19}$$

Where $\phi_1 = \frac{k\gamma_{th} + \gamma_{th}\gamma_{th}}{\gamma_{D_0R_k}^0 \gamma_{R_kD_2}^0}$

$$I_2 = F_{\gamma_{R_kD_2}, \gamma_{D_0R_k}}(\gamma_{th}) = \Pr\left(\gamma_{\gamma_{R_kD_2}, \gamma_{D_0R_k}} = \frac{\beta_2 H_k^* Q_{2k}^*}{H_k^* + Q_{2k}^* + 1} < \gamma_{th}\right) \tag{20}$$

$$\begin{aligned} F_{\gamma_{R_kD_2}, \gamma_{D_0R_k}}(\gamma_{th}) &= \Pr\left(H_k^* < \frac{Q_{2k}^* + 1}{\frac{\beta_2 Q_{2k}^*}{\gamma_{th}} - 1}\right) \\ &= F_{Q_{2k}^*}\left(\frac{\gamma_{th}}{\beta_2}\right) + \int_{\frac{\gamma_{th}}{\beta_2}}^{+\infty} F_{Y_k^*}\left(\frac{\gamma_{th}(z+1)}{z - \frac{\gamma_{th}}{\beta_2}}\right) \times f_{Q_{2k}^*}(z) dz \\ &= F_{Q_{2k}^*}\left(\frac{\gamma_{th}}{\beta_2}\right) + \int_{\frac{\gamma_{th}}{\beta_2}}^{+\infty} \left[1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \exp\left(-\frac{k}{\gamma_{D_0R_k}^0} \left(\frac{\gamma_{th}(z+1)}{z - \frac{\gamma_{th}}{\beta_2}}\right)\right)\right] \times f_{Q_{2k}^*}(z) dz \\ &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \frac{1}{\gamma_{R_kD_2}^0} \times \int_{\frac{\gamma_{th}}{\beta_2}}^{+\infty} \exp\left(-\frac{k}{\gamma_{D_0R_k}^0} \left(\frac{\gamma_{th}(z+1)}{z - \frac{\gamma_{th}}{\beta_2}}\right)\right) \exp\left(-\frac{z}{\gamma_{R_kD_2}^0}\right) dz \\ &= 1 - \sum_{k=1}^K \binom{K}{k} (-1)^{k-1} \times \exp\left[-\frac{\gamma_{th}}{\beta_2} \left(\frac{k}{\gamma_{D_0R_k}^0} + \frac{1}{\gamma_{R_kD_2}^0}\right)\right] 2\sqrt{\phi_2} K_1(2\sqrt{\phi_2}) \end{aligned} \tag{21}$$

where $\phi_2 = \frac{k\gamma_{th}}{\gamma_{D_0R_k}^0} \left(1 + \frac{\gamma_{th}}{\beta_2}\right) \frac{1}{\gamma_{R_kD_2}^0}$.

In next step, the mathematics expression in closed-form for OP_2 is provided as

$$OP_2 = I_1 \times I_2 \tag{22}$$

3.3. The Proposed BS Selection Criteria

In case of detecting $x_{D_{02}}$ at D_2 , it can initially detect signal for $x_{D_{01}}$ and afterward applying SIC for detecting the remaining signal. Accordingly, the overall outage for collecting signal related to both D_1 and D_2 can be computed as below

$$S_1 = \left\{ \gamma_{R_kD_2}, \gamma_{D_0R_k} < \gamma_{th}, \gamma_{R_kD_1}, \gamma_{D_0R_k} < \gamma_{th}, \gamma_{R_kD_2}, \gamma_{D_0R_k} < \gamma_{th} \right\} = OP_1 \times OP_2 \tag{23}$$

Note that the BS selection criteria are defined as follows

$$k^* = \arg \max \gamma_{D_0R_k} \text{ and } H_k^* = \max_{k=1,2,\dots,K} H_k \tag{24}$$

where $\gamma_{D_0R_k}$ is denoted SNR at relay k .

4. NUMERICAL RESULTS

In this section, to confirm the outage performance, the proposed BS selection strategy for D2D transmission is verified and several corresponding simulations are conducted. The specific values of the adopted simulation parameters are summarized in specific result. In this paper, all simulation results are performed by averaging over 10^6 random trials, unless mentioned otherwise. Particularly, in this part, our numerical results are provided to evaluate the outage performance of two far devices in NOMA scheme and in several scenarios. The simulation results can be obtained, which based on the Monte Carlo simulation, in which BPCU is denoted for bit per channel use.

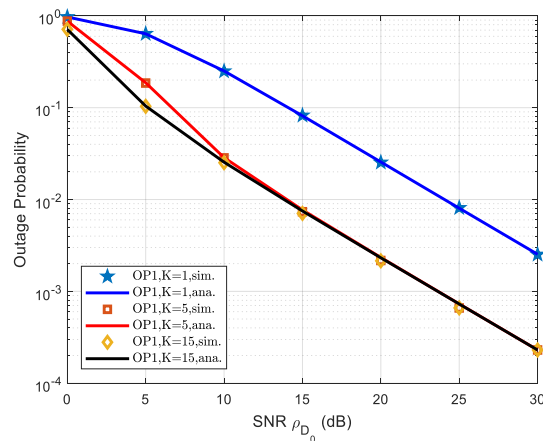


Figure 2. Outage probability of D_1 , $\beta_1 = 0.8$, $\lambda_{D_0, R_k} = 1$, $\lambda_{R_k, D_1} = 10$, $\gamma_{th} = 1$

In Figure 2, the outage performance of the proposed scheme is shown versus the SNR r_{D_0} when varying number of relay node which is in role of helping relay for the near device can be communicated with the far device. We set power allocation for two far devices in NOMA scheme. From Figure 1, one can see that the proposed schemes with high number of relay node significantly outperform the scheme use only relay. The performance gap is large when SNR large. As can be seen from such simulation, the proposed optimal scheme has the similar performance as the number of relay is 5 or 15, and this situation confirmed that floor outage occur at limited number of relay. Furthermore, Figure. 2 manifest that D2D NOMA can remarkably enhance the outage performance at high transmit SNR at the first device. More importantly, the analytical curves match very well with Monte-Carlo results.

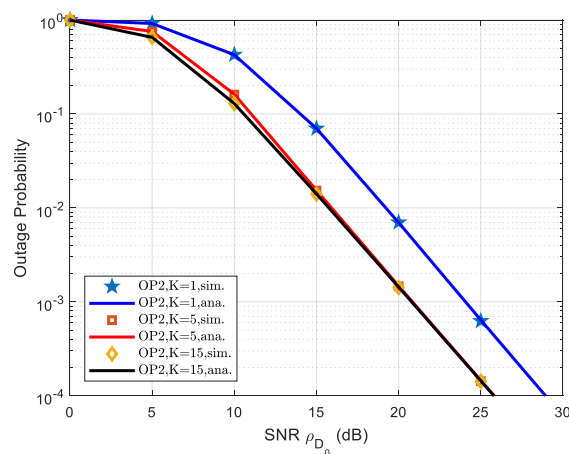


Figure 3. Outage probability of D_2 , $\beta_1 = 0.8$, $\lambda_{D_0, R_k} = 1$, $\lambda_{R_k, D_2} = 1$, $\gamma_{th} = 1$

Similarly in Figure 3, the outage performance for detecting signal of D2 and performance gap provide the enhanced performance at high number of relay in all values of SNR regime. This is because more relays bring higher diversity gains, which improves the reliability of the cooperative networks. In the low to moderate SNR range, the performance of the proposed scheme declines sharply.

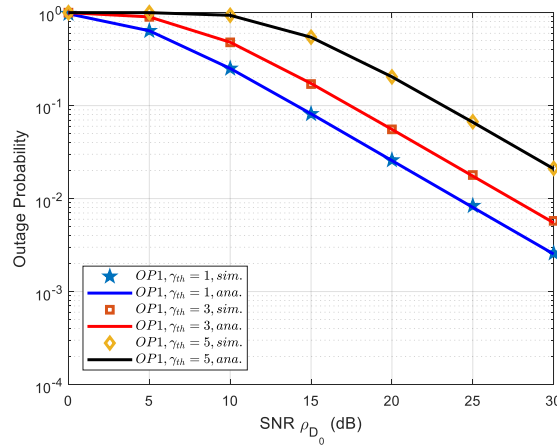


Figure 4. Outage probability of detecting D_1 's signal as varying threshold SNR, $\beta_1 = 0.8$, $\lambda_{D_0 R_k} = 1, \lambda_{R_k D_1} = 10, K = 1$

Figure 4 shows outage performance of detecting signal of far device denoted as D_1 as changing the threshold SNR. In this case, the analysis lines of the outage probability match coincides with the simulation lines. It can be seen that the performance of such D2D NOMA with low data rate produce lower outage event. Similarly trend can be seen in Figure 5 for detecting signal of D_2 .

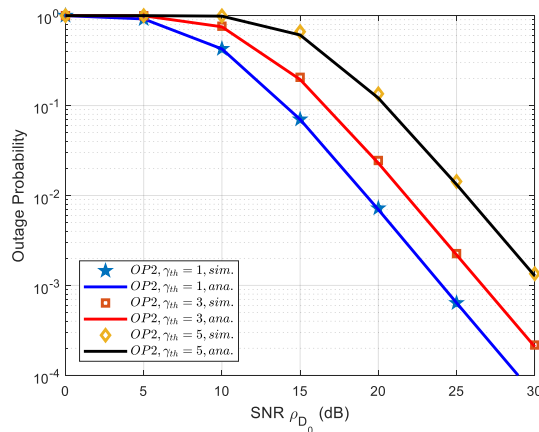


Figure 5. Outage probability of detecting D_2 's signal as varying threshold SNR, $\beta_1 = 0.8$, $\lambda_{D_0 R_k} = 1, \lambda_{R_k D_2} = 1, K = 1$

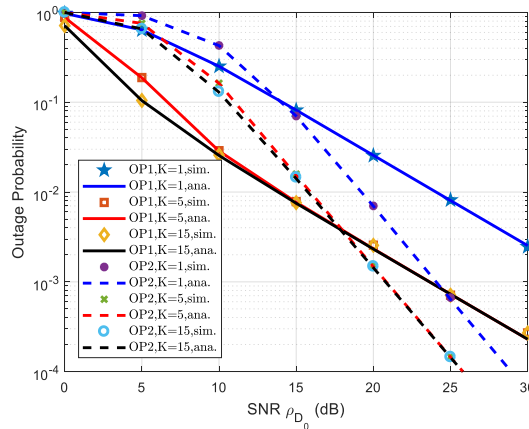


Figure 6. Comparison of probability between OP_1 and OP_2 , $\beta_1 = 0.8$, $\lambda_{D_0, R_k} = 1, \lambda_{R_k, D_1} = 10, \lambda_{R_k, D_2} = 1$.

It is shown that the number of relay node (BS node) in the considered networks which strongly affect on the outage performance at all values of SNR regime. With the number of relay node is selected and at specific SNR at source device, the outage probability for D_1 and D_2 is the same. Another observation is that the performance of two far device is differ value at high SNR.

Figure 7 plots the outage probability of overall D2D system as considering detection of two signal for two devices with different number of BS node. One can observed that adjusting the number of BS node in D2D NOMA will affect the outage behaviors of overall system. As the value of SNR increases, the outage will be improved remarkably. It is worth noting that based on the application requirements of different scenarios, the setting of reasonable number of BS in D2D NOMA is prerequisite.

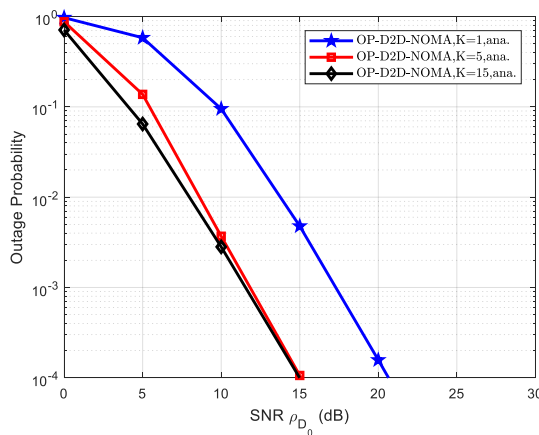


Figure 7. Outage event of overall D2D NOMA, $\beta_1 = 0.8$, $\lambda_{D_0, R_k} = 1, \lambda_{R_k, D_1} = 10, \lambda_{R_k, D_2} = 1$.

5. CONCLUSION

In this paper, a cooperative non-orthogonal multiple access whose main objective is to improve the spectrum efficiency of D2D communication system was studied and proposed. Besides, the BS selection scheme as a best channel condition for dedicated devices was also investigated. The performance of the proposed model is evaluated by considerations on the outage probability in closed-form expressions, the power distribution coefficient and the system outage. Our results are verified by simulation results. From the exact outage probability expression and simulation results, it is easy to realize that the quantity of relay node and the threshold rate have consequences on system performance. Our suggested scheme can dramatically increase the spectral efficiency of the system via a cooperative D2D-NOMA scheme.

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