International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING

ISSN:2147-6799 www.ijisae.org Original Research Paper

Performance Enhancement of AF/DF User Cooperation using Fixed Power Allocation of NOMA

Shatha Hellan Saeed [1], Assistant Prof. Dr. Ibrahim Khalil Sileh [2]

Submitted: 24/04/2023 **Revised**: 25/06/2023 **Accepted**: 06/07/2023

Abstract: NOMA is one of the methods seen to be a good way to solve performance issues and an additional way to grant multi-user access. NOMA should be integrated with cooperative reliance on to significantly improve the performance parameter for NOMA wireless networks, such as outage probability and attainable rate, In order to overcome the deep fading of wireless propagation and reduce the outage probability In this paper, a fixed power allocation for an AF/DF cooperative NOMA scheme for downlink transmission with two users is presented, in which more power was allocated to the distant user and less to the close user at the base station. When the AF and DF protocols are used at the relay node, the signals are superimposed and sent to the relay. Simulation results confirm the analytic findings and show that the proposed method outperforms orthogonal multiple access (OMA), conventional NOMA, and cooperative NOMA in terms of throughput, sum rate, and outage probability. This paper demonstrates the advantages of a fixed power allocation of NOMA over an OMA scheme for the cooperative AF/DF NOMA protocols. Contrast with previous work , all performance metrics was investigated such System Outage Probability (SOP), BER, and throughput for both AF and DF relaying, along with the impact of the fixed power allocation in a cooperative NOMA system under AF and DF relaying protocol.

***Keywords*:** *Cooperative NOMA, amplify-and-forward, decode-and-forward, outage probability, BER, throughput, fixed power allocation.*

1. Introduction

The rapid expansion of mobile data traffic via progressively constrained bandwidth and spectrum has recently been explored and has sparked much study and intense development work on fifth generation (5G) networks [1]. the massive growth in data mobile traffic through gradually limited bandwidth and spectrum has been discussed and gives rise to profound research and intensive development efforts on the fifth generation (5G)networks[2]. In 5G wireless networks, non-orthogonal multiple access (NOMA), a spectrally efficient multiple access technology, has the potential to relieve huge connection for billions of devices and to fulfill the traffic demand that is growing exponentially[3].Non- Orthogonal multiple access is in contrast with (OMA), For users with a variety of channel conditions, NOMA offers a more favorable trade-off between system throughput and fairness[4].To implement cooperative communication, the fixed relaying and adaptive relaying techniques have been suggested[5]. In [6], the full-duplex and relaying network are examined . Two well-known cooperative relaying algorithms, amplify forward (AF) and decode forward (DF), are examined for the relaying networks in [7, 8]. Whereas the received signal in DF protocols must first be decoded, then re-encoded and forwarded to the destination, where’s the received signal in AF protocols is amplified and forwarded to the users [9]. In comparison to previous OMA the appropriate selection of user data rates and power allotments can have a significant impact on NOMA performance [10]. techniques, even higher spectral efficiency may be attained. Even more encouraging, NOMA systems are combined with cooperative strategies to improve performance[11]. In [12], The strong channel user selects a cooperative relay for the weak channel users. The outage performance in a downlink cooperative NOMA was examined in [13] with the aid of an AF relay. In [14], In terms of each NOMA user's outage behavior in downlink NOMA, only the feedback of one bit of its Channel State Information (CSI) to a Base Station (BS) is taken into consideration. When employing half-duplex, the strong users in NOMA can forward signals to the weak users' messages in the second time slot by using the energy that was harvested in the first time slot (HD) scheme [15]. Recent works demonstrate the system performance with fixed power allocations, including ergodic rate and power efficiency, such as [16]. Several studies have examined how outage performance in relaying networks with higher coverage might be paired with NOMA , such as in [17-18]. . This work differs from earlier work in that it uses the AF/DF protocol to check all metrics represented by BER, Outage probability, and channel capacity using fixed power

[1,2] *Collage of Engineering, University of Tikrit, Tikrit, Iraq*
[1]*shatha.h.saeed44348@st.tu.edu.iq*
[2] *ibrahimks65@tu.edu.iq*

allocation method to allocate the power to the users . The remainder of the paper can be arranged using fallows .In section 2,discussed the proposed system. Section 3, conclude our discussion with the results.

3. System Model

We take into account a downlink cooperative NOMA situation with a single base station, designated as BS. two users and one relay (i.e., the nearby user U1,far user U2).

• Stage I → implementation of transmitter.

The power is allocated to the signals by fixed power allocation scheme ,the signals is superposed and transmit to near (strong user),which works as a relay and impalement AF/DF protocols and send the signals to the destination.

• Stage II → implementation of receiver

The receiver receives the superposed signal and try to decode the signals and eliminate the interference by using successful interference cancellation (SIC)

• Stage III → Performance metrics

To measure the performance of outage probability , BER and throughput and compere the results with the previous papers that dealing with fixed power allocation of cooperative AF/DF NOMA systems techniques .

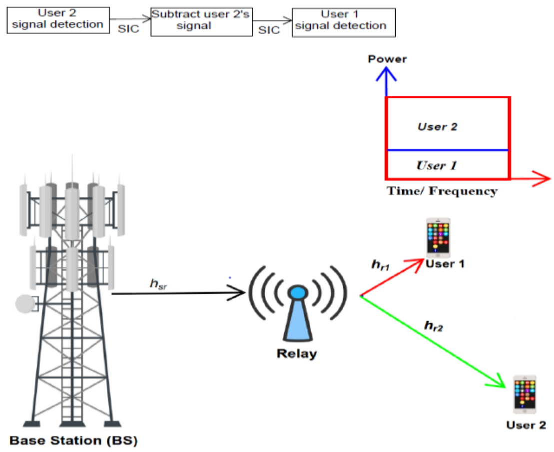

Fig1. Downlink CNOMA for 2user

In downlink NOMA for N users the transmitted signal from the BS can be written as

$X(t)=\sum_{n=1}^{N}\sqrt{\alpha_n P_T}\ x_{(t)}$

Where is

α_n is power allocation coefficient for each user

P_T is the total power at the base station

$x(t)$ is the individual information of each user

So the power allocated to each user becomes $P_{n=}\alpha_n p_T$

According to the distance between the base station and users, the power is distributed, with the closest user receiving the least power and the farthest user receiving the most power .The received signal at the user n isاكتب المعادلة هنا.

$Y_n\ (t) = g_{n*}x_{(t)}+w_{n(t)}$

Where the g_n is the channel gain factor between the BS and the users. With a mean of zero and a density of W_O, the W_n is the additive Wight Gaussian noise at the user. Each user's power is distributed using a predetermined power allocation. According to this system, users are given fixed power based on channel gain. Users with bad channel gain are given more power (0.7P/0.6P), whereas users with strong channel gain are given less power (0.4P/0.3), which is straightforward and has less singling overhead but lacks a set formula to determine power allocation[19].

Bit Error rate BER

The most widely used performance statistic in a communication system is bit error rate (BER). In a communication system, information is conveyed as bits. During the communication procedure, bit mistakes happen. The average rate at which these bit mistakes take place during communication is known as BER:

$$BER=\frac{Number\ of\ error\ bits}{Total\ number\ of\ transmitted\ bits}$$

Outage Performance(OP)

The threshold value at which the receiver power value drops below is known as the outage probability. (where power value relates to the minimum signal to the noise ratio (SNR)).

*For DF protocol

$C_{\max DF} = \frac{1}{2}\log_2(1+\frac{P_t}{N})$ *channel capacity

Throughput for user1

$R_{1,1=} \log_2(1+\frac{P_{1,1}|h_{1,1}|^2}{p_{1,1}|h_{1,1}|^2+N_{O1}})$

$R_{2,1}= \log_2(1+\frac{P_{1,1}|h_{1,1}|^2}{P_{1,2}|h_{1,1}|^2+N_{O1}}+\frac{p_{2,1}|h_{2,1}|^2}{p_{2,2}|h_{2,1}|^2+N_{O2}})$

Throughput for user2

$R_{2=} \log_2(1+\frac{P_2|h_2|^2}{N_{O2}})$

* Achievable rate for general

$R_{K=} \log_2(1+\frac{|h_k|^2 p_k}{1+N_{ok}})$

*Outage probability for user1 occurs when SNR1< R1

R1 = $\frac{\rho_1}{\rho_2}$ unity without noise

*outage probability

$OP_{1=}$ 1- exp (-$\frac{R_1}{(\rho_1-\rho_2 R_1)\rho_2 \delta_1{}^2}$) , $\delta_1 = E|h_1|^2$

*Outage probability of user2 occurs when $SNR_2 < R_1$

When $R_2 = \frac{\rho_2}{\rho_1}$

OP_2 =1- exp (-$\frac{1}{\delta_2{}^2}$ max ($\frac{R_1}{(\rho_1-\rho_2 R_1}$.$\frac{1}{\rho_s}$), ($\frac{R_2}{\rho_2\rho_S}$) ,δ_2 = E $|h_2|^2$

*AF NOMA

$R_{relay=}$h($\sqrt{a_1 . p_T}x_1$+$\sqrt{a_2 . p_T}\,x_2$ +w_r)
(first time slot)

$a_1 + a_2 = 1$, $a_1 > a_2$

Amplify factor β = $\frac{1}{\sqrt{p_r|h_r|^2+\sigma^2}}$ =

*In second time slots after relay amplify the signal and forward it to the destination .The received signal at user1 D1

$Y_1 = \beta\sqrt{P}g_1[h_1(\sqrt{\alpha_1 p_T}\; x_1+\sqrt{\alpha_2 p_T}\; x_2+w_r)]+w_{d1}$

The received signal at user2 D2

Y_{D2} =β$\sqrt{P}g_2$[h($\sqrt{\alpha_1 p_T}$ x_1+$\sqrt{\alpha_2 p_T}$ x_2) +β $\sqrt{p}$ $g_2\, w_r$]+w_{d2}

SNR threshold $\varepsilon_1 = 2^{2R_1}-1$,$\varepsilon_2 = 2^{2R_2}-1$

*Outage probability of D_1 when $\gamma_1 < \varepsilon_1$

$O_{P1} = P_r(\gamma_1 < \varepsilon_1)$

$O_{p1} = p_r[\frac{\alpha_1\rho^2|h_1|^2|g_1|^2}{\alpha_1\rho^2|h_1|^2|g_1|^2+\rho|h_1|^2+\rho|g_1|^2+1} < \varepsilon_1]$

*outage probability of D_2

O_{P2} = 1- $P_r(J_1, J_2)$

$J_1 = \frac{\alpha_1\rho^2|h_1|^2|g_2|^2}{\alpha_2\rho^2|h_2|^2|g_2|^2+\rho|h_2|^2+\rho|g_2|^2+1} \geq \varepsilon_1$

$J_{2=} \frac{\alpha_1\rho^2|h_2|^2|g_2|^2}{\rho|h_2|^2+\rho|g_2|^2+1} \geq \varepsilon_2$

The total equation is

$O_{P2=}$1-P_r ($\frac{\alpha_1\rho^2|h_1|^2|g_2|^2}{\alpha_2\rho^2|h_2|^2|g_2|^2+\rho|h_2|^2+\rho|g_2|^2+1} \geq \varepsilon_1$, $\frac{\alpha_1\rho^2|h_2|^2|g_2|^2}{\rho|h_2|^2+\rho|g_2|^2+1} \geq \varepsilon_2$)

At high SNR , the outage probability at D_1 will become

OP_{D_1} = exp(-$\frac{2\varepsilon_1}{\rho(\alpha_1-\alpha_2\varepsilon_1)}$)

At high SNR , the outage probability at D_2 will become

OP_{D2} = exp (-$\frac{2\varepsilon_2}{\rho\alpha_2}$)

4. Numerical Results

This section examines the downlink AF/DF NOMA systems' throughput, BER, and outage probability under Rayleigh fading channels. In addition to evaluating NOMA, fixed power allocation was used. I set the fixed power allocation factors for NOMA users in the simulations that follow

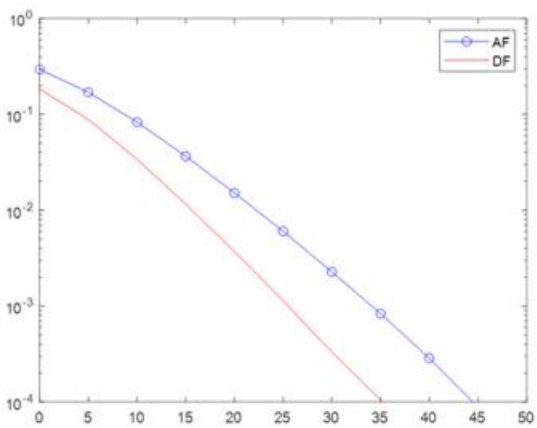

Fig 2. AF/DF cooperative system

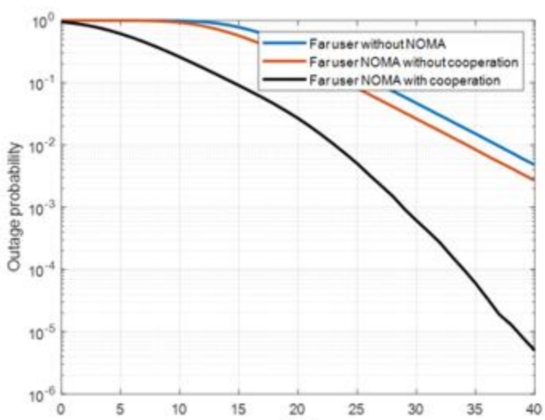

Fig3. Outage performance comparison in C-NOM

In Fig 2 Several threshold SNR parameters for the outage probability versus system SNR are shown. The analytical results can be seen in the high SNR region. performance that the better than AF.

In fig 3. Several thresholds and SNR parameters are given in a plot of system outage probability vs SNR. The findings indicate that the likelihood of an outage lowers as system SNR rises. Another finding is that the likelihood of an outage is lower for distant users who cooperate than for far users who don't..

*THE RESULT OF AF FIXED POWER ALLOCATION

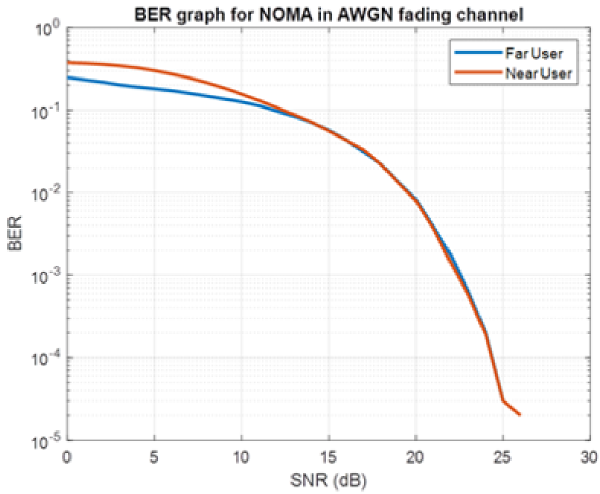

Fig 4. BER Vs SNR(AF)

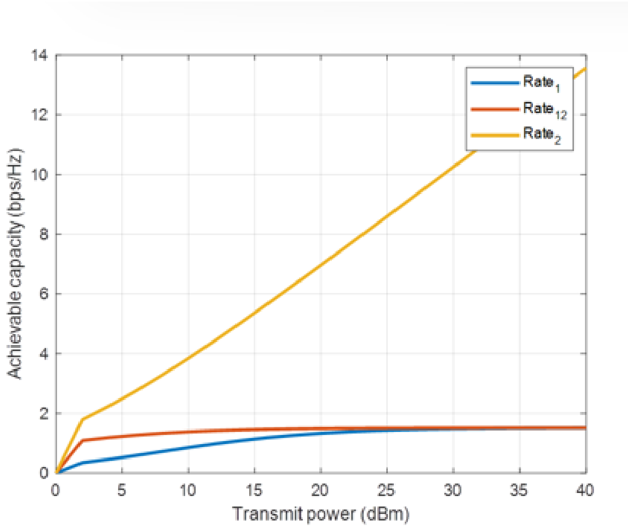

Fig 5. Achievable capacity(AF)

Fig 4. Plot system BER versus SNR is presented in different thresholds SNR parameters. The results shows that as the system SNR increases, the BER increases .

Fig 5. The results showed that the whenever we increase the power of the remote user by 0.65 and near user 0.35. The greater capacity in far user and the relationship between them is direct proportional.

Fig 6. The plot of outage probability shows the increasing in power supply to the far user (0,65) leads to decreasing the outage probability of far user.

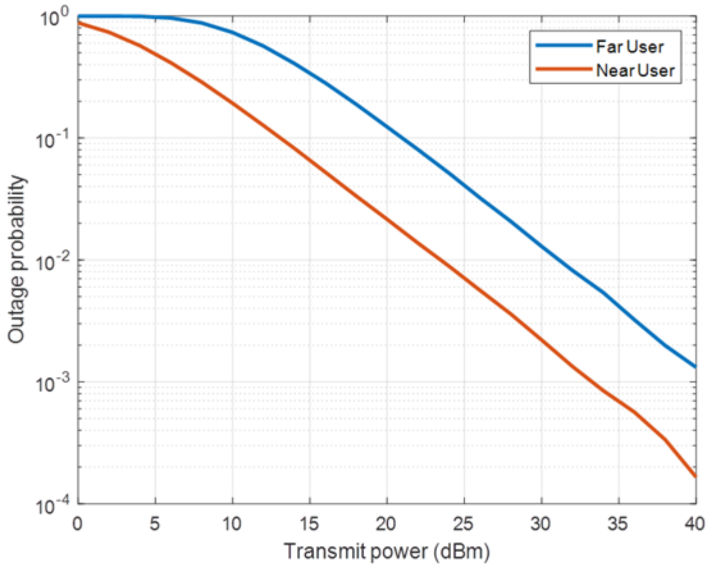

Fig 6. Outage probability (AF)

*The Results of DF Fixed Power Allocation .

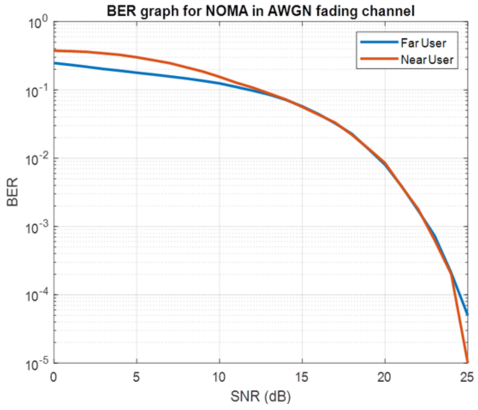

Fig 7. BER Vs SNR

Fig7. BER Vs SNR(DF) .applied DF protocol in different SNR thresholds and the results showed enhancement in BER over AF protocol when supplied the near user with 0.35 power and far user 0.65 power

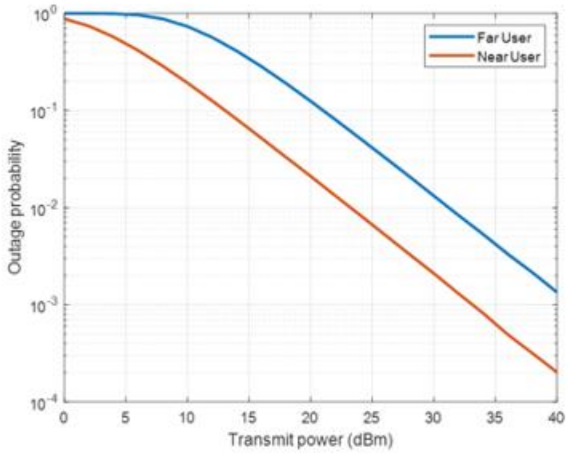

Fig.8 outage probability(DF)

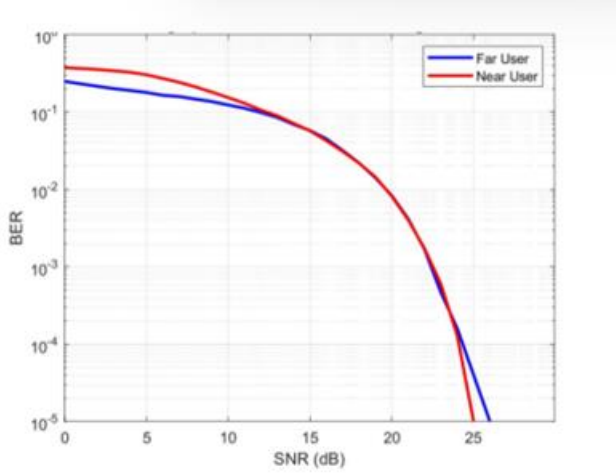

Fig.9 achievable capacity(DF)

In Fig[8,9] the results showed that the outage probability is decreased and achievable rate increased when the power increasing .

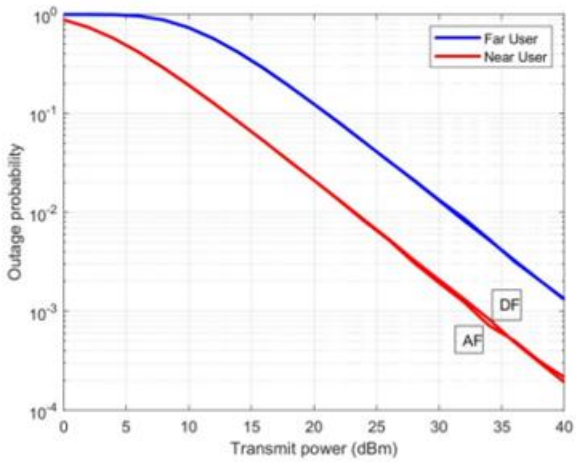

Fig 10. Outage probability (AF/DF)

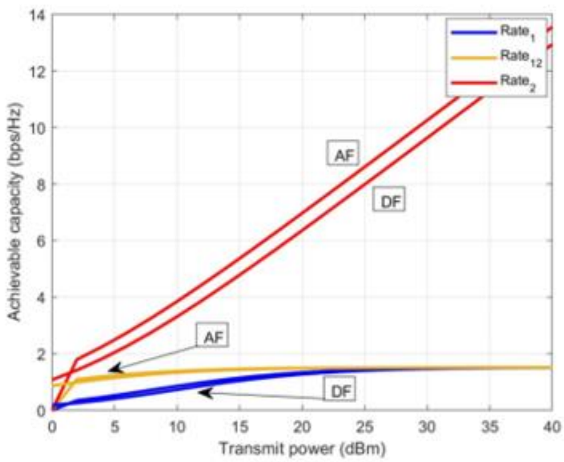

Fig 11. Achievable capacity (AF/DF)

These results in Figs [10,11] showed that when comparison AF /DF , it appears that DF is better than AF.

5. Conclusion

In this research, we suggested a cooperative NOMA scheme for downlink transmission with two users, examined the outage probability, throughput, and BER for the system under AF and DF protocols, and provided a fixed power allocation for DF/AF of the scheme .The simulation findings supported the performance study by showing that the DF protocol performs better than the AF protocol and that performance metrics for both protocols have increased, the system's throughput and BER for the AF and DF protocols. The performance analysis was corroborated by simulation results, which demonstrated that the DF protocol outperforms the AF protocol and that performance measures for both protocols have improved.

References

[1] SHAFI, Mansoor, MOLISCH, Andreas F., SMITH, Peter J., et al. 5G:A tutorial overview of standards, trials, challenges, deployment, andpractice. IEEE Journal on Selected Areas in Communications, 2017,vol. 35, no 6, p. 1201-1221

[2] J. Zeng, J. Sun, Y. Song, J. Mei, T. Lv, and S. Zhou, "Cooperative System," pp. 1–19, 2022.

[3] S. T and S. M N, "Investigation of power allocation schemes in NOMA," Int. J. Electron., vol. 109, no. 1, pp. 169–180, 2022, doi: 10.1080/00207217.2021.1939434.

[4] V. B. Kaba, "Fractional Power Allocation Scheme for NOMA," Int. J. Eng. Res. Technol., pp. 130–134, 2020.

[5] K. T. Nguyen, D. T. Do, X. X. Nguyen, N. T. Nguyen, and D. H. Ha, "Wireless information and power transfer for full duplex relaying networks: Performance analysis," in Proc. Recent Advances in Electrical Engineering and Related Sciences, HCMC, Vietnam, 2015, pp. 53-62.

[6] X. X. Nguyen and D. T. Do, "Maximum harvested energy policy in full-duplex relaying networks with SWIPT," International Journal of Communication Systems (Wiley), vol. 30, no. 17, 2017.

[7] D. T. Do, H. S. Nguyen, M Voznak, and T. S. Nguyen, "Wireless powered relaying networks under imperfect channel state information: System performance and optimal policy for instantaneous rate," Radio engineering, vol. 26, no. 3, pp. 869-877, 2017.

[8] J. Zeng, J. Sun, Y. Song, J. Mei, T. Lv, and S. Zhou, "Cooperative System," pp. 1–19, 2022.

[9] G. Li and D. Mishra, "Cooperative NOMA Networks: User Cooperation or Relay Cooperation?," IEEE Int. Conf. Commun., vol. 2020-June, 2020, doi: 10.1109/ICC40277.2020.9148973.

[10] X. X. Nguyen, D. T. Do, "Optimal power allocation and throughput performance of full-duplex DF relaying networks with wireless power transfer-aware channel," EURASIP Journal on Wireless Communications and Networking, p. 152, 2017.

[11] DING, Zhiguo, DAI, Huaiyu, et POOR, H. Vincent. Relay selection for cooperative NOMA. IEEE Wireless Communications Letters, 2016, vol. 5, no 4, p. 416-419.

[12] LIANG, Xuesong, WU, Yongpeng, NG, Derrick Wing Kwan, et al. Outage performance for cooperative NOMA transmission with an AF relay. IEEE Communications Letters, 2017, vol. 21, no 11, p. 2428-2431.

[13] FANG, Dongfeng, QIAN, Yi, et HU, Rose Qingyang. Security for 5G Mobile Wireless Networks. IEEE Access, 2018, vol. 6, p. 4850-4874.

[14] P. Xu, Y. Yuan, Z. Ding, X. Dai, and R. Schober, "On the outage performance of non-orthogonal multiple access with 1-bit feedback," IEEE Trans. Wireless Commun., vol. 15, no. 10, pp. 6716–6730, Oct. 2016.

[15] M. Ashraf, A. Shahid, J. W. Jang, and K. G. Lee, "Energy harvesting non-orthogonal multiple access system with multi-antenna relay and base station," IEEE Access, vol. 5, 2017.

[16] Z Ding, Z Yang, P Fan, H V Poor. On the performance of non-orthogonal multiple access in 5G systems with randomly deployed users. IEEE Signal Process. Lett., 2014; 21(12): 1501-1505.

[17] HS Nguyen, AH Bui, Dinh huan Do, M Voznak. Imperfect Channel State Information of AF and DF Energy Harvesting Cooperative Networks. China Communications. 2016; 13(10): 11-19.

[18] TL Nguyen, Dinh Thuan Do. A new look at AF two-way relaying networks: energy harvesting architecture and impact of co-channel interference. Annals of Telecommunications. 2017. 72(11): 669-678.

[19] D. T. Do and T. T. T. Nguyen, "Fixed power allocation for outage performance analysis on AF-assisted cooperative NOMA," J. Commun., vol. 14, no. 7, pp. 560–565, 2019, doi: 10.12720/jcm.14.7.560-565.

[20] Z. Ding, M. Peng and H. V. Poor, "Cooperative Non-Orthogonal Multiple Access in 5G Systems," in IEEE Communications Letters, vol. 19, no. 8, pp. 1462-1465,Aug.2015,doi:10.1109/LCOMM.2015.2441064.

[21] Dharmesh D, Natural Language Processing for Automated Document Summarization , Machine Learning Applications Conference Proceedings, Vol 3 2023.

[22] Christopher Davies, Matthew Martine, Catalina Fernández, Ana Flores, Anders Pedersen. Improving Automated Essay Scoring with Machine Learning Techniques. Kuwait Journal of Machine Learning, 2(1). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/173

[23] Kumar, S. A. S., Naveen, R., Dhabliya, D., Shankar, B. M., & Rajesh, B. N. (2020). Electronic currency note sterilizer machine. Paper presented at the Materials Today: Proceedings, 37(Part 2) 1442-1444. doi:10.1016/j.matpr.2020.07.064 Retrieved from www.scopus.com