The International Journal of Engineering and Information Technology

journal homepage:www.ijeit.misuratau.edu.ly

Performance Evaluation of Non Orthogonal Multiple Access (NOMA) with digital modulation schemes

Fathi Masoud
CommunicationsEngineeringDepartment, College of Electronic Technology
Bani-walid, Libya

Abdelbary Mostafa Algamel
2Communications Engineering Department, College of Electronic Technology
Bani-walid, Libya

Abstract— **Non Orthogonal Multiple Access (NOMA) is new significant research area, as it gives novel idea of multiplexing the communication channels on the same frequency and time slot , which can present revolutionary outcomes.**

The general idea of (NOMA) is based on using Successive Interface Cancelling (SIC) , where each user of the channel is distinguished by its unique power level, and then all the users are modulated/demodulated in certain order.

In this study, many experiments are run to examine NOMA with digital modulation schemes, such as ASK, PSK, FSK, QPSK, and 8 QAM. MATLAB codes are built to perform each experiment.

According to the performed simulation, 8-QAM has the lowest Bit Error Rate (BER).

Index Terms: **NOMA, SIC, ASK , PSK, 8-QAM, FSK.**

I. INTRODUCTION

Multiple Access concept is to arrange the users of the channel in order to prevent collision, there are many common ways to perform multiple access, such as Time Division Multiple Access (TDMA) , where the users share the channel in timely sequence, each user has specific time slot. The other common way is Frequency Division Multiple Access (FDMA), where all the users share the channel at the same time but with different frequency bandwidths.

NOMA , on the other hand, put all users in the same time slot with the same frequency bandwidth, and distinguishes between them by their power levels, which means, each user must have unique power level, leading to save large amount of frequency resources (great spectral efficiency). [7]

A. Successive Interfasce Cancelling

SIC is a method uses sequence modulation/demodulation order, according to the power level of the user.

SIC is the main used technique in NOMA, where every user is dedicated by a portion of power, the first user takes high percentage of the total transmitting power, say

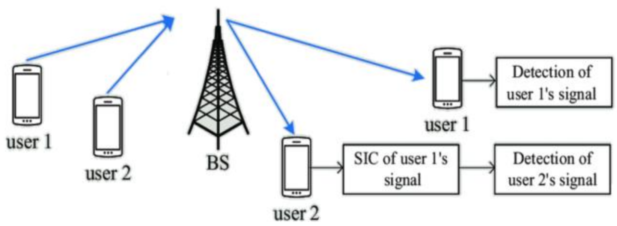


Figure 1. Diagram representation of NOMA

80%, the other users shares the remaining in same manner, one of them takes 80% (of the remaining 20%) and so on.

All users are modulated/transmitted on the same frequency carrier and during the same time.

At the receiver, each user knows its turn, first one considers only the first message with the highest power, the remaining messages are just noise, therefore, the demedulation is performed immediately.

The second user takes a copy of the whole message, and demodulate it to recover the first message, and then substract it from the copy of original one, the result is demodulated for the second message, as the rest of the messages is cosidered to be noise. The same sequence continous until the last user. [8]

Received 2 Oct , 2021; revised 3 Nov, 2021; accepted 7 Nov, 2021.

Available online 19 Nov, 2021.

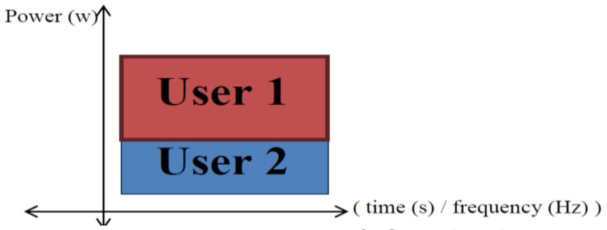


Figure 2. Power Domain Multiplexing (PDM)

B. Related Studies

The advantages of NOMA for heterogeneous networks are studied in [1], [2]–[3], the study shows that Cellular System can serve more users with high spectral efficiency using NOMA theory.

In [4]–[5], Machine-to-Machine (M2M) communications, Ultra-Dense Networks (UDN), and massive machine type communications (MTC) are studied, they proved that using NOMA can successfully improve connectivity of 5G.

In [6] NOMA is adopted with Content caching, as a significant method, which is concluded as a frequency efficient scheme to relay content to customers. [7]

II. RESULTS

To avoid complexity, only two users are considered in Rayleigh fading channel, the first user is assigned with 80% of the total power, while the other user has the remaining 20%.

A. Phase Shift Keying Modulation

In PSK, each signal is represented by a unique phase in the carrier signal [9], the following figure shows its performance with NOMA.

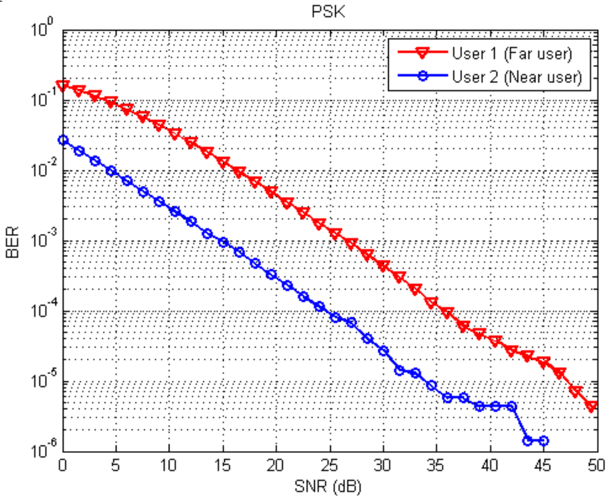


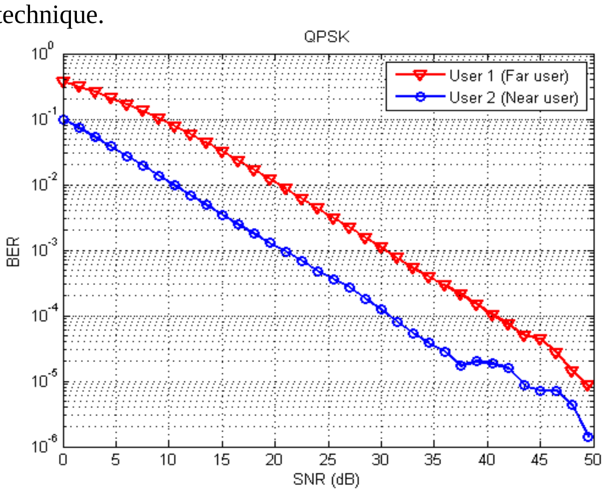
Figure 3. Two PSK users using NOMA.

Figure 3 shows that user2 at 25 dB, BER is 0.00001

B. Quadrature Phase-Shift Keying Modulation

In QPSK, the signal modulates both the phase and the amplitude of the carrier. [9]

Figure 4 shows BER curve versus SNR using NOMA technique.



At 45 dB user2 has BER=0.00001

Figure 4. Two QPSK users using NOMA.

C. Frequency Shift Keying

In FSK, the signal modulates the carrier frequency. [9]

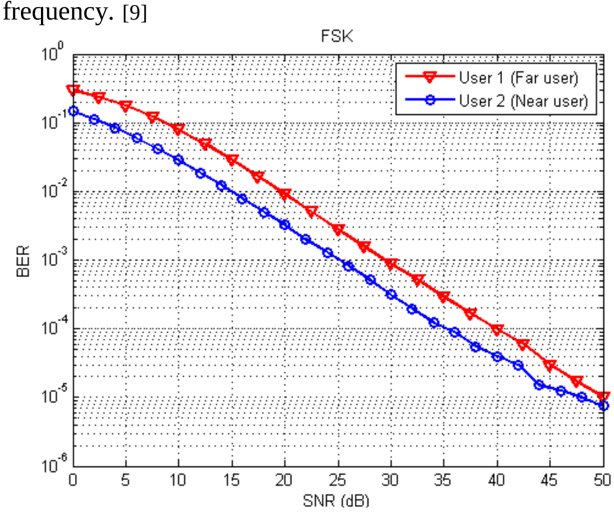


Figure 5. Two FSK users using NOMA

At 45 dB user2 has BER=0.00001

D. Amplitude Shift Keying

Changes in the signal causes changes in the carrier amplitude. [9]

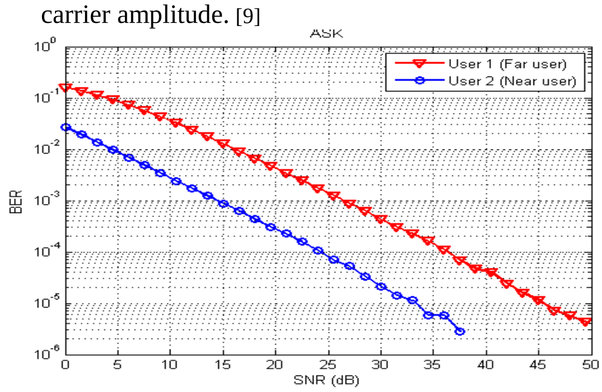


Figure 6. Two ASK users using NOMA

At 33 dB user2 has BER=0.00001

E. 8 QAM

This scheme has two possible amplitudes and four possible phases, each carrier represents three bits. Fig. 6 shows all the modulation schemes on the same graph for comparison. [9]

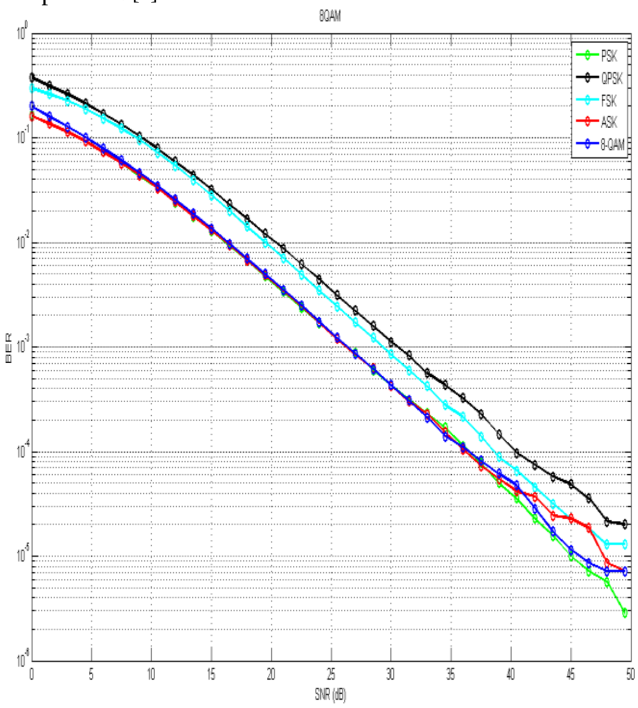


Figure 7. All schemes on the same Graph

PSK is represented by the orange curve, it can be seen that it is almost identical with the blue curve, 8QAM, , and both of them have the lowest Bit Error Rate , number of erroneous bits in the received stream.
ASK, with red line, is a little above the lowest two, which means it has a lower performance, and then, we have FSK, and QPSK respectively.

Since 8 QAM maps three bits to each signal carrier, while the other schemes maps only one bit to each signal carrier, therefore, 8 QAM has the most effiecient performance according to our experiment.

III. CONCLUSION

Simulation experiments have been run by Matlab, in order to test the performance of NOMA with PSK, 8QAM, ASK, FSK, and QPSK modulation schemes.
The evaluation is based on Bit Error Rate, the case of lowest BER is considered to be the best.

8-QAM assigns three bits to each carrier, while the other systems assigns only one bit, generally, it could be noted from Figure 6 that all systems are almost have the same BER, therefore, it can be concluded that 8-QAM has triple performance as the others, because three bits are carried by each signal carrier.

ACKNOWLEDGMENTS

The authors wish to thank CETB staff for their valuable help and support.

BIOGRAPHY

FATHI.M.MASOUD received his Master in systems and signals area from West Virginia University in 2012. He joined CETB as lecturer and Head of Training Department in 2013. Then as the General Registrar in 2017 Also worked as Telecom Specialist for ENI GAS Company from 2003 to 2009 and attended enhancing intensive courses in ALCATEL company/Italy in 2003.

Abdelbary Mostafa Algamel student in College of Electronic Technology,Bani-walid, in Communications Engineering Department, Also Researcher at (UNDP)

REFERENCES

[1] Y. Liu, Z. Ding, M. Elkashlan, and J. Yuan, *"Nonorthogonal multiple access in large-scale underlay cognitive radio networks*," *IEEE Trans. Veh. Technol.*, vol. 65, no. 12, pp. 10152–10157, Dec. 2016.

[2] Z. Zhang, Z. Ma, M. Xiao, and P. Fan, "*Modeling and analysis of nonorthogonal MBMS transmission in heterogeneous networks*," *IEEE J. Sel. Areas Commun.*, to be published.

[3] B. Xu, Y. Chen, J. R. Carrion, and T. Zhang, "*Resource allocation in energy cooperation enabled two-tier NOMA hetnets towards green 5G,*" *IEEE J. Sel. Areas Commun.*, to be published.

[4] M. Shirvanimoghaddam, M. Condoluci, M. Dohler, and S. J. Johnson, "*On the fundamental limits of random non-orthogonal multiple access in cellular massive IoT*," *IEEE J. Sel. Areas Commun.*, to be published.

[5] Y. Du *et al.*, "*Multi-user detection for uplink grant-free NOMA with prior-information aided adaptive compressive sensing*," *IEEE J. Sel. Areas Commun.*, to be published.

[6] Z. Zhao, M. Xu, Y. Li, and M. Peng, "*A non-orthogonal multiple access (NOMA)-based multicast scheme in wireless content caching networks*," *IEEE J. Sel. Areas Commun.*, to be published.

[7] Zhiguo Ding, Senior Member, IEEE, Xianfu Lei, Senior Member, ," *A Survey on Non-Orthogonal Multiple Access for 5G Networks: Research Challenges and Future Trends*", IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 35, NO. 10, OCTOBER 2017.

[8] Dehuan Wan, Miaowen Wen, Fei Ji, Hua Yu, and Fangjiong Chen "*Non-Orthogonal Multiple Access for Cooperative Communications: Challenges, Opportunities, and Trends*". IEEE Wireless Communications • April 2018

[9] John G.Proakis, and Masoud Salehi , "*Digital Communications*" ,fifth edition, MC Graw-Hill 2001.