Indonesian Journal of Electrical Engineering and Informatics (IJEEI)
Vol. 12, No. 3, September 2024, pp. 700~710
ISSN: 2089-3272, DOI: 10.52549/ijeei.v12i3.5670

Novel Polar Coded MIMO Power Domain NOMA Scheme for 5G New Radio (NR)

B Pavithra[1], Parnasree Chakraborty[2]
[1, 2] Department of ECE, B.S.Abdur Rahman Crescent Institute of Science and Technology, Vandalur, India-600048.

Article Info

Article history:

Received Jun 28, 2024
Revised Sep 21, 2024
Accepted Sep 25, 2024

Keyword:

Polar codes
MIMO-NOMA
5G
Channel coding
Power Domain NOMA.

ABSTRACT

The use of Polar coded Multiple Input Multiple Output Power Domain Non-Orthogonal Multiple Access (MIMO PD-NOMA) technology has the potential to greatly improve the capacity and spectral efficiency of 5G NR systems. From the on-going research, there is a combination of polar coded NOMA and Polar coded MIMO techniques are approached separately with other channel coding techniques. This paper introduces a novel approach to combine polar coded with MIMO power domain NOMA to enhance the system performance. MIMO Power Domain NOMA that utilizes polar codes for channel coding and power allocation. By combining the benefits of NOMA and MIMO, which permits multiple users to share frequency-time resources simultaneously and the MIMO employs multiple antennas to increase diversity gain and spatial multiplexing gain. The proposed scheme provides effective utilization of radio resources where the polar codes are an optimal choice for 5G NR systems due to their strong error correction capability and low complexity decoding. Successive Cancellation List -Singular Value Decomposition adaptive scaling algorithm (SCL-SVD) is proposed in the polar decoding process. The suggested method attains 6.5 dB coding gain and improved throughput of 95.90% using MATLAB simulation. The proposed model compared with the other existing model such as Power Domain NOMA (PD-NOMA), multiple input single output NOMA (miso-NOMA) and multiple input multiple output NOMA (mimo-NOMA) in terms of Bit Error Rate (BER) and Signal to Noise Ratio (SNR). This scheme has the potential for practical implementation and can play a crucial role in meeting the increasing demands of future wireless communication systems.

Corresponding Author:

Dr.Parnasree Chakraborty
Associate Professor,
Department of ECE,
B.S.Abdur Rahman Crescent Institute of Science and Technology, Vandalur-600048, India
Mail Id: prernasree@crescent.education
ORCID: 0000-0003-1093-0685

1. INTRODUCTION

Polar coding is an error correction technique proposed by Arikan in 2009, stands out for its robust error correction capability with low-complexity decoding. The channel polarization method, proposing it for constructing Sequences of code that achieve the symmetric capacity $I(W)$ for any specified discrete memoryless channel with binary input (B-DMC) denoted as W [1].The recent trend involves exploring the synergies among these advanced techniques to further amplify the performance of 5G NR systems.

Arikan's Polar codes, acknowledged as a major breakthrough in channel coding, leverage the mathematical concept of polarization to transform binary channels into two perfectly reliable channels and two completely unreliable channels. By constructing a code from a subset of reliable channels, polar codes attain the capacity of the channel and have been chosen as the coding scheme for the control channels in the 5G New Radio (NR) standard, owing to their superior performance in comparison to alternative coding schemes. The authors explore various methods to enhance the performance of their codes for a finite length. Additionally, we examine the effectiveness of these codes in single-user scenarios and distributed applications within the context of both lossless and lossy source coding [2]. The authors provided the overview of polar codes, including their principle, generation, and decoding techniques, as well as the concept of channel polarization and decoding algorithms at the forefront of technology. It also discusses the performance of polar codes coupled with CRC codes compared to other types of codes [3]. The authors reviewed the state of the art in polar decoders, including different decoding algorithms, their advantages, and the construction and limitations of polar codes [4]. The authors presented findings that establish the superiority of MIMO-NOMA over MIMO-OMA in overall channel capacity, excluding single-user communication scenarios [5]. In another study [6], the authors compared NOMA with conventional OMA in MIMO channels.

The fifth-gen (5G) NR wireless communication system is meticulously designed to cater to the growing requirements for elevated data speeds, increased capacity, and enhanced accuracy in mobile communication networks. Advanced techniques for instance, technologies like Multiple Input Multiple Output (MIMO), Non-Orthogonal Multiple Access (NOMA) and Polar coding have been proposed to achieve these ambitious goals. MIMO technology utilizes multiple antennas for both signal transmission and reception, thereby elevating diversity gain and spatial multiplexing gain to yield higher data rates and improved reliability. Conversely, NOMA facilitates numerous users sharing identical time-frequency resources, effectively boosting the overall system capacity.

The paper's structure is as follows: Section 1.1 delivers a concise review of polar codes and NOMA related works. Section 2 gives an in-depth account of the proposed scheme, covering aspects such as polar coding, SIC and SCL-SVD decoding. Simulation results and performance analysis information regarding the proposed scheme is elucidated in Section 3. The paper concludes in Section 4, summarizing key points and suggesting future research directions.

1.1. RELATED WORKS

MIMO NOMA represents a promising multiple access approach, incorporating superposition coding and successive interference cancellation (SIC) to enhance spectral efficiency in 5G communication systems. MIMO NOMA surpasses traditional orthogonal multiple access techniques (OMA) for optimizing spectral efficiency. Channel polarization is introduced as a method to construct code sequences, optimizing binary-input discrete memoryless channels. The adaptability of NOMA, particularly in power-domain multiplexing, further underscores its advantages over existing techniques. As the 5G NR system continues to evolve, the exploration of synergies among these advanced technologies remains a focal point. The intricate balance of MIMO, NOMA, and Polar coding is poised to unlock new frontiers in wireless communication, paving the way for a future where high data rates, increased capacity, and improved reliability become the standard in mobile networks.

Z. Ding et al. [7] highlight that the NOMA principle functions as a comprehensive framework, with various recently suggested 5G multiple access schemes considered as specific instances. The overview encompasses the latest research, innovations, and applications of NOMA. Y. Liu et al. [8] underscore the advantages of power-domain multiplexing NOMA, address challenges in existing research, propose solutions, and offer design guidelines with future research opportunities. A. Mohan et al. [9] reviewed polar codes, devised by Erdal Arikan, stand as error correction codes that accomplish channel capacity reduced complexity, and they have great potential in 5G technology.

C. Chen et al. [10] employ NOMA in their paper, which is utilized to boost the attainable sum rate in MIMO enabled visible light communication systems with multiple users. J. Dai et al. [11] introduce polar codes in incorporating NOMA into 5G systems entails extending channel polarization to NOMA. The proposed PC-NOMA scheme dissects the NOMA channel into binary-input channels through a two-stage polarization transform. X. Deng et al. [12] employ polar codes in OFDM-IDMA for enhanced performance, introducing a joint detection and decoding (JDD) scheme, along with a sign-aided JDD (SA-JDD) approach for increased efficiency.

Y. Li et al. [13] proposed a theoretical framework, PC-GFDM, to optimize binary polar coding and GFDM modulation for efficient interference coordination in GFDM systems. Z. Gao et al. [14] explore enhancing reliability and reducing complexity in next-gen wireless communication, focusing on VLC and NOMA. It introduces a low-complexity polarization coding scheme for improved performance. W. A. Al-Hussaibi et al. [15] proposed a cutting-edge massive MIMO NOMA employing receive antenna selection in the uplink channel to enhance connectivity, sum rate, user-fairness, and reduce complexity. Hemlata Marne et al. [16] proposed an integrated bio-inspired algorithm to improve channel estimation in OFDM–IDMA systems. Ngu War Hlaing et al. [17] explored the efficacy of an MIMO-NOMA system employing LDPC codes, a prospective multiple access solution for fifth-generation technology.

V. Bioglio et al. [18] outlines 5G-standard polar code encoding, addressing challenges in designing a family for 5G system demands, emphasizing rate flexibility, low decoding latency, and presenting a framework with novel coding techniques for solid NR channel coding. Ce Sun et al. [19] introduced a polar encoding scheme within a MISO system for the non-degraded wiretap channel. In this approach, simulated interference is produced at the base station to obscure the unauthorized listener's channel using transmit beamforming. F. Ivanov et al. [20] introduced an enhancement to SCL-Flip decoding for polar codes, proposing a unique bit selection metric for critical sets based on the path metric of SCL decoding. Hongfei Zhu et al. [21] proposed a spectrum of distances algorithm based on SCL polar decoder for rate-compatible codes to estimate ML decoding in in codes with puncturing and shortening modifications.

O. P. Babalola et al. [22] proposed the CWPC-OSTBC scheme, integrating constant weight (CW) polar code with orthogonal space time block code (O-STBC), for indoor MIMO-VLC systems. M. C. Coşkun et al. [23] demonstrated through simulations, that the probability distribution functions (p.d.f.s) of the logarithmic values across Binary Erasure Channel centralize around the estimated mean as the block length of modified RM codes increases. Zaki, A.I. et al [24] proposed the system combines diversity in time with NOMA to enhance the error rate performance of the system. Rouchi Chen et al. [25] developed a polar-coded underwater communication system employing orthogonal frequency division multiplexing for acoustic transmission, enhancing performance with a Monte Carlo method for optimal polar code construction in a shallow-water acoustic channel. M. Meenalakshmi et al. [26] proposed the novel CNN-CENet which is incorporated into the MIMO-OFDM receiver with polar coding to tackle challenges posed by interference and noise in 5G systems.

Polar codes emerge as a prominent theme throughout the literature. This error correction code is recognized for achieving channel capacity with reduced complexity, showcasing their great potential in 5G technology. Researchers proposed and investigated novel schemes that integrate polar codes with different communication technologies, such as OFDM-IDMA, visible light communication, and MIMO systems. Moreover, the studies address challenges of advanced decoding schemes in existing research and proposed solutions, providing design guidelines and future research opportunities. In summary, the literature collectively contributes to the advancement of communication systems by presenting innovative solutions, exploring various applications of NOMA and polar codes, and addressing challenges in the rapidly evolving landscape of 5G technology.

To our knowledge, this work presents several significant contributions in various key areas. Specifically, it enhances the understanding of channel coding with MIMO NOMA for optimizing 5G multiple access schemes. The following contributions are made in this paper:

1. Evaluate the performance of combined polar codes with MIMO NOMA without increasing system complexity. This is in contrast to existing literature, which employs alternative techniques with limited constraints.
2. Introduce a modified polar decoding algorithm utilizing SCL-SVD adaptive scaling of codeword length up to 1024. In comparison, existing literature lacks practical implementation of decoding techniques.
3. Perform a comprehensive analysis of the suggested architectures in contrast to the standalone polar code employed in 5G. Evaluate both scenarios with and without polar coded transmission, showcasing the efficacy of the modified scheme in addressing data distortion caused by tangible transmission interference. The overall representation of the system model is shown in Figure 1.

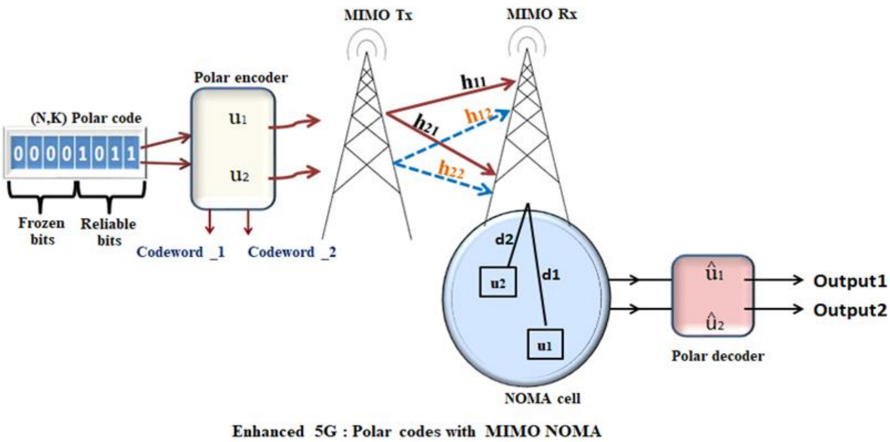

Figure 1. General representation of the proposed system model

2. MODIFIED POLAR CODED SYSTEM MODEL

The spectral efficiency in 5G NR can be improved by utilizing a polar coded MIMO NOMA scheme, which combines polar codes, MIMO, and power domain NOMA. This section will provide a detailed explanation of the modified algorithm and the flow diagram of the system model for the proposed scheme is represented in Figure 2.

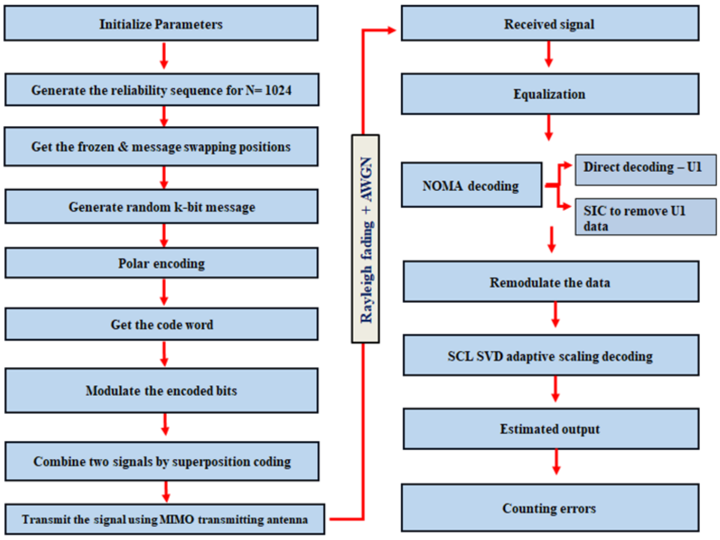

Figure 2. Flow diagram of the proposed system

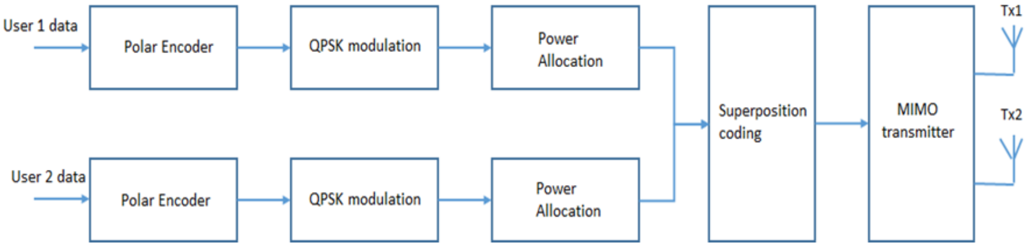

Figure 3. Proposed polar coded MIMO NOMA transmitter model

From Figure 3, The transmitted signal vector of user 1 and user 2 can be described as follows:

$$X_1 = m_1 + m_2 + \cdots + m_k \tag{1}$$

$$X_2 = m_1 + m_2 + \cdots + m_k \tag{2}$$

For user 1 and 2, the transmitted random message data is represented as X_1 and X_2 corresponds to (N,k) polar codes, where N represents codeword length and k represents message bit length. These signal vectors X_1 and X_2 undergo encoding with polar codes to facilitate error correction and are subsequently modulated using the QPSK modulation scheme. The modulated bits are denoted as u_1 and u_2 for two users. Following the steps of polar encoding and modulation, the system implements the NOMA concept. This involves superposition coding for the transmitted signal and successive interference cancellation decoding of the received signal, as indicated by the provided equation.

The superposition coded signal is denoted by,

$$S = \sqrt{p}\sqrt{a_1}u_1 + \sqrt{p}\sqrt{a_2}u_2 \tag{3}$$

In the above given equation $\sqrt{p}$ represents the overall transmit power ($\sqrt{p} = 1$), where a_1 and a_2 signifies the power allocation for user 1 (weak user = far user) who is allocated additional more power and user 2 (strong user = near user) who is assigned reduced power (Given that $a_1 > a_2$ specified in section 4 table1).

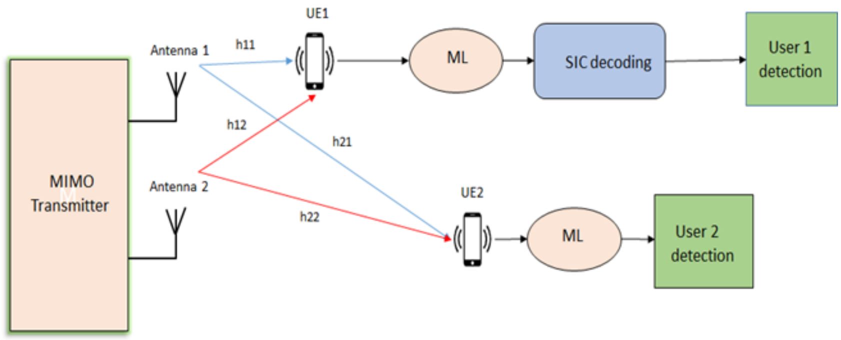

Figure 4. (2 x 2) MIMO Power Domain NOMA system model

From Figure 4, the received signal R_i, the supercoded signal S is multiplied by the (2 x 2) MIMO channel matrix H_i along with the addition of Rayleigh fading coefficients h_1 & h_2 and AWGN noise n, where i denotes the number of users.

$$R_i = H_i S + n \tag{4}$$
$$H_i = h_1 + h_2 \tag{5}$$
$$h_1 = h_{11} + h_{21} \tag{6}$$
$$h_2 = h_{12} + h_{22} \tag{7}$$

In below Figure 5 represents the received signal for two users after Maximum Likelihood estimation and NOMA decoding process can be expressed as,

$$z_1 = h_1 R_1 + n \tag{8}$$
$$z_2 = h_2 R_2 + n \tag{9}$$

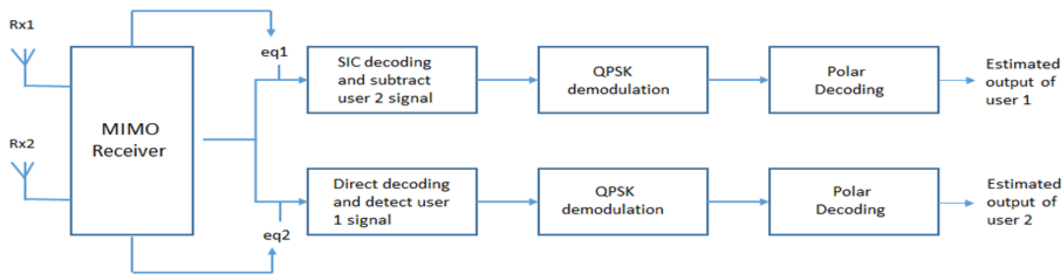

Figure 5. Proposed polar coded MIMO NOMA Receiver model

Each user's contribution to the received signal is scaled by its respective singular value from the SVD decomposition:

$$H = U.\sum.V^T \tag{10}$$

The NOMA decoding with SVD adaptive scaling can be expressed as,

$$y = H.[R_1, R_2]^T \tag{11}$$
$$y_1 = U_1^T.R_1.\sigma_1 + U_2^T.R_2.\sigma_2 + n \tag{12}$$
$$y_2 = U_1^T.R_1.\sigma_1 + U_2^T.R_2.\sigma_2 + n \tag{13}$$

The adaptive scaled signal can be expressed as,

$$\text{Scaled signal 1} = A_1.y_1 \tag{14}$$
$$\text{Scaled signal 2} = A_2.y_1 \tag{15}$$

The soft decision updates using SVD and Adaptive scaling is denoted by,

$$\tanh\,(\text{term1}) = \left\{\frac{Scaled\ Signal\ 1}{2}\right\} \tag{16}$$

$$\tanh\,(\text{term2}) = \left\{\frac{Scaled\ Signal\ 2}{2}\right\} \tag{17}$$

$$llr_1 = A_1.log\left\{\frac{1+\tanh\,(\text{term1})}{1-\tanh\,(\text{term1})}\right\} \tag{18}$$

$$llr_2 = A_2.\log\left\{\frac{1+\tanh\,(\text{term2})}{1-\tanh\,(\text{term2})}\right\} \tag{19}$$

$$llr_1 = llr_2 = A.(y_1 + y_1) \tag{20}$$

The Successive Cancellation List polar decoding algorithm employs a recursive process of eliminating unreliable bits and adjusting Log-Likelihood Ratios (LLRs) until the initial information bits are recovered through SCL SVD. Successive Cancellation List (SCL) Decoding improves polar code decoding performance by considering a list of possible decoding paths rather than a single path. SCL decoding checks multiple codeword candidates and selects the one with the highest likelihood, improving error correction.

In adaptive scaling, the variable A typically represents a scaling factor that is used to adjust the reliability or weights of the soft decision values received during decoding. After decoding, final LLRs (log-likelihood ratios) guide the decision-making process to obtain decoded bits. By adjusting the LLRs according to the current channel conditions, adaptive scaling allows the decoder to more accurately assess the reliability of each bit, enhancing error correction performance. The combination of polar codes with SCL SVD adaptive scaling decoding improves error correction, leading to a lower bit error rate (BER). A lower BER increases coding gain, as the system can operate closer to the Shannon limit while preserving data integrity. The algorithm also boosts throughput by minimizing the overhead needed for error correction or retransmissions. With the improved error correction provided by adaptive scaling, the method not only lowers the BER and increases coding gain but also maximizes bandwidth usage, resulting in higher throughput.

3. PERFORMANCE EVALUATION OF THE PROPOSED SYSTEM

This paper introduces a novel approach for 5G NR communication systems, particularly emphasizing polar coded MIMO NOMA. We assess the performance of the modified algorithm, analysing its effectiveness in comparison to conventional schemes like SISO-NOMA (single input single output), MISO-NOMA (multiple input single output), and MIMO-NOMA. Detailed simulation parameters and results are provided in subsequent sections.

Table 1. Simulation Parameters of polar coded MIMO power domain NOMA

S.NO	PARAMETERS	SPECIFICATIONS
1	Number of Users	2
2	Bandwidth	1GHz (5G NR FR1 sub 6GHz)
3	Distance	$d_1 = 500\ m$ (weak user) $d_2 = 200\ m$ (strong user)
4	Assigned power	$a_1 = 0.75\%$ $a_2 = 0.25\%$
5	Coding	Channel coding: Polar encoding and successive cancellation List(SCL-SVD) with adaptive scaling decoding, NOMA: Superposition coding and Successive Interference Cancellation Decoding (SIC)
6	Codeword length and code rate	1024 and 0.5
7	Modulation used	QPSK
8	Fading model	Rayleigh Fading with AWGN noise
9	No. of Antennas	(2 x 2) MIMO
10	Equalization	Maximum Likelihood(ML)

Table 2. Algorithm of modified polar coded MIMO NOMA

Input : Define (N, k) polar code where, N - codeword Length and k - information length, CRC Len=11, code rate = k/N, List size = 4;

Output : Reduced BER and increased throughput (N, k, CRC)

1. Get the reliability sequence for N.
2. Generate random k bit message and get the codeword by polar encoding.
3. Do QPSK bit to symbol conversion, use superposition coding of NOMA and transmit the signal through 2x2 MIMO antennas.
4. Receive the signal with AWGN.
5. Separate the supercoded signal with NOMA SIC decoding procedure and receive the output.
6. Using SVD adaptive scaling algorithm to get soft decision updated LLRs.
7. Decode the output using SCL decoding with updated LLRs and count the errors.

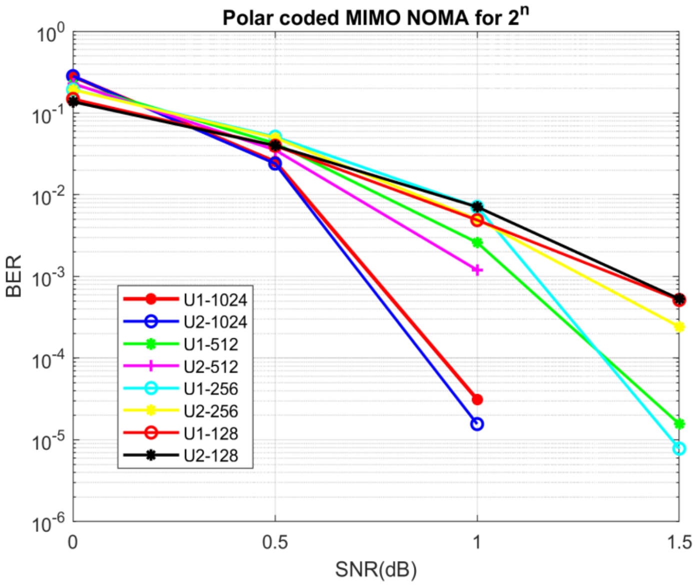

Figure 6. Polar coded MIMO NOMA for 2^nrandom binary sequence

In Figure 6, the polar coded signal for 2^{10} (i.e.1024) attains reduced bit error rate when compared with2^9, 2^8, 2^7 (i.e. 512, 256, 128) for both user 1 and user 2.

Table 3. BER performance evaluation of codeword length (N = 1024, k = 512)

BER of NOMA		**BER of MISO NOMA**		**BER of MIMO NOMA**		**BER of Conventional Polar code (Ref [27])**		**BER of Modified Polar coded MIMO NOMA**	
u_1	u_2	u_1	u_2	u_1	u_2	u_1	u_2	u_1	u_2
0.4950	0.4895	0.4785	0.4502	0.3834	0.3674	0.2300	0.3088	0.2810	0.2832
0.4914	0.4814	0.4590	0.4375	0.2342	0.2238	0.0600	0.0325	0.0254	0.0241
0.4851	0.4681	0.4287	0.3896	0.1121	0.1078	0.0038	0.0025	3.1250e-05	1.562e-05
0.4738	0.4491	0.3848	0.2832	0.0439	0.0625	0.0005	0.0007	4.5260e-05	2.1250e-06
0.3649	0.3062	0.1445	0.0195	0.0051	0.0081	0.00001	0.00003	5.1250e-07	4.9730e-08

Table 3 provides a thorough comparison of BER values for PD-NOMA, MISO PD-NOMA, MIMO-PD-NOMA, and the proposed Polar coded MIMO-PD-NOMA are presented at varying signal-to-noise ratios

(SNRs). The Polar coded MIMO NOMA consistently outperforms other schemes in different SNR conditions for both users, exhibiting superior performance. The BER performance comparison is visualized in Figure 7 for individual users and in Figure 8 for an overall assessment through simulation results.

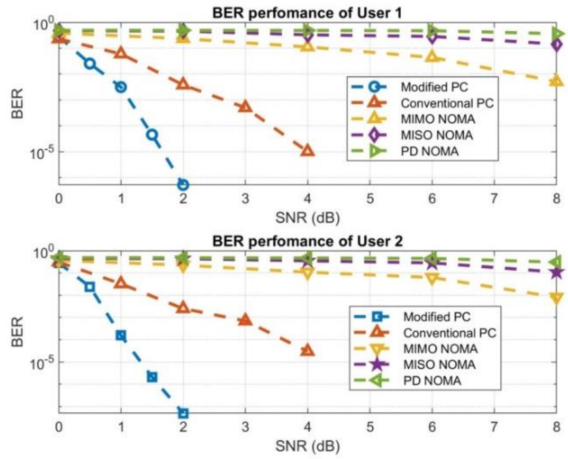

Figure 7. BER performance comparison of user 1 and user 2

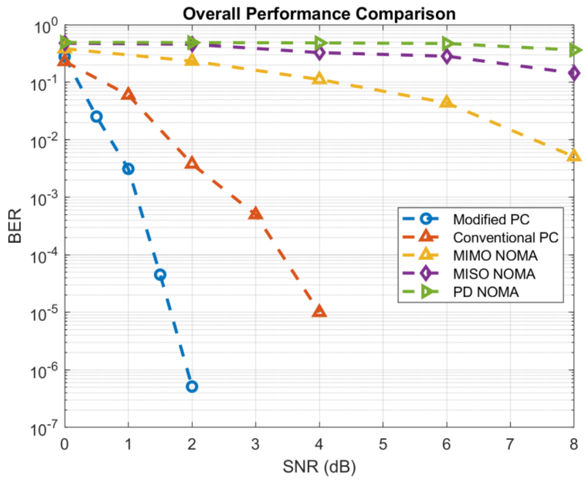

Figure 8. Overall BER performance comparison

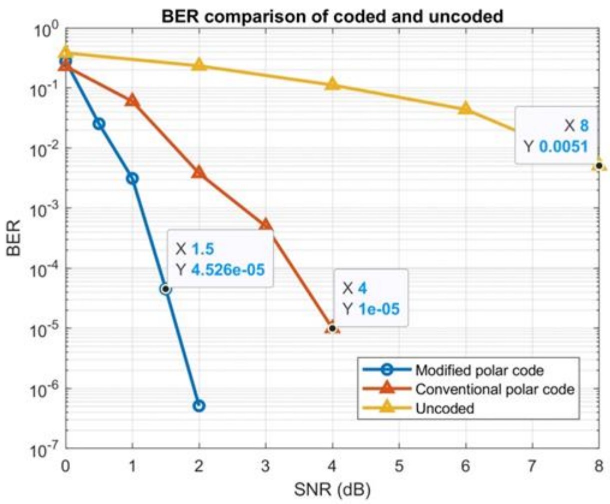

Figure 9. Performance evaluation of proposed and existing codes

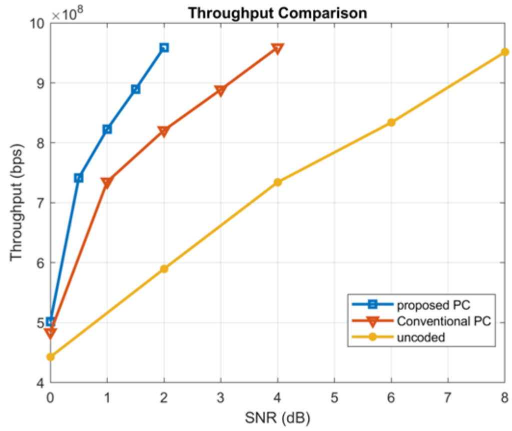

Figure 10. Comparison of proposed polar coded MIMO NOMA with uncoded NOMA

Table 4. Performance comparison

Code	**Throughput** **T = C * (1-BER)**	**Coding Gain (dB)** **(SNR uncoded – SNR coded)**
Proposed polar code (code length = 1024)	0.9590 Gbps @2 dB SNR	(8-1.5) = 6.5
Existing polar code (code length = 1024)	0.8208 Gbps @2 dB SNR	(8-4) = 4

Table 4 outlines a thorough performance evaluation between the proposed polar code and an existing counterpart from Figures 9 and 10, each featuring a code length of 1024. The proposed polar code achieves a notably higher throughput (based on the Shannon capacity C) surpassing the existing polar code. This substantial improvement underscores the efficacy of the proposed polar code in facilitating efficient data transmission. Moreover, the coding gain reinforces the superiority of the proposed code exhibiting a 6.5 dB coding gain from the 4 dB coding gain of the existing polar code. The coding gain is calculated by the difference of uncoded and coded SNR (dB) values.

The results illustrates the broad applicability of the proposed Polar coded MIMO-PD-NOMA in various telecommunications scenarios. The consistent outperformance of this coding scheme evidenced by lower BER values across different SNR levels and significantly enhanced throughput compared to existing polar codes demonstrates its robustness in diverse channel conditions. Notably, the substantial coding gains achieved (6.5 dB versus the 4 dB of existing methods) underscores its effectiveness in optimizing data transmission. These findings indicate that the proposed polar code has the potential for widespread application in different environments, likely leading to improved performance in real-world telecommunications.

4. CONCLUSION

This paper suggested a novel adaptation known as the modified polar coded MIMO NOMA for deployment as a channel coding technique in 5G NR communication systems. The modified algorithm outperforms the traditional polar code, showcasing an impressive 2.5dB approximately increase in coding gain at 10^{-5} BER. In this paper, we assessed and compared the Error Rate - BER performance of various schemes that have been validated to attain the Gigahertz transmission limit. When scrutinized at a SNR of 2 dB within a 1 GHz bandwidth (aligned with the 5G NR frequency range of FR1 covering 450 MHz to 6 GHz), the proposed configuration attains a peak throughput of around 0.95 Gbps. The integration of polar codes with MIMO NOMA preserves a manageable level of complexity. However, it is crucial to acknowledge that further exploration and refinement are necessary for the modified polar coded MIMO NOMA scheme.

Future Work:

Future work includes integrating emerging 6G technologies, leveraging AI-driven optimization, and exploring larger MIMO configurations, increasing the number of users in the NOMA setup and hybrid modulation techniques for further enhancing the proposed polar-coded MIMO power domain NOMA scheme in 5G NR.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

REFERENCES

[1] E. Arikan, “Channel polarization: A method for constructing capacity-achieving codes for symmetric binary-input memoryless channels,” *IEEE Trans. Inf. Theory*, vol. 55, no. 7, pp. 3051–3073, 2009, doi: 10.1109/TIT.2009.2021379.

[2] N. Hussami, S. B. Korada, and R. Urbanke, “Performance of polar codes for channel and source coding,” in *IEEE International Symposium on Information Theory - Proceedings*, 2009, pp. 1488–1492. doi: 10.1109/ISIT.2009.5205860.

[3] K. Niu, K. Chen, J. Lin, and Q. T. Zhang, “Polar codes: Primary concepts and practical decoding algorithms,” *IEEE Commun. Mag.*, vol. 52, no. 7, pp. 192–203, 2014, doi: 10.1109/MCOM.2014.6852102.

[4] P. Giard *et al.*, “Hardware decoders for polar codes: An overview,” in *Proceedings - IEEE International Symposium on Circuits and Systems*, May 2016, vol. 2016-July, pp. 149–152. doi: 10.1109/ISCAS.2016.7527192.

[5] Y. Liu, G. Pan, H. Zhang, and M. Song, “On the capacity comparison between MIMO-NOMA and MIMO-OMA,” *IEEE Access*, vol. 4, pp. 2123–2129, 2016, doi: 10.1109/ACCESS.2016.2563462.

[6] M. Zeng, A. Yadav, O. A. Dobre, G. I. Tsiropoulos, and H. V. Poor, “On the Sum Rate of MIMO-NOMA and MIMO-OMA Systems,” *IEEE Wirel. Commun. Lett.*, vol. 6, no. 4, pp. 534–537, Aug. 2017, doi: 10.1109/LWC.2017.2712149.

[7] Z. DIng, X. Lei, G. K. Karagiannidis, R. Schober, J. Yuan, and V. K. Bhargava, “A Survey on Non-Orthogonal Multiple Access for 5G Networks: Research Challenges and Future Trends,” *IEEE J. Sel. Areas Commun.*, vol. 35, no. 10, pp. 2181–2195, Oct. 2017, doi: 10.1109/JSAC.2017.2725519.

[8] Y. Liu, Z. Qin, M. Elkashlan, Z. Ding, A. Nallanathan, and L. Hanzo, “Nonorthogonal Multiple Access for 5G and beyond,” *Proceedings of the IEEE*, vol. 105, no. 12. Institute of Electrical and Electronics Engineers Inc., pp. 2347–2381, Dec. 01, 2017. doi: 10.1109/JPROC.2017.2768666.

[9] A. Mohan and R. P. Sreedharan, “A Review on the Concept of Polar Codes,” *2018 Int. Conf. Wirel. Commun. Signal Process. Networking, WiSPNET 2018*, Nov. 2018, doi: 10.1109/WISPNET.2018.8538538.

[10] C. Chen, W. De Zhong, H. Yang, and P. Du, “On the Performance of MIMO-NOMA-Based Visible Light Communication Systems,” *IEEE Photonics Technol. Lett.*, vol. 30, no. 4, pp. 307–310, Feb. 2018, doi: 10.1109/LPT.2017.2785964.

[11] J. Dai, K. Niu, Z. Si, C. Dong, and J. Lin, “Polar-Coded Non-Orthogonal Multiple Access,” *IEEE Trans. Signal Process.*, vol. 66, no. 5, pp. 1374–1389, Mar. 2018, doi: 10.1109/TSP.2017.2786273.

[12] X. Deng *et al.*, “Joint Detection and Decoding of Polar-Coded OFDM-IDMA Systems,” *IEEE Trans. Circuits Syst. I Regul. Pap.*, vol. 66, no. 10, pp. 4005–4017, Oct. 2019, doi: 10.1109/TCSI.2019.2914671.

[13] Y. Li, K. Niu, and C. Dong, “Polar-Coded GFDM Systems,” *IEEE Access*, vol. 7, pp. 149299–149307, 2019, doi: 10.1109/ACCESS.2019.2947254.

[14] Z. Gao, Y. Wang, X. Liu, and F. Zhou, “Using Polar Codes in NOMA-Enabled Visible Light Communication Systems,” *IEEE Sensors Lett.*, vol. 3, no. 5, May 2019, doi: 10.1109/LSENS.2019.2912651.

[15] W. A. Al-Hussaibi and F. H. Ali, “Efficient User Clustering, Receive Antenna Selection, and Power Allocation Algorithms for Massive MIMO-NOMA Systems,” *IEEE Access*, vol. 7, pp. 31865–31882, 2019, doi: 10.1109/ACCESS.2019.2902331.

[16] H. Marne, P. Mukherji, M. Jadhav, and S. Paranjape, “Bio-inspired hybrid algorithm to optimize pilot tone positions in polar-code-based orthogonal frequency-division multiplexing–interleave division multiple access system,” *Int. J. Commun. Syst.*, vol. 34, no. 3, Feb. 2021, doi: 10.1002/DAC.4676.

[17] N. W. Hlaing, A. Farzamnia, M. Mariappan, and M. K. Haldar, “Network coding schemes with efficient LDPC coded MIMO-NOMA in two-way relay networks,” *IET Commun.*, vol. 14, no. 2, pp. 337–348, Jan. 2020, doi: 10.1049/iet-com.2019.0503.

[18] V. Bioglio, C. Condo, and I. Land, “Design of Polar Codes in 5G New Radio,” *IEEE Commun. Surv. Tutorials*, vol. 23, no. 1, pp. 29–40, Jan. 2021, doi: 10.1109/COMST.2020.2967127.

[19] C. Sun, Z. Fei, B. Li, X. Wang, N. Li, and L. Hu, “Secure transmission in downlink non-orthogonal multiple access based on polar codes,” *China Commun.*, vol. 18, no. 9, pp. 221–235, Sep. 2021, doi: 10.23919/JCC.2021.09.017.

[20] F. Ivanov, V. Morishnik, E. Krouk, and F. Ivanov, “Improved Generalized Successive Cancellation List Flip Decoder of Polar Codes with Fast Decoding of Special Nodes,” *J. Commun. Networks*, vol. 23, no. 6, pp. 417–432, Dec. 2021, doi: 10.23919/JCN.2021.000038.

[21] H. Zhu, P. Guan, Z. Cao, and Y. Zhao, “Rate-compatible systematic polar codes,” *IET Commun.*, vol. 15, no. 15, pp.

1930–1940, Sep. 2021, doi: 10.1049/CMU2.12204.

[22] O. P. Babalola and V. Balyan, "Constant Weight Polar Coded Orthogonal Space-Time Block Codes for Dimmable Indoor MIMO-VLC Systems," *IEEE Commun. Lett.*, vol. 26, no. 10, pp. 2395–2399, Oct. 2022, doi: 10.1109/LCOMM.2022.3193974.

[23] M. C. Coskun and H. D. Pfister, "An Information-Theoretic Perspective on Successive Cancellation List Decoding and Polar Code Design," *IEEE Trans. Inf. Theory*, vol. 68, no. 9, pp. 5779–5791, Sep. 2022, doi: 10.1109/TIT.2022.3173152.

[24] A. I. Zaki, A. A. Samy, A. K. Garg, and M. H. Aly, "Non-orthogonal multiple access system based on time diversity for 5G applications," *Opt. Quantum Electron.*, vol. 54, no. 7, pp. 1–14, Jul. 2022, doi: 10.1007/S11082-022-03877-4/TABLES/4.

[25] R. Chen, W. Wu, Q. Zeng, and S. Liu, "Construction and application of polar codes in OFDM underwater acoustic communication," *Appl. Acoust.*, vol. 211, p. 109473, Aug. 2023, doi: 10.1016/J.APACOUST.2023.109473.

[26] M. Meenalakshmi, S. Chaturvedi, and V. K. Dwivedi, "Enhancing channel estimation accuracy in polar-coded MIMO–OFDM systems via CNN with 5G channel models," *AEU - Int. J. Electron. Commun.*, vol. 173, p. 155016, Jan. 2024, doi: 10.1016/J.AEUE.2023.155016.

[27] H. Yang, S. Yan, H. Zhang, Y. Ren, X. Hu, and S. Lin, "A simplified decoding algorithm for multi-CRC polar codes," *J. Syst. Eng. Electron.*, vol. 31, no. 1, pp. 12–18, 2020, doi: 10.21629/JSEE.2020.01.02.

BIOGRAPHY OF AUTHORS

B PAVITHRA (First author), received B.E (ECE) in Sudharsan Engineering College, Pudukkottai in the year 2016 secured First Class. Completed M.E (Communication Systems) in the year 2020 secured first class with distinction and currently pursuing PhD, Department of ECE, B S Abdur Rahman Crescent Institute of Science and Technology. Published 3 journal papers in informatica (Slovenia), IJRTE and IJEAT and 1 International conference in IEEE Xplore. Area of interest includes wireless communication, signal processing, error control coding and information theory, 5G and beyond technologies, MIMO etc.
mail id : pavithrab_ece@crescent.education

Dr. Parnasree Chakraborty (Second / Corresponding Author*) currently working as an Associate professor in B.S.Abdur Rahman Crescent Institute of Science and Technology. She has received B.E. degree in Electronics and Communication Engineering from SJCIT, Chikballapur, Visvesvaraya Technological University, Belgaum in the year 2002 and secured first-class with distinction. She did her Masters in M.E Communication Systems from Crescent Engineering College, Anna University in the year 2007 and completed her Ph.D in the year 2019. She has sixteen years of teaching experience.Her Ph.D. Degree in signal processing in sensor networks in the department of Electronics and Communication Engineering of B.S. Abdur Rahman Institute of Science & Technology. Her areas of interest include signal processing, image processing, communication engineering etc. She has published eight papers in international journals and presented many papers in International conferences.
mail id: prernasree@crescent.education