A taxonomy on power optimization techniques for fifth-generation heterogenous non-orthogonal multiple access networks

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Article Info

Article history:

Received Jul 21, 2023
Revised Oct 30, 2023
Accepted Dec 5, 2023

Keywords:

Fast-fading propagation
Interference management
Network selection
Power optimization
Precoding
Soft-computing

ABSTRACT

Non-orthogonal multiple access (NOMA) is an anticipated technology for fifth-generation networks for increasing mass connectivity, spectrum efficiency, user-fairness, and higher capacity. NOMA allows end-clients to share indistinguishable radio resources such as spreading code, subcarrier, and time slots simultaneously. Thus, the main challenge involved in conceptualizing effective NOMA design is selection of resource allocation (i.e., user clustering, power allocation, and quality-of-service (QoS) assurance) algorithms. NOMA can be easily integrated with current fifth-generation multi-access methodologies. In this survey paper, the NOMA methodologies are discussed, and provide an overview of the methodologies and algorithms designed for optimizing power allocation, interference management, and network selection management in the heterogenous multiple carrier NOMA. The survey highlights the current limitation of the existing resource provisioning framework and presents a solution to overcome the current limitation.

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1. INTRODUCTION

In recent times there has been increased usage of social networks and smart devices for communication, where a huge amount of multi-media information has been circulated. The multimedia data are bulky with high data-rate requirements. Many important key technologies have recently been suggested to solve these problems and establish the foundation for the full implementation of 5G as well as 6G networks, which are predicted to achieve a peak data throughput of 20 Gbit/s with low latency [1]. Non-orthogonal-multiple-access (NOMA) is a feasible 5G technology because of the high efficiency with which it uses the radio spectrum [2]. Moreover, assigning users to separate or orthogonal resources such as code, time, and frequency is a standard practice in orthogonal-multiple-access (OMA) [3] to reduce the probability of interference. Nevertheless, the demands of numerous linked devices cannot be met by the available spectrum. Multiplexing the users inside the power domain allows NOMA to share similar resources [4]. As a result, NOMA can provide improved spectrum efficiency in comparison to OMA.

Low latency, massive connectivity, and fast data-rate are all benefits provided by NOMA. It has been demonstrated as a feasible option for next-generation internet of things (IoT) devices and dense networks. NOMA is a form of OMA that employs successive-interference-cancellation (SIC) [5] and superposition-coding (SC) in the power domain for providing service to numerous users with varying power levels simultaneously using the same code, as well as frequency [6]. Recent studies have revealed an expansion of NOMA designs that incorporate novel techniques, such as multiple-input and multiple-output (MIMO) [7], cooperative-relaying [8], as well as millimeter-wave-communications [9]. In study [10], a random-opportunistic-beamforming (ROB) was proposed for the MIMO-NOMA network, where the ROB was utilized in different wireless systems as a signal processing method for directional communication presented in [11]. Several beams were generated by the ROB transmitter, and multiple users were superimposed within every beam. In [12], for the downlink multi-user NOMA network, a beamforming architecture that is built on zero-forcing as well as a user pairing technique has been developed. This is done on the assumption that the transmitter has access to complete channel-state-information (CSI).

Hence, the integration of multi-user beamforming with NOMA does have the ability to harness the advantages of both beamforming and NOMA. However, in real-time scenarios obtaining perfect CSI is difficult; especially considering fast time-varying multipath fading channels for provisioning diverse applications. These open challenges motivated the current survey to explore the current technique of precoding, power allocation, user pairing, interference, and propagation methodologies in section 2; and section 3, highlights the problem involved in designing an efficient framework of provisioning diverse applications to end-users using massive NOMA networks.

2. LITERATURE SURVEY

In this section, the primary emphasis is on the critical analysis and exploration of contemporary methodologies applied in the realm of precoding, power allocation design, interference management, and soft-computing techniques. These sophisticated approaches play a pivotal role in enhancing the quality-of-service delivery within NOMA networks. By delving into the intricate details of precoding strategies, optimal power allocation designs, and advanced interference management mechanisms, this work aims to elevate the overall performance and efficiency of NOMA networks, thereby contributing to the seamless provision of high-quality services. The incorporation of soft-computing methodologies further adds a layer of adaptability and intelligence, allowing for dynamic adjustments and improvements in the network's service quality based on evolving conditions and requirements.

2.1. Precoding methodologies

This section studies various precoding techniques applied for improvising performance in NOMA-enabled next-generation wireless networks. Baig [13] first analyzed the existing orthogonal-frequency-division-multiplexing based non-orthogonal-multiple-access (OFDM-NOMA) method. Baig came to the result that the problem with using the OFDM-NOMA is that it gives a high peak-to-average-power-ratio (PAPR). Hence for solving this issue, Baig proposed a discrete-cosine transform-matrix precoding-based uplink-multi-carrier method for the OFDM-NOMA method to reduce the PAPR. Moreover, the bit-error-rate (BER) is decreased because of the proposed method which utilizes the information spreading across the full signal spectrum. Further, Hama and Ochiai [14] proposed a time-frequency-domain NOMA (TF-NOMA). In TF-NOMA, this method requires superimposing the OFDM as well as the discrete-Fourier-transform-spread orthogonal-frequency-division-multiplexing (DFT-s-OFDM) in the TF-NOMA. In this work, by using the discrete-Fourier-transform-precoding, the PAPR has been reduced. Moreover, PAPR can be effectively reduced by the TF-NOMA in both the up-link signal which is transmitted using the devices, and the down-link signal which is transmitted by the base-station (BS) which is located at a significant distance from the BS.

Sadique *et al.* [15] proposed a Walsh Hadamard transform method which has been integrated using QR-decomposition (QR) which is based on the zero-forcing (ZF) as well as the block-diagonalization (BD) method. The main focus of this work was to provide a precoding technique for the interference-reduction, filtering method as well as a non-iterative clipping method for reducing the PAPR for the multi-users. In this method they have introduced a minimum-mean-square-error-signal (MMSES) detection method to enhance the BER. Muhammed *et al.* [16] proposed a user-grouping algorithm which will help simplify the process of user clustering. Muhammed *et al.* also proposed a digital precoding/hybrid analog method at the macro-base station (MBS). The main aim of this proposed algorithm was to increase the overall energy-efficiency of the system in the NOMA heterogeneous network by optimizing the bandwidth partition, power allocation, and transmission of the hybrid-precoding. An energy-efficient distribution power-allocation (EEDPA) algorithm has been proposed for optimizing the allocation of resources for the small as well as the macro-cell.

Zhang *et al.* [17] proposed a precoding technique for the MIMO uplink communication using a multi-group NOMA method. In this decoding technique, Zhang *et al.* used the QR detection technique for decoding the user signal for every group for the imperfect SIC. For generating the SIC residue error, the symbol demodulation is used. As a result, the precoder was designed to minimize the overall transmission power while still satisfying the user's symbol-error-probability (SEP) requirements, even though SIC errors will have an impact. An effective "logarithmic" golden-section searching technique for suboptimal designs was also proposed in this work. Kim *et al.* [18], designed a precoding technique for maximizing the total achievable-rate for the downlink of NOMA-aided short-packets in the IoT communication. Kim *et al.* considered that every IoT device has low-resolution analog-to-digital converters (LR-ADCs). In their work, Kim *et al.* begin by selecting an additive-quantization-noise approach to linearize the quantization distortion. Further, LogSumExp is then used to approximatively evaluate non-smooth functions. Finally, Kim *et al.* offered a new precoding algorithm that finds a low-complexity local optimum solution and constructs a first-order optimization criterion for the transformed issue.

2.2. Power allocation methodologies

This section studies various power allocation optimization techniques designed for NOMA-enabled next-generation wireless networks. Many previous research, as shown in Wu *et al.* [19] have so far not taken into consideration the computation difficulty of the allocation of power while the user-terminals (UTs) are in motion inside a slow-fading channel setting. To address these issues, Wu *et al.* presented an energy allocation approach for compressing the search-space of a full-search-power (FSP) allocation algorithm by a significant amount. The power reallocation coefficients in this work were first assigned to previously optimal settings until a search was conducted for optimum power re-allocation coefficients depending on overall throughput efficiency. Power combinations that are unlikely to work will be eliminated from the search sooner by adjusting the step length as well as corrective granularity inside a considerably more constrained search range.

Abd-Elnaby *et al.* [20] have the main aim to provide a power allocation method to increase the overall weighted-energy-efficiency power-allocation (WEE-PA) inside the NOMA network. The suggested WEE-PA method improves on such metrics as user-to-user fairness, the number of users required for system operation, the likelihood of service interruptions, as well as the average information throughput for weak users. To optimize the WEE as well as guaranteed user equality, the PA optimization issue was defined as an optimal issue including a complete power restriction as well as a collection of variable PA settings. In study [21], a greedy-asynchronous-distributed-interference-avoidance-algorithm (GADIA) was proposed as kind of a dynamic spectrum allocation technique for a NOMA-based device-to-device transmission network that coexists with the use of a mobile network. To guarantee a fair downstream boundary rate for all cellular users as well as the devices inside the network regardless of overall transmission power, Rajab *et al.* [21] investigated a min-max fairness optimizing issue with power budget restrictions. The effectiveness of a reconfigurable intelligent surface (RIS)-enabled NOMA based device-to-device (D2D) wireless communication network was examined by Shaikh *et al.* [22]. This network had the RIS partitioned such that it could support a set of D2D users. In particular, Shaikh *et al.* [22] developed closed-form formulas for the maximum and minimum achievable efficiencies in terms of energy efficiency and spectral-efficiency (SE). The findings indicate that RIS contributes significantly to a NOMA-based D2D network's remarkable improvement in performance.

The primary goal of the study presented by Khan *et al.* [23] was to ensure the signal decoding as well as the minimal rate of every cellular device while maximizing the energy effectiveness of the suggested heterogeneous network. A non-convex optimization is used to simultaneously frame the issue of cell phone pairing as well as power management. Sub-optimal power control methods depending mostly on Karush-Kuhn-Tucker parameters are presented as a benchmark in this work. Zhu *et al.* [24] proposed a new initial agglomerative-nesting (AGNES) based user grouping method by using the benefits of correlations of the channel. To avoid the complex brute-force-searching method and to solve the issue of overlapping beams, Zhu *et al.* proposed two beam selection and sub-optimal low-complexity user grouping methods. The methods are called the direct agglomerative-nesting (D-AGNES) and joint-successive-agglomerative-nesting (JS-AGNES) methods. In addition to this, Zhu *et al.* implemented the quadratic-transform (QT) to convert the non-convex power allotment optimization issue into a convex one that is bound by the minimum necessary data rate for every individual user. Elhattab *et al.* [25] analyzed the decoding order as well as the power allocation at the BS for two-users uplink cooperative-NOMA (C-NOMA)-based cellular networks. Therefore, Elhattab *et al.* developed a joint optimization issue to increase the minimal feasible rate for users. Instead of solving a convex issue, Elhattab *et al.* develop near-optimal, low-complexity-analytic equations for the power distribution coefficients.

2.3. Interference and propagation methodologies

This section studies various interference and propagation methodologies applied for NOMA-enabled next-generation wireless networks. El-ghorab *et al.* [26] analyzed the efficiency of three existing pairing methodologies for the NOMA-based network. These three pairing methodologies include correlation-based, Gale-Shapley, and Hungarian methods. First, El-ghorab *et al.* provided an analysis of the energy efficiency of MIMO-NOMA. El-ghorab *et al.* presented a mathematical study for the energy-efficiency of downlink

NOMA inside a large MIMO system. Their study focuses on the non-line-of-sight (NLoS) channeling approach having ideal SIC. In the end, the sequential-convex-programming (SCP) methodology was applied to solve the problem of power allocation. Hassan *et al.* [27] focused to reevaluate and enhance the average capacity-rate, bit-error-rate, outage-probability of the up-link and spectrum-efficiency of the down-link of a given 5G network utilizing MIMO. The suggested approach operates on selected frequencies Rayleigh fading channels as well as makes use of quadrature phase shift keying (QPSK) modulation, four users having varying power placement coefficients, signal-to-noise-ratio, and transmission power, as well as two contrasted bandwidths of 80 and 200 MHz.

Chauhan *et al.* [28] presented two new reconfigurable-intelligent-surface (RIS) systems called RISP-quadrature-NOMA (RISP-Q-NOMA) and RIS partition-assisted (RISP) PD-NOMA (RISP-PD-NOMA) for maximizing the diversifying order and for enhancing the quality of the signal of all the users by providing a fixed reconfigurable-intelligent-surface unit to every user. A. Chauhan *et al.* have evaluated the closed-form-expressions such as outage-probability, diversity-order, and average sum-rate for both the systems having the Rician-fading-channel for imperfect as well as perfect SIC functions. Li *et al.* [29] proposed an adaptive multi-user-association technique for NOMA in the visible-light-communication (VLC) system. The proposed technique can obtain the number of user-association (UA) and various schemes for enhancing the multi-user system efficiency. In addition, two novel ideas that have been named the redundant-user (RU) as well as the multi-user-association-matrix have been developed to convey the state of the UA as well as data-rates while considering residual interference.

Chitra and Dhanasekaran [30] presented a NOMA-based spectrum sharing method having imperfect SICs. In this method, the second user helps the first one to accomplish cooperative multiplexing. The suggested technique prevents interference from the primary-transmitter (PT) at the second-receiver (SR) by having the two main transmitters emit in different time slots. To boost the functionality of both primary and secondary networks, the presented approach applies the varying interference-threshold-constraint (v-ITC) to ST transmission power. Chitra and Dhanasekaran computed the presented approach ergodic-rate as well as outage-probability using closed-form equations. Mahmood *et al.* [31] analyzed the efficiency of the multi-user downlink PD-NOMA in suburban environments under Stanford University Interim (SUI) fading channels. Before performing superposition coding at the base station, power levels were assigned to the baseband-modulated user signals with phase shifts, taking into account the user's distances from the base station. At the receivers, SIC was carried out, and it was done at multiple levels. Up to four users per cluster were considered, and the performance of each SUI model was assessed based on how well it handles the tradeoff between bit-error-rate (BER) and signal-to-noise ratio (SNR) in a variety of suburban environments with differing densities of vegetation.

2.4. Soft-computing approaches

This section studies various soft-computing techniques applied for improvising performance in NOMA-enabled next-generation wireless networks. The allocation of resources issue inside the NOMA system was explored in [32], where it is noted that it has not been thoroughly investigated because it is a high-dimensional-non-linear-programming (HD-NLP) issue. To maximize overall energy efficiency, Cui *et al.* [32] broke down the HD-NLP issue into its constituent parts, namely, the allocation of power and sub-channel. Cui *et al.* used a low-complexity optimistic method to tackle the issue of sub-channel assignment. Cui *et al.* employed the updated particle swarm optimization (PSO) method for the allocation of the power to the NOMA down-link system. This is done to enhance the energy effectiveness of the communication network to the greatest extent achievable while maintaining the quality-of-service (QoS). Multi-cell-multi-carrier NOMA (MCMC-NOMA) networks were studied in [33] about user power allocation as well as scheduling. For this purpose, Adam *et al.* [33] took into account the weighted-sum-rate-maximization (WSRM) as well as weighted-sum-energy-efficiency-maximization (WSEEM) issues. Adam *et al.* [33] began by applying fractional-programming (FP), the Lagrange-dual approach, as well as the decomposition approach to the problems of user scheduling under constrained power. Then, for solving the WSRM issue, Adam *et al.* [33] utilized the successive-pseudo-convex-approximation (SPCA). In conclusion, SPCA is applied to the WSEEM issue to partition it into independent scalar issues suitable for parallel computation.

The goal of the work presented in [34] was to optimize the energy-efficiency (EE) of smaller cell networks through the strategic use of power distribution as well as channel-assignment. An iteration technique for simultaneous allocation of power as well as sub-channel assignment is presented for use in scenarios where CSI is unavailable. The Dinkelbach approach is then used to turn the initial issue together into a convex optimum formulation by modeling the unknown CSI as just an elliptical probability set. Lastly, the Lagrangian dual method is used to obtain a close approximation to the result. Power allocation minimization inside a mobile NOMA transmission network with two users was studied in [35]. To begin, a design of a mobile NOMA transmission network is developed. Then, Fu *et al.* [35] examined the performance of the outage-probability (OP) and its correlation with the user allocation of power coefficient in a mobile NOMA transmission network. The objective function for optimizing is then defined, as well as a Monarch-butterfly-optimization (MBO)-based algorithm for optimal allocation of power is developed.

Using the Nash-bargaining-solution (NBS) gaming strategy in full-duplex cooperation beam-forming (BF) with multi-carrier (MC) NOMA, [36] presented a balanced energy as well as channel distribution strategy. When it comes to increasing the overall cooperative NOMA (CNOMA) rate, NBS offers a reasonable and optimal solution. BF vectors that use the signal-to-leakage (SLR) ratio pre-coding approach to produce power-domain CNOMA players were studied as a potential performance benchmark for the proposed design. Abuajwa *et al.* [37] presented a simulated-annealing (SA) technique for optimizing the allocation of power and for performing the user pairing to increase the throughput of the NOMA network. Abuajwa *et al.* [38] applied the integer-linear-programming (ILP) for pairing the users and for adopting the PSO for the allocation of power to the users and decreasing the complexity of the resource allocation in the NOMA network. For formulating the given multi-objective issue, Abuajwa *et al.* [39] used the scalarization method for the multi-objective-optimization (throughput-fairness), which will provide flexible and various weights for a given objective, i.e., sum-rate or fairness.

In [40], the non-linearity among cluster construction as well as channel heterogeneity and transmitting power is efficiently characterized by using deep-neural-network-based user-clustering (DNN-UC). Because UC is a non-convex-NP-complete issue, it cannot be fully addressed mostly by artificial-neural-network (AAN) framework, making the DNN-UC highly effective. Mean-square-error (MSE), as well as throughput efficiency inside an asymmetric faded NOMA channel, was analyzed first by teaching the DNN-UC with said training data and afterward validating it utilizing the test samples. In study [41], for the multi-user maximum MIMO-NOMA downlink systems [42], Akbarpour-Kasgari and Ardebilipour [41] proposed a deep-reinforcement-learning-based beam-user selection, as well as a hybrid beamforming architecture Akbarpour-Kasgari and Ardebilipour [42] began by developing a method for grouping users depending on channel correlation and gain, and afterward Akbarpour-Kasgari and Ardebilipour chosen beams utilizing a deep learning-based reinforcement-learning system. Finally, Akbarpour-Kasgari and Ardebilipour [41] achieved a beam-space-orthogonal analog precoder utilizing this method. The deep Q-network has a primary network, a secondary network for focusing on the objective, as well as an Adam optimizer. Eventually, all beam users receive the most efficient distribution of power.

2.5. Issues, challenges, problem statement, and possible solutions

In this section, potential solutions to these challenges will be explored. These might include advanced resource allocation algorithms, interference management strategies, improved channel estimation techniques, dynamic power control mechanisms, and intelligent scheduling schemes to efficiently serve the needs of diverse applications in MIMO-NOMA networks. The section will delve into innovative approaches and methodologies that aim to mitigate these challenges and provide efficient solutions, thereby enhancing the performance and capabilities of MIMO-NOMA networks for catering to various applications effectively.

2.5.1. Precoding

The conventional precoding method, as referenced in [43], focuses on mitigating peak-to-average power ratio (PAPR) by employing linear precoding of frequency domain symbols through the discrete Hartley transform (DHT). This technique is effective in addressing high PAPR in the time domain through the use of the inverse Fourier transform (IFFT). Despite its success in managing PAPR, the drawback of this traditional approach becomes evident in the context of MIMO-NOMA, as highlighted in [44], and heterogeneous networks, as discussed in [45]. The increased computational complexity associated with these scenarios leads to higher power consumption, posing a challenge for efficient operation and resource utilization in such systems.

2.5.2. Power allocation optimization

In NOMA different users are allocated different power levels to perform transmission. The current methods use various soft-computing techniques levering swarm optimization game-theory, and deep reinforcement learning to attain optimal user-pairing and power allocation. However, in massive NOMA networks, the current method failed to ensure user quality-of-experience (QoE) and quality-of-service (QoS) tradeoff constraints.

2.5.3. Interference management

The current method uses multi-level SIC at the receiver to mitigate interference; however, most of these models have been done for small-scale and large-scale fading considering static nodes and simple path-loss models. However, when employed under a fast-time varying multipath model, the current methodologies perform very poorly. Thus, the model should consider different propagation models such as highway, expressway, rural, and city environments.

2.5.4. Network selection and collision

The future networks are heterogenous and connecting user to network according to its QoE and QoS prerequisite is needed. The current work induces higher signaling overhead; as poor performance is experienced both at user-level and network-level; thus, it is important to reduce signaling overhead. Further, the current method uses random backoff as a result higher collision is experienced due to collision; thus, an enhanced power backoff mechanism is needed to reduce collision in the network.

3. RESEARCH METHOD

The research methodology to meet the research objective is given as follows. Figure 1 shows the proposed effective framework for provisioning diverse applications such as data, images, and videos. using massive multi-carrier NOMA. The framework is composed of an optimal power allocation module, superposition coding, and an N-level signal interference cancellation module. The proposed work used a game theory approach for designing an optimal power allocation design using a game theory approach; the model is focused on meeting the application demands of mobile terminals/end devices. The proposed work further optimizes the power allocation with an effective precoding design that attains low good PAPR performance considering fast-fading multipath mobility models. The proposed work reduces signaling overhead and selects a better network using machine learning models. The proposed is expected to attain better BER performance with reduced PAPR and also improve overall network throughput as shown in the next section.

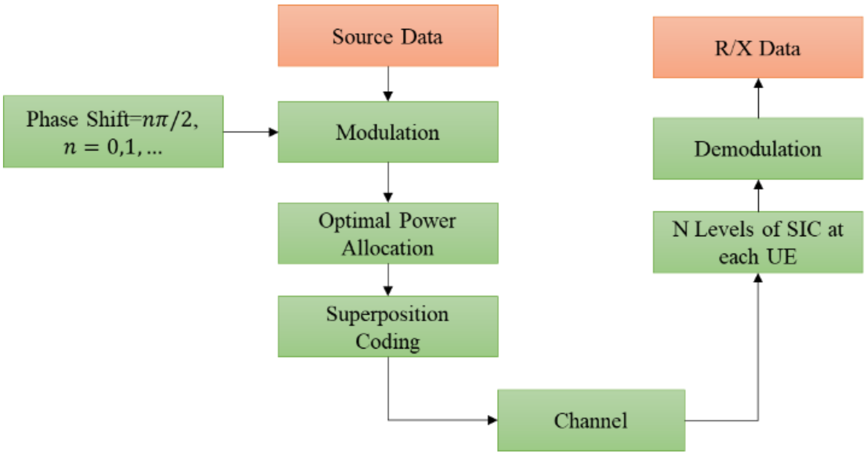

Figure 1. Framework for provisioning diverse applications using massive multicarrier NOMA

4. RESULTS AND DISCUSSION

The performance of the proposed efficient power optimization (EPO) design and power allocation-existing system (PA-ES) [25] is discussed. The EPO and PA-ES model is implemented using NYUSIM [46], [47] using MATLAB framework and to enable node mobility and fast-fading propagation model SIMITS [48], [49] using C#. In this work, we have used a fast-fading multipath model representing a highway scenario that defines a complex path loss due to fast-moving vehicles and intermittent connectivity, the BER and PAPR performance is measured considering different SNR i.e., between -4 dB to 4. The throughput performance is measured by varying node density and node speed.

5.1. BER and PAPR performance

The section studies the BER performance achieved using PA-ES and EPO under varied SNR considering the fast-fading multipath model [49] as shown in Figure 2. Further, studies the PAPR performance achieved using PA-ES and EPO under varied SNR considering fast-fading multipath model [49] as shown in Figure 3. From Figures 2 and 3, we can see the proposed EPO model attain much better BER and PAPR performance in comparison with PA-ES.

5.2. Throughput performance

The section studies the throughput performance achieved using PA-ES and EPO under varied devices considering a fast-fading multipath model [49] as shown in Figure 4. Further, studies the throughput performance achieved using PA-ES and EPO under varied speeds considering the fast-fading multipath model [49] as shown in Figure 5. From Figures 4 and 5 we can see the proposed EPO model attain much better throughput performance in comparison with PA-ES.

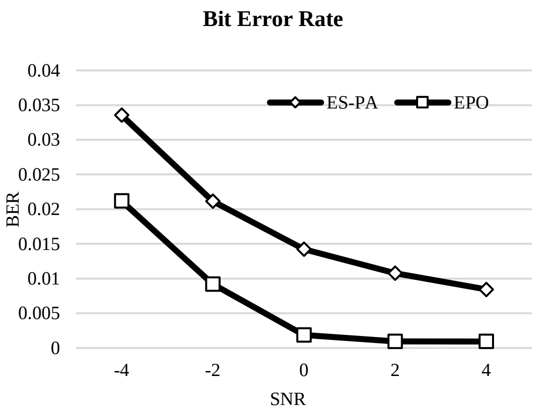

Figure 2. BER performance under varied SNR

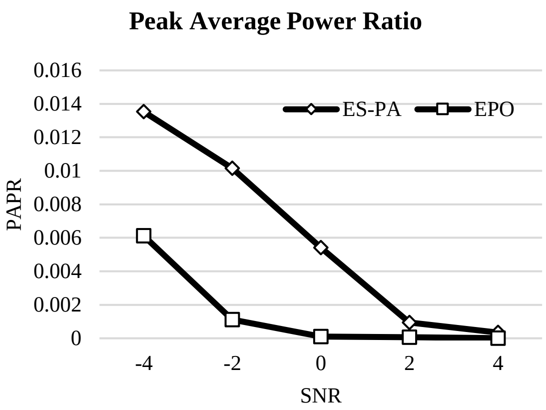

Figure 3. PAPR performance under varied SNR

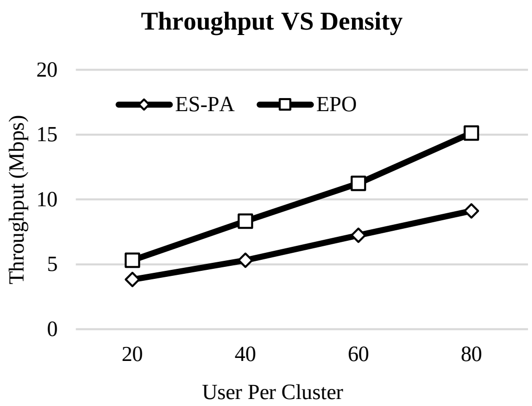

Figure 4. Throughput vs density

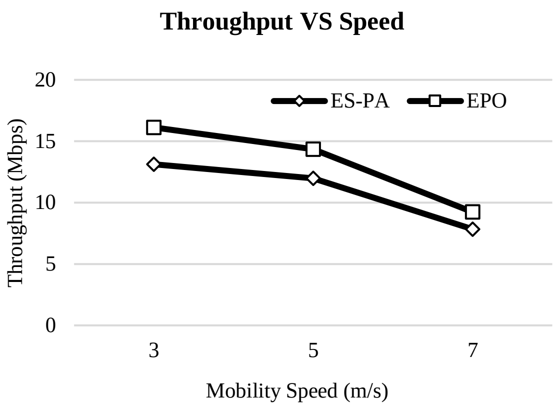

Figure 5. Throughput performance vs mobility speed

5. CONCLUSION

This paper conducted an extensive survey of different approaches involved in the effective usage of NOMA in 5G networks. the survey mainly focused on studying different precoding techniques, power allocation design, interference management techniques, and propagation methodologies. In particular, focused on the usage of different soft-computing methodologies for fair and optimal power optimization in the NOMA multicarrier 5G network. the survey identifies the limitations i.e., issues and challenges involved in the current NOMA framework, and presents a new NOMA framework for achieving effective performance. Simulation is conducted under the presence of a fast-fading model by varying SNR and BER and PAPR performance is measured. Further, the throughput is measured by varying speed and density. The overall result shows the proposed EPO achieves better performance than existing PA-ES in terms of BER, PAPR, and throughput.

REFERENCES

[1] A. de la Fuente, R. P. Leal, and A. G. Armada, "New technologies and trends for next generation mobile broadcasting services," *IEEE Communications Magazine*, vol. 54, no. 11, pp. 217–223, Nov. 2016, doi: 10.1109/MCOM.2016.1600216RP.
[2] Z. Ding *et al.*, "Application of non-orthogonal multiple access in LTE and 5G networks," *IEEE Communications Magazine*,

vol. 55, no. 2, pp. 185–191, Feb. 2017, doi: 10.1109/MCOM.2017.1500657CM.
[3] S. M. R. Islam, N. Avazov, O. A. Dobre, and K. Kwak, "Power-domain non-orthogonal multiple access (NOMA) in 5G systems: Potentials and challenges," *IEEE Communications Surveys & Tutorials*, vol. 19, no. 2, pp. 721–742, 2017, doi: 10.1109/COMST.2016.2621116.
[4] X. Su, A. Castiglione, C. Esposito, and C. Choi, "Power domain NOMA to support group communication in public safety networks," *Future Generation Computer Systems*, vol. 84, pp. 228–238, Jul. 2018, doi: 10.1016/j.future.2017.06.029.
[5] K. Higuchi and A. Benjebbour, "Non-orthogonal multiple access (NOMA) with successive interference cancellation for future radio access," *IEICE Transactions on Communications*, vol. E98.B, no. 3, pp. 403–414, 2015, doi: 10.1587/transcom.E98.B.403.
[6] Y. Saito, Y. Kishiyama, A. Benjebbour, T. Nakamura, A. Li, and K. Higuchi, "Non-orthogonal multiple access (NOMA) for cellular future radio access," in *2013 IEEE 77th Vehicular Technology Conference (VTC Spring)*, Jun. 2013, pp. 1–5, doi: 10.1109/VTCSpring.2013.6692652.
[7] Z. Ding, F. Adachi, and H. V. Poor, "The application of MIMO to non-orthogonal multiple access," *IEEE Transactions on Wireless Communications*, vol. 15, no. 1, pp. 537–552, Jan. 2016, doi: 10.1109/TWC.2015.2475746.
[8] D. Wan, M. Wen, F. Ji, Y. Liu, and Y. Huang, "Cooperative NOMA systems with partial channel state information over nakagami-m fading channels," *IEEE Transactions on Communications*, vol. 66, no. 3, pp. 947–958, Mar. 2018, doi: 10.1109/TCOMM.2017.2772273.
[9] B. Wang, L. Dai, and M. Xiao, "Millimeter wave NOMA," in *Encyclopedia of Wireless Networks*, Cham: Springer International Publishing, 2018, pp. 1–3.
[10] A. Benjebbour, Y. Saito, Y. Kishiyama, A. Li, A. Harada, and T. Nakamura, "Concept and practical considerations of non-orthogonal multiple access (NOMA) for future radio access," in *2013 International Symposium on Intelligent Signal Processing and Communication Systems*, Nov. 2013, pp. 770–774, doi: 10.1109/ISPACS.2013.6704653.
[11] W. Wu and B. Wang, "Robust secrecy beamforming for wireless information and power transfer in multiuser MISO communication system," *EURASIP Journal on Wireless Communications and Networking*, vol. 2015, no. 1, Dec. 2015, doi: 10.1186/s13638-015-0378-2.
[12] B. Kimy *et al.*, "Non-orthogonal multiple access in a downlink multiuser beamforming system," in *MILCOM 2013 - 2013 IEEE Military Communications Conference*, Nov. 2013, pp. 1278–1283, doi: 10.1109/MILCOM.2013.218.
[13] I. Baig, "A precoding-based multicarrier non-orthogonal multiple access scheme for 5G cellular networks," *IEEE Access*, vol. 5, pp. 19233–19238, 2017, doi: 10.1109/ACCESS.2017.2752804.
[14] Y. Hama and H. Ochiai, "Time-frequency domain non-orthogonal multiple access for power efficient communications," *IEEE Transactions on Wireless Communications*, vol. 22, no. 9, pp. 5711–5724, Sep. 2023, doi: 10.1109/TWC.2023.3235910.
[15] J. J. Sadique, S. E. Ullah, M. R. Islam, R. Raad, A. Z. Kouzani, and M. A. P. Mahmud, "Transceiver design for full-duplex UAV based zero-padded OFDM system with physical layer security," *IEEE Access*, vol. 9, pp. 59432–59445, 2021, doi: 10.1109/ACCESS.2021.3073488.
[16] A. J. Muhammed, H. Chen, A. M. Seid, Z. Han, and Q. Yu, "Energy-efficient resource allocation for NOMA HetNets in millimeter wave communications," *IEEE Transactions on Wireless Communications*, vol. 22, no. 6, pp. 3790–3804, Jun. 2023, doi: 10.1109/TWC.2022.3221469.
[17] R. Zhang *et al.*, "Precoding design for multi-group MIMO-NOMA scheme with SIC residual analysis," *IEEE Transactions on Vehicular Technology*, vol. 72, no. 4, pp. 4733–4750, Apr. 2023, doi: 10.1109/TVT.2022.3225195.
[18] S. Kim, J. Choi, and J. Park, "Downlink NOMA for short-packet internet of things communications with low-resolution ADCs," *IEEE Internet of Things Journal*, vol. 10, no. 7, pp. 6126–6139, Apr. 2023, doi: 10.1109/JIOT.2022.3224204.
[19] G. Wu, W. Zheng, W. Xiong, Y. Li, H. Zhuang, and X. Tan, "A novel low-complexity power allocation algorithm based on the NOMA system in a low-speed environment," *Digital Communications and Networks*, vol. 7, no. 4, pp. 580–588, Nov. 2021, doi: 10.1016/j.dcan.2021.07.001.
[20] M. Abd-Elnaby, G. G. Sedhom, E.-S. M. El-Rabaie, and M. Elwekeil, "An optimum weighted energy efficiency approach for low complexity power allocation in downlink NOMA," *IEEE Access*, vol. 10, pp. 80667–80679, 2022, doi: 10.1109/ACCESS.2022.3194539.
[21] H. Rajab, F. Benkhelifa, and T. Cinkler, "Analysis of power allocation for NOMA-based D2D communications using GADIA," *Information*, vol. 12, no. 12, Dec. 2021, doi: 10.3390/info12120510.
[22] M. H. N. Shaikh, S. Arzykulov, A. Celik, A. M. Eltawil, and G. Nauryzbayev, "Performance of RIS-empowered NOMA-based D2D communication under Nakagami-m fading," in *2022 IEEE 96th Vehicular Technology Conference (VTC2022-Fall)*, Sep. 2022, pp. 1–5, doi: 10.1109/VTC2022-Fall57202.2022.10012767.
[23] W. U. Khan, X. Li, A. Ihsan, Z. Ali, B. M. Elhalawany, and G. A. S. Sidhu, "Energy efficiency maximization for beyond 5G NOMA-enabled heterogeneous networks," *Peer-to-Peer Networking and Applications*, vol. 14, no. 5, pp. 3250–3264, Sep. 2021, doi: 10.1007/s12083-021-01176-5.
[24] J. Zhu, Q. Li, Z. Liu, H. Chen, and H. V. Poor, "Enhanced user grouping and power allocation for hybrid mmWave MIMO-NOMA systems," *IEEE Transactions on Wireless Communications*, vol. 21, no. 3, pp. 2034–2050, Mar. 2022, doi: 10.1109/TWC.2021.3109053.
[25] M. Elhattab, M. A. Arfaoui, C. Assi, A. Ghrayeb, and M. Qaraqe, "Power allocation optimization and decoding order selection in uplink C-NOMA networks," *IEEE Communications Letters*, vol. 27, no. 1, pp. 352–356, Jan. 2023, doi: 10.1109/LCOMM.2022.3214445.
[26] M. A. El-ghorab, M. R. El-meligy, M. M. Ibrahim, and F. Newagy, "Energy-efficient user pairing for downlink NOMA in massive MIMO networks," *Applied Sciences*, vol. 12, no. 11, May 2022, doi: 10.3390/app12115421.
[27] M. Hassan, M. Singh, K. Hamid, R. Saeed, M. Abdelhaq, and R. Alsaqour, "Modeling of NOMA-MIMO-based power domain for 5G network under selective rayleigh fading channels," *Energies*, vol. 15, no. 15, Aug. 2022, doi: 10.3390/en15155668.
[28] A. Chauhan, S. Ghosh, and A. Jaiswal, "RIS partition-assisted non-orthogonal multiple access (NOMA) and quadrature-NOMA with imperfect SIC," *IEEE Transactions on Wireless Communications*, vol. 22, no. 7, pp. 4371–4386, Jul. 2023, doi: 10.1109/TWC.2022.3224645.
[29] Q. Li, T. Shang, T. Tang, and Z. Xiong, "Adaptive user association scheme for indoor multi-user NOMA-VLC systems," *IEEE Wireless Communications Letters*, vol. 12, no. 5, pp. 873–877, May 2023, doi: 10.1109/LWC.2023.3247420.
[30] C. M and S. Dhanasekaran, "Performance analysis of NOMA-based spectrum sharing system with imperfect SIC," *IEEE Transactions on Vehicular Technology*, vol. 72, no. 6, pp. 8198–8203, Jun. 2023, doi: 10.1109/TVT.2023.3243103.
[31] A. Mahmood, S. Khan, S. Hussain, and M. Zeeshan, "Performance analysis of multi-user downlink PD-NOMA under SUI fading channel models," *IEEE Access*, vol. 9, pp. 52851–52859, 2021, doi: 10.1109/ACCESS.2021.3070147.
[32] Y. Cui, P. Liu, Y. Zhou, and W. Duan, "Energy-Efficient resource allocation for downlink non-orthogonal multiple access systems," *Applied Sciences*, vol. 12, no. 19, Sep. 2022, doi: 10.3390/app12199740.

[33] A. B. M. Adam, X. Wan, and Z. Wang, "User scheduling and power allocation for downlink multi-cell multi-carrier NOMA systems," *Digital Communications and Networks*, vol. 9, no. 1, pp. 252–263, Feb. 2023, doi: 10.1016/j.dcan.2022.03.010.

[34] Q. Zhao, W. Yang, and L. Zhang, "Energy-efficient resource allocation for NOMA-based heterogeneous 5G mine internet of things," *IEEE Access*, vol. 10, pp. 67437–67450, 2022, doi: 10.1109/ACCESS.2022.3184798.

[35] X. Fu, Z. Tang, and P. Xiao, "Power allocation intelligent optimization for mobile NOMA communication system," *Journal of Advanced Transportation*, vol. 2022, pp. 1–6, May 2022, doi: 10.1155/2022/5838186.

[36] M. Fadhil, A. H. Kelechi, R. Nordin, N. F. Abdullah, and M. Ismail, "Game theory-based power allocation strategy for NOMA in 5G cooperative beamforming," *Wireless Personal Communications*, vol. 122, no. 2, pp. 1101–1128, Jan. 2022, doi: 10.1007/s11277-021-08941-y.

[37] O. Abuajwa, M. B. Roslee, and Z. B. Yusoff, "Simulated annealing for resource allocation in downlink NOMA systems in 5G networks," *Applied Sciences*, vol. 11, no. 10, May 2021, doi: 10.3390/app11104592.

[38] O. Abuajwa, M. Roslee, Z. B. Yusoff, L. L. Chuan, and P. W. Leong, "Resource allocation for throughput versus fairness trade-offs under user data rate fairness in NOMA systems in 5G networks," *Applied Sciences*, vol. 12, no. 7, Mar. 2022, doi: 10.3390/app12073226.

[39] O. Abuajwa, M. Bin Roslee, Z. Binti Yusoff, L. C. Lee, and W. L. Pang, "Throughput fairness trade-offs for downlink non-orthogonal multiple access systems in 5G networks," *Heliyon*, vol. 8, no. 11, Nov. 2022, doi: 10.1016/j.heliyon.2022.e11265.

[40] S. P. Kumaresan, C. K. Tan, and Y. H. Ng, "Deep neural network (DNN) for efficient user clustering and power allocation in downlink non-orthogonal multiple access (NOMA) 5G networks," *Symmetry*, vol. 13, no. 8, Aug. 2021, doi: 10.3390/sym13081507.

[41] A. Akbarpour-Kasgari and M. Ardebilipour, "Deep reinforcement learning in mmW-NOMA: Joint power allocation and hybrid beamforming," *arXiv preprint arXiv:2205.06814*, 2022.

[42] A. Akbarpour-Kasgari and M. Ardebilipour, "Joint power allocation and beamformer for mmW-NOMA downlink systems by deep reinforcement learning," *arXiv preprint arXiv:2205.06489*, 2022.

[43] A. Krishnamoorthy, M. Huang, and R. Schober, "Precoder design and power allocation for downlink MIMO-NOMA via simultaneous triangularization," in *2021 IEEE Wireless Communications and Networking Conference (WCNC)*, Mar. 2021, pp. 1–6, doi: 10.1109/WCNC49053.2021.9417424.

[44] J. Pauls and M. Vaezi, "Secure precoding in MIMO-NOMA: A deep learning approach," *IEEE Wireless Communications Letters*, vol. 11, no. 1, pp. 77–80, Jan. 2022, doi: 10.1109/LWC.2021.3120594.

[45] P. Deng, W. Wu, X. Shen, P. Li, and B. Wang, "Precoding design of NOMA-enabled D2D communication system with low latency," *EURASIP Journal on Wireless Communications and Networking*, vol. 2019, no. 1, Dec. 2019, doi: 10.1186/s13638-019-1501-6.

[46] S. Sun, G. R. MacCartney, and T. S. Rappaport, "A novel millimeter-wave channel simulator and applications for 5G wireless communications," in *2017 IEEE International Conference on Communications (ICC)*, May 2017, pp. 1–7, doi: 10.1109/ICC.2017.7996792.

[47] S. Ju, O. Kanhere, Y. Xing, and T. S. Rappaport, "A millimeter-wave channel simulator NYUSIM with spatial consistency and human blockage," in *2019 IEEE Global Communications Conference (GLOBECOM)*, Dec. 2019, pp. 1–6, doi: 10.1109/GLOBECOM38437.2019.9013273.

[48] M. Manzano, F. Espinosa, Á. M. Bravo-Santos, and A. Gardel-Vicente, "Cognitive self-scheduled mechanism for access control in noisy vehicular ad hoc networks," *Mathematical Problems in Engineering*, vol. 2015, pp. 1–12, 2015, doi: 10.1155/2015/354292.

[49] Al-Absi, Al-Absi, and Jae Lee, "Performance enriching channel allocation algorithm for vehicle-to-vehicle city, highway and rural network," *Sensors*, vol. 19, no. 15, Jul. 2019, doi: 10.3390/s19153283.

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