A Pragmatic Look at Power-Domain NOMA

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ABSTRACT
Non-Orthogonal Multiple Access (NOMA) received significant attention in the field of wireless communications during the last ten years, particularly focusing on Power-Domain NOMA (PD-NOMA) that uses a successive interference cancellation (SIC) receiver. This review paper reexamines PD-NOMA from a pragmatic angle and sheds light on its virtues and limitations in uplink and downlink scenarios. We observe that the concept of PD-NOMA in the downlink can be seen as a pure signal constellation design and that a simple threshold detector is sufficient at the receiver end. For the uplink, we first address the fairness concerns arising from the mismatch between the users' data rates that can be achieved by the SIC receiver and the fair rates suggested by the power distribution among users. Furthermore, we discuss findings from a recent analysis comparing PD-NOMA to Multi-User MIMO under a common system framework. This study reveals that assigning the same power levels to users, thereby aligning PD-NOMA with Multi-User MIMO, optimizes performance in terms of average bit error rate. These insights raise questions about the fundamental utility of PD-NOMA and suggest that its best application is hierarchical multiple access, where devices with different power capabilities are paired together.

INTRODUCTION

Multiple access technologies have been crucial in the evolution of wireless communications as cellular networks transitioned through various generations. The Global System for Mobile Communications (GSM), established in the 1980s as the first globally adopted digital mobile radio standard, utilized Time-Division Multiple Access (TDMA). These GSM-based networks, known as 2G, marked a digital shift from the analog-based first generation of mobile radio systems. Primarily designed for voice services, 2G networks provided only low-speed data capabilities. As demand for higher-speed data grew, the Third Generation Partnership Project (3GPP) developed the 3G standard, which employed Wideband Code-Division Multiple Access (WCDMA). Following the rollout of 3G networks, the focus shifted to the Long-Term Evolution (LTE) standard, foundational to 4G, which introduced a significant advancement in transmission and multiple access techniques by adopting Orthogonal Frequency-Division Multiplexing (OFDM) and transitioning from WCDMA to Orthogonal Frequency-Division Multiple Access (OFDMA). Most recently, the 3GPP developed the 5G standard, aimed at accommodating a diverse array of new services and applications. Within this context, non-orthogonal multiple access (NOMA) is considered a pivotal technology by experts to fulfill the expansive requirements of 5G.

The heightened interest in NOMA, as noted in [1]-[3], stems from a key insight in multi-user information theory: orthogonal multiple access is generally suboptimal, whereas superposition coding paired with successive interference cancellation (SIC) offers an optimal solution for multiple access [4]. This understanding led to the development of Power-Domain NOMA (PD-NOMA), where multiple users share the same time-frequency resources but with varying power levels, managed by a SIC receiver to mitigate interference. In the downlink scenario, this approach requires the base station (BS) to allocate different power levels to the signals of paired or grouped users, and in the uplink, user pairing or grouping must ensure that signals reach the BS at differing power levels. While other NOMA variants have been proposed, PD-NOMA dominates the literature. In a shift from this dominant focus, the current authors and colleagues recently revisited an early NOMA concept initially proposed in 2000 [5] and subsequently known as NOMA-2000. Comparative studies indicate that NOMA-2000, in terms of bit error rate (BER) performance, substantially surpasses PD-NOMA [6], [7]. Although other forms like Interleave-Division NOMA and Pattern-Division NOMA are known, the literature primarily categorizes NOMA into two types: PD-NOMA and Code-Domain NOMA [8], with NOMA-2000 classified under the latter.

In our study, we reevaluate PD-NOMA to better understand its characteristics, capabilities, and shortcomings. While existing literature predominantly highlights the advantages of this method, our pragmatic examination suggests that PD-NOMA might generally be considered an ill concept. This conclusion arises from an analysis of power imbalances in the uplink, demonstrating that the lowest average BER occurs when users' signals reach the receiver with identical powers on uncorrelated Rayleigh fading channels. This scenario aligns with Multi-User MIMO (MU-MIMO) employing power control [9], [10]. If achieving minimal average BER necessitates equal power at the receiver, it logically follows that employing the power domain for multiple access may not be the right approach when users have comparable data rate and performance needs and can transmit at similar power levels. Such insights substantially diminish the appeal of PD-NOMA, suggesting its suitability is limited to hierarchical multiple access scenarios, where there is a mix of high-power user equipment and lower-power devices like sensors.

For a comprehensive understanding, it is important to note the recent discussion on the evolution of multiple access techniques across different generations of wireless networks, as highlighted in [11]. In this context, Rate-Splitting Multiple Access (RSMA) is introduced as a hybrid approach bridging Space-Division Multiple Access (SDMA) and Non-Orthogonal Multiple Access (NOMA). The classification of these techniques is based on the method of signal detection at the receiver: SDMA decodes signals by treating interference from other users as noise, while NOMA relies on a Successive Interference Cancellation (SIC) receiver, where at least one user decodes the signals of all other users. RSMA, on the other hand, involves partial decoding of interference and treating it partially as noise, where user messages are divided into a common part and a private part. The common parts are merged into one stream, and each user initially decodes this common stream, considering the interference from their private streams as noise. Following this, they extract their private signals from the received signal, treating the private signals of others as noise. This explanation, however, diverges from traditional definitions of multiple access techniques that typically refer to how user signals are allocated across time, frequency, and other resources, rather than how signals are decoded. Although PD-NOMA often uses a SIC receiver, recent research also employs maximum-likelihood (ML) receivers for signal detection, as indicated in [12]. It is crucial to recognize that the ML receiver is optimal for both PD-NOMA and MU-MIMO (described as SDMA in [11]), and we intend to apply this receiver type for both multiple access methods.

SHEDDING LIGHT ON THE DOWNLINK

The basic principle of the PD-NOMA downlink for two users as illustrated in Fig. 1.

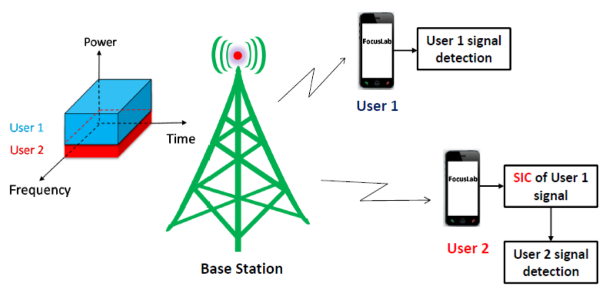


FIGURE 1. Illustration of PD-NOMA downlink with 2 users.

Using the same time and frequency resources, the BS allocates the same time and frequency resources to send signals to two different users, but at varying power levels. It transmits a stronger signal to User 1 and a weaker one to User 2. User 1 receives its signal amidst interference from User 2's weaker signal, leading to some degradation of the signal-to-noise ratio (SNR) compared to a scenario without interference. In contrast, User 2, whose signal is overshadowed by that of User 1, must first identify and eliminate the interference from User 1's signal before it can clearly detect its own signal. This traditional approach to PD-NOMA downlink underlines the necessity for a substantial power difference between the signals to adequately control the SNR degradation.

Let us take now another look at the PD-NOMA downlink and see it from another angle. Suppose that the BS intends to transmit symbol x_1 to User 1 and symbol x_2 to User 2. Suppose further that it allocates power $P_1 = \alpha P$ to User 1, and power $P_2 = (1-\alpha)P$ to User 2, where P is the total transmit power. The power imbalance factor α is assumed to satisfy $0.5 \leq \alpha \leq 1$ so that User 1 has a stronger power in accordance with Fig. 1. The signal transmitted by the BS to serve the two users is of the form $\boldsymbol{x} = \sqrt{\alpha}x_1 + \sqrt{1-\alpha}x_2$. This signal takes its values from a signal constellation that is determined by the constellation(s) of the x_1 and x_2 symbols and the power imbalance factor α. When the x_1 and x_2 symbols take their values from the quaternary phase shift keying (QPSK) signal constellation, the signal $\boldsymbol{x}$ takes its values from a multi-resolution 16-QAM constellation as shown in Fig. 2. The specific plot in this figure actually corresponds to $\alpha = 0.9$, while a uniform 16QAM signal constellation corresponds to $\alpha = 0.8$. A uniform signal constellation implies that the minimum distance that dictates asymptotic BER performance is the same for both users. A value $\alpha > 0.8$ will favor User 1, and $\alpha < 0.8$ will favor User 2.

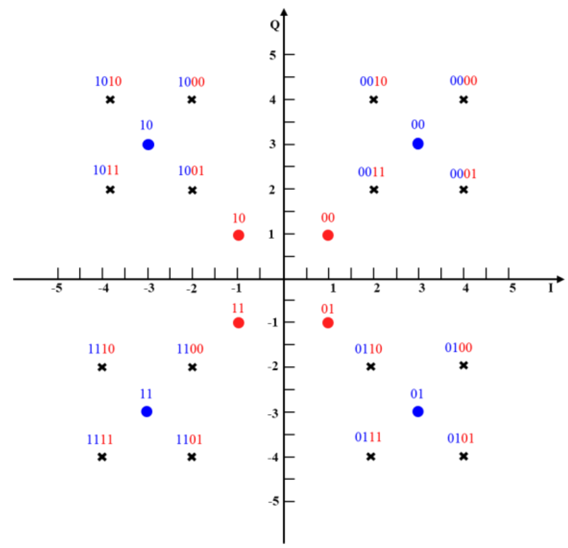


FIGURE 2. Constellations of the users' symbols and of the transmitted signal $\boldsymbol{x}$.

The blue dots in Fig. 2 represent the constellation of the User-1 signal $\sqrt{\alpha}x_1$, the red dots closer to the center represent the constellation of the User-2 signal $\sqrt{1-\alpha}x_2$, and the black crosses represent the multi-resolution 16QAM constellation of the combined signal. The figure also shows the bit mapping of the user signals to the transmitted signal constellation. The first two bits (in blue) of the four bits assigned to the signal points are those intended to User 1, and the other two (in red) are those intended to User 2.

For both users, the received signal is of the form $r_i = (\sqrt{\alpha}x_1 + \sqrt{1-\alpha}x_2)h_i + w_i$ with $i = 1$ for User 1, and $i = 2$ for User 2. From the received signal, User 1 is only interested in extracting the first two bits representing symbol x_1. A simple inspection of Fig. 2 reveals that a 2-level threshold detector (with threshold value 0) is all that is needed to extract these bits, because their values are 00 in the top right quadrant of the constellation plane, 01 in the bottom right quadrant, 11 in the bottom left quadrant, and 10 in the top left quadrant. As for detection of the x_2 symbol by User 2, a threshold detector with 3 threshold values $(0, \pm 3$ in this figure) is required.

To encapsulate PD-NOMA downlink discussions, while traditionally explained through information theory with signal superposition and successive interference cancellation, it can also be seen as a straightforward constellation design requiring only a threshold detector at the receiver. This raises the question of whether such constellation design qualifies as NOMA. In fact, the term *multiple access* may be somewhat misleading for downlink scenarios, as the base station's activity in serving different users is more specifically *multiplexing* rather than *multiple access*. The design of transmit signal constellations essentially represents a form of "non-orthogonal multiplexing" where bits intended for different users are transmitted over the same time and frequency resources, utilizing the constellation space defined by amplitude and phase parameters. This contrasts with orthogonal multiplexing techniques such as time-division multiplexing (TDM), frequency-division multiplexing (FDM), and code-division multiplexing (CDM).

PD-NOMA UPLINK

Next, we revisit the PD-NOMA uplink and take a pragmatic look at it. As on the downlink, the basic principle is to assign different power levels to the users' signals, as shown in Fig. 3 for two users. For a more comprehensive review, the reader can refer to [1] – [3] and [8]. In Fig. 3, a strong signal power P_1 is allocated to User 1, and a weaker signal power P_2 is allocated to User 2. These signals are transmitted over the same time and frequency resources using different channels. Upon reception of these overlapping signals, the BS first detects the User-1 signal in the presence of interference from User 2, then it cancels the interference of this user on User 2 (using a SIC receiver), and finally it detects the User-2 signal.

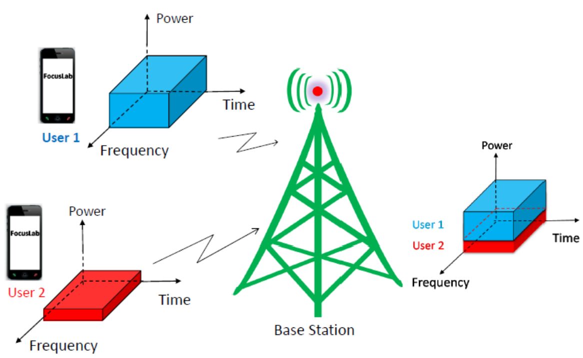


FIGURE 3. Illustration of PD-NOMA uplink with 2 users.

In this approach, it is essential to have a strong power imbalance between the two user signals. Otherwise, detection of the User-1 signal in the presence of interference from User 2 will involve a strong SNR degradation, and the SIC receiver will be inefficient in cancelling the interference from this user, leading to poor performance in the detection of the User-2 signal as well. The SNR degradation in PD-NOMA with different levels of the power imbalance is extensively discussed in [6], [7], and other publications by the same authors. Note that Fig. 3 is given for illustration purposes only, and it does not explicitly indicate user distances to the BS and the corresponding path losses. The power imbalance in this discussion refers to the power imbalance at the receiver, because this is what finally matters for the SIC receiver performance. For a desired power imbalance at the receiver, it is understood that power control must be used at the transmitters to compensate for different signal attenuations, which result from unequal user distances to the BS, shadowing, and other factors.

THE FAIRNESS ISSUE

We will now give further insight into the PD-NOMA uplink and highlight the inherent fairness issue. As for the downlink, we introduce a power imbalance factor α, and write the signal powers received from the two users as $P_1 = \alpha P$ and $P_2 = (1-\alpha)P$, respectively, where P designates the received total signal power. Further, we assume that $1/2 \leq \alpha < 1$ so that we have $P_1 \geq P_2$ in accordance with Fig.3. As is well known, the users' rates achievable with a SIC receiver are $R_1 = log\left(1 + P_1/(P_2 + \sigma^2)\right)$ for User 1 and $R_2 = log(1 + P_2/\sigma^2)$ for User 2, where σ^2 is the noise power. Consider for a moment the case $\alpha = 1/2$, which gives $P_1 = P_2$. In this extreme case, the rate achievable by User 1 can never be higher than 1 bit per channel use (bpcu), and this holds even if power P becomes infinitely large. Virtually all of the capacity will go User 2 whose signal is detected after interference cancellation. More precisely, if $R = R_1 + R_2$ bpcu is the total data rate for the two users, at most 1 bpcu will be for User 1 and the remaining $R - 1$ bpcu will be for User 2 when the total power is equally shared between the two users. From the fairness standpoint, this distribution of the total data rate makes little sense, because fairness means that if the same signal power is received from two users, these users should get the same data rate.

In the past, in addition to providing a higher sum capacity, it was often claimed that PD-NOMA also increases fairness with respect to orthogonal multiple access, but fairness can be defined in many different ways involving the physical layer alone or also the radio resource management. In the award-winning paper [13], a new definition of fairness was given which essentially measures the difference between the data rates provided to the different users and the fair rates corresponding to the power distribution among them. Using this fundamental definition, the fairness issue appears as specific to PD-NOMA with a SIC receiver, and it is inexistent in orthogonal multiple access. It is interesting to note that the lowest fairness in the 2-user case corresponds to $\alpha = 1/2$ and fairness increases with α. Full fairness is only achieved in the limiting case $\alpha = 1$, i.e., when the concept of NOMA vanishes.

The discussion above is for PD-NOMA with a SIC receiver, which is used in the vast majority of the literature. But as indicated in the previous section, ML detection was proposed in replacement of the SIC receiver in some recent studies including [12]. This detector overcomes the limitations of the SIC receiver when the users' signals have similar powers, and therefore it can be used for all values of the power imbalance factor.

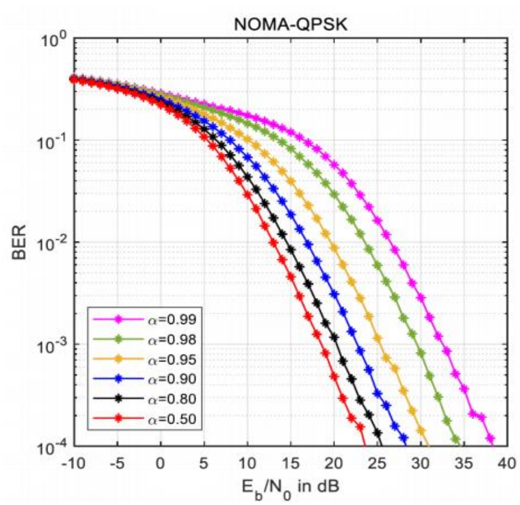
ANALYZING THE POWER IMBALANCE

We will now delve deeper into the issue of power imbalance for the uplink. To start, let us clarify that Multi-User MIMO refers to a cellular MIMO system where the multiple antennas on the user side are not dedicated to a single user. For instance, a system consisting of a BS with multiple antennas communicating with several single-antenna users qualifies as a MU-MIMO system when these users simultaneously access and share time and frequency resources. In fact, the configuration depicted in Fig. 3 can also represent the uplink scenario in a MU-MIMO system with 2 users. The primary distinction between PD-NOMA and MU-MIMO lies in the power imbalance. In situations where the powers received from the two users are equal, the system operates as a MU-MIMO system with power control. Conversely, when the power levels differ, the system operates as a PD-NOMA system. Essentially, MU-MIMO can be considered a type of power-balanced NOMA, where using a SIC receiver is not suited for signal detection. Therefore, for both MU-MIMO and PD-NOMA, we will employ the ML receiver to handle signal detection.

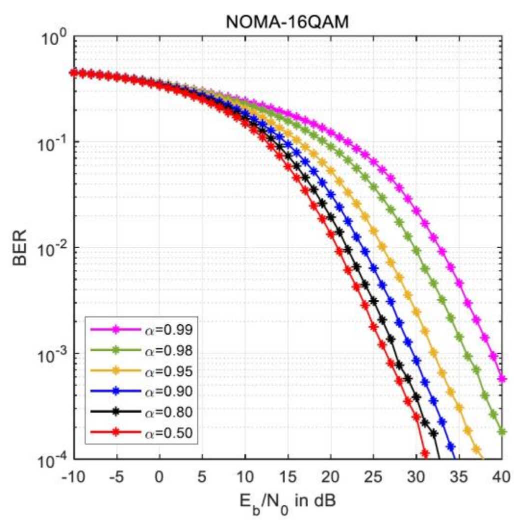
In the unified system model introduced in [14], MU-MIMO corresponds to choosing the power imbalance factor as $\alpha = 1/2$, and PD-NOMA corresponds to $\alpha \neq 1/2$. The authors utilized this model to explore the ideal power imbalance that would minimize the Average Bit Error Probability (ABEP). The initial step in calculating the ABEP involves determining the Pairwise Error Probability (PEP), which assesses the likelihood of erroneously detecting a codeword that differs from the one actually transmitted. After calculating the PEP for every potential error scenario, they employed the well-established Union Bound to establish a stringent upper limit for the ABEP. In this context, a codeword is comprised of a two-component vector, where the first component represents the symbol transmitted by User 1 and the second by User 2. It is important to note that an error event is recorded when any symbol in the transmitted codeword is incorrectly detected, indicating a symbol error for one or both users.

Using the PEP, a straightforward method was employed to show that the most effective NOMA configuration, minimizing the ABEP, corresponds to $\alpha = 1/2$. This proof utilized an upper bound on the PEP, as presented in [4], for 2x2-MIMO systems functioning on uncorrelated Rayleigh fading channels. The key idea was to consider two symmetric error events, say $E_1 = (u, v)$ and $E_2 = (v, u)$, where the first component is the error corresponding to the symbol transmitted by User 1, and the second component is the error corresponding to the symbol transmitted by User 2. For $|u| >$

$|v|$, the PEP corresponding to error event E_2 was shown to be higher than the PEP corresponding to error event E_1 whenever $\alpha \neq 1/2$. The opposite holds for $|u| < |v|$. With $\alpha = 1/2$, both error events give the same PEP whose value is located between the two PEP values corresponding to $\alpha \neq 1/2$. Also, exploiting the properties of the PEP upper bound function, it was determined that the sum of the PEPs corresponding to error events E_1 and E_2 is always higher for $\alpha \neq 1/2$, except when $|u| = |v|$. In the latter case, the sum of the two PEPs is independent of α. By considering all error events determined by the signal constellation and weighing them by the corresponding number of bit errors, the analysis showed that the ABEP of the two users is minimized with $\alpha = 1/2$. For details of the analytic calculations, the reader can refer to [14]. Here, we will only report the simulation results, which confirmed these calculations.



(a) QPSK



(b) 16QAM

FIGURE 4. BER Performance of PD-NOMA with different values of the power imbalance.

The simulation was performed using QPSK and 16QAM modulation schemes for the symbols transmitted by the two users, incorporating Gray coding for the bit mapping process, on uncorrelated Rayleigh fading channels, with ML detection employed at the BS. The outcomes of this study are depicted in Fig. 4(a) for QPSK and Fig. 4(b) for 16QAM, respectively. As can be seen, the best performance is obtained with $\alpha = 1/2$ in both cases, and performance degrades as this parameter is increased. For example, with $\alpha = 0.9$ corresponding to an amplitude imbalance of 9.5 dB, the SNR degradation with respect to the amplitude-balanced case at the BER of 10^{-3} is about 4.5 dB in QPSK and 3 dB in 16QAM. These numbers speak for themselves: Transmitting user signals with PD-NOMA leads to a strong SNR degradation compared to transmitting them with equal power. Those simulation results confirm the theoretical finding of [14] that the best strategy consists of having the user signals perfectly balanced in terms of power at the receiver. Since power-balanced NOMA coincides with MU-MIMO, our analysis clearly indicates that this technique is superior to PD-NOMA in terms of average BER.

HIERARCHICAL MULTIPLE ACCESS

The average BER analysis made in the previous section and the results that it revealed suggest that strictly speaking, the power domain is not appropriate for multiple access in general, because better performance is achieved when the users' signals arrive with the same power at the receiver. This revelation may come as a surprise, given the high promises and expectations concerning PD-NOMA, which have regularly appeared in the literature for over a decade. The question we address now is in what scenarios and use cases the PD-NOMA concept truly finds its place and represents an appealing solution for multiple access. The answer to this question lies in hierarchical multiple access, which involves the pairing of users and devices with substantially different requirements, features, and constraints. For multiple access, we use the terminology of "hierarchical" in the same way it is used for modulation and transmission (see, e.g., [15]), where a multi-resolution signal constellation is used to provide unequal error rates for data streams corresponding to different services. By analogy to hierarchical transmission, hierarchical multiple access refers to multiple access schemes in which the users have different BER performances and/or data rate requirements. Since it involves different signal powers for different users, PD-NOMA appears as a natural candidate for hierarchical multiple access.

From this perspective, 2-user PD-NOMA is especially advantageous when pairing a high-profile user capable of transmitting at high power levels, with a low-power device, such as a sensor with modest data rate needs. The power disparity at the receiver offers two potential utilization strategies: (1) If both users adopt the same modulation scheme, they will achieve identical data rates. However, the high-profile user will experience superior Bit Error Rate (BER) performance due to a better SNR, and (2) Given that BER performance can be balanced against data rate, the high-profile user might opt for a more complex modulation scheme, achieving a higher data rate compared to the low-power device. It is beneficial from the viewpoint of the high-profile user that the low-power user transmits at very low power, minimizing the adverse effects on the high-profile user's performance. If the low-power device does not meet the required performance using a simple modulation scheme like binary phase-shift keying (BPSK) or QPSK, coupled with error correction coding, then reducing its symbol rate relative to that of the high-profile user can be an effective solution. In this way, the desired performance level can be reached through sufficient reduction of the data rate.

CONCLUSIONS

In this technology review, we have taken a new look at PD-NOMA, providing new insights into its principles, potential, and limitations. Initially, we noted that the principle of PD-NOMA in the downlink effectively boils down to constellation design and bit mapping, with a simple threshold detector sufficing for signal detection by users. For the uplink, we initially addressed the significant fairness issue arising from the mismatch between the data rates achievable through the SIC receiver and those rates considered equitable, as suggested by the power distribution among users. Subsequently, we discussed findings from a recent study which showed that the average Bit Error Rate (BER) is optimized when the signal powers received from users are identical, akin to the scenario in Multi-User MIMO with power control. These results challenge the underlying premise of PD-NOMA for users with similar data rate and performance needs who are capable of transmitting at comparable power levels. Furthermore, they highlight that PD-NOMA's true value may lie in its suitability for hierarchical multiple access scenarios, where a high-profile user and a low-power device, transmitting at very low data rates, share the same time and frequency resource blocks.

References

[1] Y. Saito et al., "Non-Orthogonal Multiple Access (NOMA) for Cellular Future Radio Access," Proc. VTC 2013-Spring, June 2013.

[2] Z. Ding et al., "On the Performance of Non-Orthogonal Multiple Access in 5G Systems with Randomly Deployed Users," IEEE Signal Proc. Lett., vol. 21, no. 12, pp. 1501 – 1505, Dec. 2014.

[3] L. Dai et al., "Non-Orthogonal Multiple Access for 5G: Solutions, Challenges, Opportunities, and Future Research Trends," IEEE Comm. Mag., vol. 53, no. 9, pp. 74 – 81, Sept. 2015.

[4] D. Tse and P. Viswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.

[5] H. Sari, F. Vanhaverbeke, and M. Moeneclaey, "Multiple Access Using Two Sets of Orthogonal Signal Waveforms," IEEE Comm. Letters, vol. 4, no. 1, pp. 4-6, January 2000.

[6] H. Sari et al., "On the Foundation of NOMA and its Application to 5G Cellular Networks," Proc. WCNC 2018, April 2018, Barcelona, Spain.

[7] A. Maatouk et al., "Frequency-Domain NOMA with Two Sets of Orthogonal Signal Waveforms," IEEE Comm. Lett., vol. 22, no. 5, pp. 906 – 909, May 2018.

[8] M. Vaezi, Z. Ding, and H. V. Poor (Editors), *Multiple Access Techniques for 5G Wireless Networks and Beyond*, Springer, 2019.

[9] Q. H. Spencer et al., "An Introduction to the Multi-User MIMO Downlink," IEEE Comm. Mag., vol. 42, no. 10, pp. 60 - 67, October 2004.

[10] X. Chen et al., "Double Proportional Fair User Pairing Algorithm for Uplink Virtual MIMO Systems," IEEE Trans. Wireless Commun., vol. 7, no.7, pp. 2425 – 2429, July 2008.

[11] Y, Mao et al., "Rate-Splitting Multiple Access: Fundamentals, Survey, and Future Research Trends," arXiv: 2201.03192, 30 September 2022 (v3).

[12] J. S. Yeom et al., "BER Performance of Uplink NOMA with Joint Maximum-Likelihood Detector," IEEE Trans. Vehicular Technology, vol. 68, no. 10, pp. 10295–10300, Oct. 2019.

[13] G. Gui, H. Sari, and E. Biglieri, "A New Definition of Fairness for Non-Orthogonal Multiple Access," IEEE Comm. Letters, vol. 23, no. 7, pp. 1267–1271, July 2019.

[14] S. Hu et al., "An Analysis of the Power Imbalance on the Uplink of Power-Domain NOMA," Proc. VTC 2022 - Fall, September 2022, London/Beijing.

[15] M. J. Hossain, M.-S. Alouini, and V. K. Bhargava, "Hierarchical Constellation for Multi-Resolution Data Transmission over Block Fading Channels," IEEE Trans. Wireless Comm., vol. 5, no. 4, pp. 849–857, Apr. 2006.

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