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Comparative analysis of OMA and NOMA: Important performance indicators and optimization methods

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Abstract
NOMA (Non-Orthogonal Multiple Access) is a unique method for enhancing the spectral efficiency and resource usage of wireless networks. Here everyone transmits the data on same frequency and time resource in parallel according to the different power level or modulation scheme assigned to each user. This gives the system the ability to scale their network and support more users efficiently. NOMA further boosts the performance in large HetNets for 5G and beyond by employing various schemes such as interference cancelation by Successive Interference Cancellation (SIC) at power domain at receiver and superposition coding. this paper presented a comprehensive study for NOMA (SPC) at technology and presented various way to transmitter improve the NOMA per for mance from pervious study.

Keywords: Non-orthogonal Multiple Access, NOMA Vs OMA, NOMA Performance Enhancement

1. Introduction

Amongst various disruptive technologies for future wireless communication systems, Non-Orthogonal Multiple Access (NOMA) is gaining considerable interest because it has the ability to improve the spectral efficiency and user Equity as contrasted to conventional Orthogonal Multiple Access (OMA) schemes [1]. NOMA relies on the idea that same time-frequency resource can be simultaneously assigned to several users via power domain multiplexing and advanced signal processing [2]. In NOMA technology, the power domain multiplexing technique is utilized, wherein each user is allocated a unique value of power allocation as per the channel condition [3]. In this new method, several users can The same time-frequency resources are shared yet have separate identifiable communication links [4]. This implies that it achieves this using two fundamental components; superposition coding on one hand and on the other hand successive interference cancelation [5]. An overview of this NOMA architecture based on a SIC receiver is given in Figure 1 [6].

Better than classical orthogonal multiple access (OMA) schemes when users exhibit extremely unbalanced channel gain in some context of NOMA, e.g., [7]. To compensate for the unfairness in resource allocation among users with different channel strengths and to improve system throughput, NOMA intentionally allocates more power to the users with weaker channels [8]. It is another potential candidate technique for 5G and beyond networks to provide extensive connectivity with diverse quality-of-service (QoS) requirements [9], making NOMA become feasible with this characteristic. Similar to ORA, the NOMA realizations are mainly categorized in to two domains, power domain NOMA (PD-NOMA) and code domain NOMA (CD-NOMA) [10]. In its more well-known variant, PD-NOMA, users sharing the same resource block are assigned different power levels [11]. On the other hand, in CD-NOMA [12], even though different user exist in identical time-frequency resources, but each user is orthogonal to each other with the help of specially designed spreading codes. These enhancements in spectral efficiency and Fairness for users offered by the overall gains can be explored by a comparison of NOMA with the corresponding baseline OMA schemes [13]. While FDMA, TDMA, and CDMA types grouping methods in common are OMA [14] types allocating resource in an orthogonal unit, they are assured that they do not affect each other, these types of methods do not have the full capability of utilizing the relevant resource and limit the system capacity. In this regard, NOMA also provides a fairly unique benefit, which is the capability of interference control through power multiplexing of domains (power domain multiplexing implies the use of the same frequency and time, but with varying levels of power, followed by SIC [15] to remove the desired and non-desired signals at the receiver). Figure 3 shows that in spectrum domain NOMA yields a bigger spectral efficiency in comparison with OMA [16]. Nevertheless, NOMA itself brings several technical challenges like higher receiver complexity due to the need of SIC processing and vulnerability to imperfect channel state information [17].

In literature [18], several optimization techniques and complementary technologies have been proposed by the researchers to tackle these problems and, therewith, enhance the performance of NOMA. The line of evolution encompasses advanced power allocation strategies like Enhanced Gain Difference Power Allocation and Gain Ratio Power Allocation (GRPA),(EGDPA) [19], integration with MIMO (Multiple Input Multiple Output) systems [20] and IRS (Intelligent Reflecting Surface)-assisted hybrid approaches [21]. Such challenges, alongside new application scenarios, have been the focus of recent Maximum Achievable (NOMA) research [22]. Various optimization methods have been proposed including Particle Swarm Optimization (PSO) [23] to enhance the effectiveness of secure computation in a NOMA-enabled mobile edge computing environment. Furthermore, cognitive Radio NOMA (CR-NOMA) was proposed a new kind of beamforming (to be interpreted in sub-sectional spectrum utilization) for dynamic spectrum sharing in heterogeneous networks [24]. Furthermore, aiming to ensure the fairness needs in NOMA-based visible light communications systems, the EFOPA has been proposed in [25]. Single input Single output Noma (SISO-NOMA) [26] is the simplest form of NOMA technology which serves the scenario where antennas for transmitting and receiving are served. NOMA is legitime for its potential of high spectral efficiency and user fairness with massive users while supporting new applications that are continuously emerging along with the evolution context of 5G-Advanced and 6G networks [27].

2. NOMA (Non-Orthogonal Multiple Access)

As per NOMA technology principle, several users can achieve the access to same frequency and time resource by assigning them different power levels. As there receiver uses SIC to cancel the cross interference seeking inputs signals from other users, in this case, the output symbol vector can be written as When the difference of ideal channel gain for users is large, the superiority of NOMA over the conventional multiple access techniques (OMA) lies in the more sufficient use on bandwidth via higher data rate and the capability of resource allocation with fairness [1].Fig. An illustration of the NOMA technique is shown in Fig. 1[2]. NOMA transmission arrangements generally give rise to three distinctive benefits that can be summarized as follows NOMA enhances the transfer rates by associating more than one user to single RB (Frequency/Time) that can result in 10~50 times proficient overall system throughput and efficiency of the edge channel [3]. NOMA faces shortcomings with OMA since it provides effectively higher capacity to the weaker user (thus achieving fairness performance with the higher user) using, e.g., strategies [4], [5] and the NOMA scheme [6]. Since NOMA is an asymmetrical scheme, NOMA exploits the natural multiplicity available in 5G IoT networks better than OMA and can transmit more using less resources from the point of view of transmitting devices because in OMA it requires the same number of RBs for every device [7]. NOMA appears as a collaborative method for existing OMA approaches that could be incorporated with an extra piece of equipment to benefit from the exploited spectrum resources. SC and PIA approaches have achieved high maturity stage, so the use of NOMA may synergistically merge with those two well-established conventional Multiple Access techniques. NOMA is extremely flexible and low-complex compared to other NOMA kingdom like MUSA, EDVA and MCNE where a new performance improving functionality having incorporated data (with suitable coding and adaptation) with still the elementary NOMA kingdom [8, 9, 10, 11, 12].

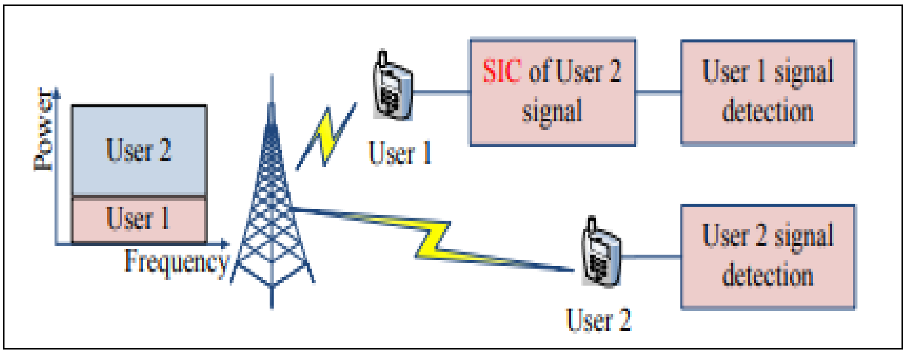

Fig 1: basic NOMA with a SIC receiver [2]

Here are some of the key equations used in NOMA technology along with their respective sources. Superposition Coding in NOMA:

The achievable rates for the two users in a NOMA system are as follows [28]:

For the far user R₁:

$$R_1 = \log_2\left(1 + \frac{p_1|h_1|^2}{p_2|h_1|^2 + \sigma^2}\right) \quad (1)$$

For the near user R_2:

$$R_2 = \log_2\left(1 + \frac{p_2|h_2|^2}{\sigma^2}\right) \quad (2)$$

Where $|h_1|^2$ are the channel gains for users 1 and 2, σ^2 is the noise power.

the authors define the superimposed signal for users 1 and 2 as [29]:

$$x = \sqrt{p_1}x_1 + \sqrt{p_2}x_2 \quad (3)$$

Where x_1 and $x_2$are the signals for users 1 and 2, respectively, p_1 and p_2 are the power allocation coefficients for each user, and the total power constraint is $p_1+p_2=P$, where P is the total power available for transmission.

the SINR Equation [30]:

$$\text{SINR}_i = \frac{p_i|h_i|^2}{\sum_{j=i+1}^{K} p_j|h_i|^2 + \sigma^2} \quad (4)$$

Where, SINR_i: The i-th user's signal to interference plus noise ratio (SINR), pi The transmitted power allocated to i-th user. $|hi|^2$The channel gain of the i-th user in dB. Which stands for the channel gain between base station and user, The total interference power received from other users for user i, where j$\sum_{j=i+1}^{k} pj$ take values from i+1 to K (K means total number of users in the system). The signal of each user causing interference at the i-th users receiver, scaled by the channel gain of user i and the power allocated to each causing user, σ^2The noise power, typically modelled as Gaussian noise of variance σ^2.

The NOMA concept has two category that is password area and code space, which have respective advantages and disadvantages in the NOMA concept PD-NOMA The NOMA Power Domain is performed by the distribution of different energy levels to people according to their channel circumstances. In particular, Users are given low power with the best channel, and users with the worst channel are given the most power. Same frequency, same time: Multiple users Stick to the same frequency in the same time, but the signal away by SIC (Successive Interference Cancellation). These aspects provide benefits like improved spectral efficiency, ability to service more users sharing the same resources [30], as well as the flexibility in order to improve system performance, adapt to the channel circumstances [31]. CD-NOMA For CD-NOMA uplink transmission, every UE multiplies its data by a spreading code and scales the power of its transmitted signal by an assigned value. The UEs powers are constrained so that, when the UE transmits, the BS obtains these with an acceptable level of interference. When it comes to CD-NOMA downlink transmission, all the data symbols are sent out from BS to UEs on common spreading codes, while the BS has the flexibility to choose the power allocation levels between the UEs continuously according to their QoS and channel conditions to which they need more reliable communication. Orthogonal (or nearly so) codes are used to minimize interference. Based on how weak the channel gain is, the BS gives full/partial power to all UEs but avoids code orthogonality constraints when multiple UEs transmit simultaneously [32].

Work of Successive Interference Cancellation Successive Interference Cancellation (SIC) inturn works on the assumption that there exists variance between users, index, and using this SIC technique in NOMA through power domain techniques, pushes that variance to the limit (maximum, max relay set power selected). The power is allocated according to the condition of the channel, by dividing the power differently in terms of user. SIC at receiver is performed on all users with an SINR above a certain level. These also eliminate their correlated signals by strong users and hence circulating its correlated signals one step far away for effective capturing of weak user signals. In descending order of SINR, the strongest user cancels the signals of weakest users first, this process is repeated [33].

A diagram illustrating SIC [34]

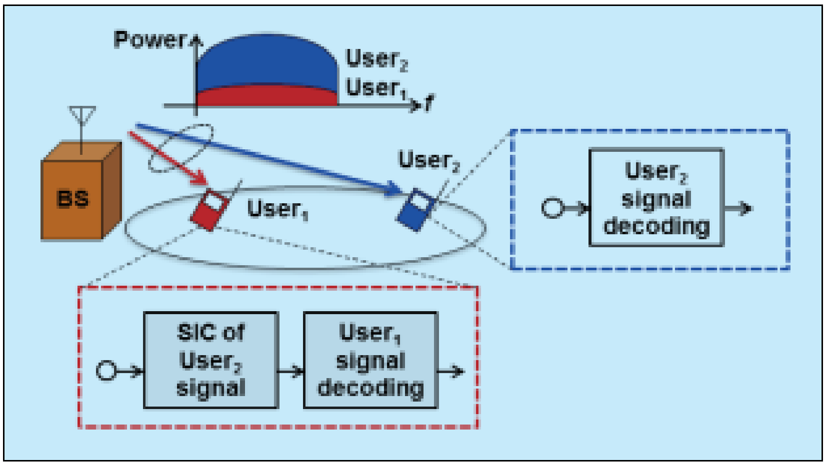

Fig 2: Concept of NOMA with SIC receiver for downlink multiple access [34]

3. OMA Vs NOMA

Orthogonal Multiplexing Access means the allocation of network resource (frequency, time or code) is orthogonal to users to avoid inter-user interference. OMA assigns a frequency band or time slot degree to every user and thus enabling users to simultaneously send data while avoiding congestion and noise from one another. Although, similar to OMA, it is a resource efficient and consumption method, it can be inefficient at the cases of high density users, this method is used frequently in communication systems such as 3G and 4G [43]. OMA (Orthogonal Multiple Access) Examples of OMA: FDMA (Frequency Division Multiple Access) - Assign different frequency band to each user In TDMA (Time Division Multiple Access) Users transmit one at a time in their own time frame. For CDMA (Code Division Multiple Access), each user is assigned a distinct

code [13].NOMA significantly outperform the conventional orthogonal multiple access (OMA) schemes, since the orthogonality incurs a capacity loss. NOMA transmission is able to overcome this capacity limitation, enabling the coexistence of several users at the same time carrier at the same time [14, 15]. While OMA will serve at most one user in each time and frequency slot, NOMA serves more than one user concurrently using same time and frequency resources by loading them with more data in time slots leading to the systems that are more spectral efficient. Thus, NOMA outperforms in the services of edge users (i.e. the users located very far from the base station) [15, 27].
The following

Table 1: presents a comparison between OMA and NOMA in terms of their Advantages and Disadvantages, as cited from source [17]:

Technique	Advantages	Disadvantages
OMA	1. Simplicity: Implementation of OMA techniques such as TDMA and FDMA, which assign dedicated time slots or frequency bands to the respective users, is easier and less complex in terms of interference management. 2. Lower Interference: There is less interference among users in OMA since users are given orthogonal resources.	1. Suboptimal Resource Allocation: In OMA, resource allocation can be less than optimal, especially in cases where few users are facing poor channel conditions as these users receive dedicated resources that are not effectively used. 2. Reduced Spectral Efficiency: Because NOMA cannot deliver the same spectral efficiency as OMA, the data rates are lower, especially in heterogeneous networks.
NOMA	1. Enhanced Spectral Efficiency: By using power domain multiplexing, Better spectrum efficiency is possible from NOMA than from conventional orthogonal multiple access (OMA) systems since they allow multiple users to share the same set of frequency, time, or code resources at the same time. 2. The Performance of Sum Rate: NOMA can get a greater sum rate than OMA under different SNR conditions, especially in situations with different user channel conditions. 3. Equitable Resource Allocation: NOMA has the potential to enhance fairness in resource distribution as it accommodates users with different channel conditions.	1. Higher Decoding Complexity: The decoding process in NOMA depends on advanced techniques like successive interference cancellation (SIC), to increase the complexity on the user side. 2. Interference Management: Multiple users can share the same resources at the same time and/or frequency thanks to NOMA, but it also comes with the cost of increasing inter-user interference. This can make interference management more complex than OMA.

Fig.3 NOMA and OMA frequency domain signals are illustrated in figure.3 [16]

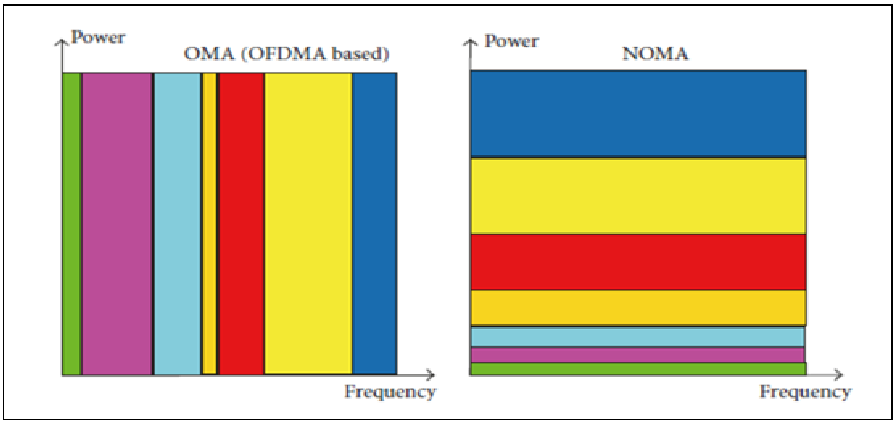

Fig 3: A pictorial comparison of OMA and NOMA [16]

4. Techniques that improve NOMA performance

The growing need for greater utilization efficiency of modern systems, as a rule, necessitated the further development of NOMA technology. Improving the energy efficiency, data rates and/or communication quality represents several ways to enhance NOMA systems. Some of the methods that are used to enhance performance.

1. Particle swarm optimization (PSO)

Under partial offloading mode, a The PSO algorithm will be proposed to optimize the secure computation effectiveness(SCE) for the successful safe computation of NOMA users in a secure and efficient manner at the same time, but while satisfactory their QoS among users as well as the QoS constraints for the common transmission. This inspired us to present an optimization problem as (PSO) in a novel wirelessly powered MEC system with a useful non-linear EH user that is enabled by NOMA [18]. Previous works [22,23] only consider the downlink delivery of signals from the transmitter to the recipients, while in in this research, we examine an uplink-downlink transmission strategy in which the AP uses a MECserver to alleviate user load. Mathematical equations (abbreviations).

2. Gain ratio power allocation (GRPA)

GRPA outperforms the method of static allotment of power by improving The total rate of the users, thus increasing the system performance. In addition, the framework is able to optimize the FOVs of the PDs and the LEDs' transmission angles to optimize system throughput. In our framework users mobility is taken into account to create a real scenario [19]. NOMA-based PRP miniaturization through GRPA Performance enhancement the rationing essay on channel. Channel gain is not static and can be varied by assigning more power to users depending on their channel gain which ultimately gives users with higher channel gain a higher SNR. Dynamic power allocation could boost the data rate and spectral efficiency of users with good channel gain by allocating bigger power to them. Thus reducing users' involvement and improving energy efficiency which ultimately contributes to the overall system's performance [35]. The equations related to Gain Ratio Power Allocation (GRPA) can be represented by the following [19]:

$$P_i = \alpha P_{i-1} \quad (5)$$

Where α is the power allocation factor (0 < α < 1).

$$P_i = \left(\frac{h_{l1}}{h_{li}}\right)^i P_{i-1}. \quad (6)$$

3. Enhanced gain difference power allocation (EGDPA)

second, a novel system for allocating power to multiple users called enhanced gain difference power allocation (EGDPA) is introduced to alleviate the negative impact of lingering interference so as to enhance achievable rate and performance of detection. The allocation factors for the amount of power the user can obtain correspond to the users' channel gain and the approach of the residual distribution that depends only on the electricity that is still available after allocated to the previous user rather than the originally assigned power. In addition, the attainable rate of data, Analysis is done on error probability and energy efficiency as functions of the power allocation factors to describe the factors that affect power allocation impact on NOMA design [36]. It is then followed here by the equations of enhanced [36]:

signal-to-noise-plus-interference ratio (SINR) for U_k can be articulated as follows:

$$\gamma_k = \frac{(h_k\mu_k)^2}{\kappa\sum_{\rho=1}^{k-1}(h_k\mu_\rho)^2 + \sum_{v=k+1}^{K}(h_k\mu_v)^2 + \sigma^2}, \quad 1 \le k \le K, \quad (7)$$

where $\sigma 2 = \sigma^2_{noise}/Pt$.

One can compute the energy efficiency by:

$$\eta_{EE} = \frac{\sum_{k=1}^{K} R_k}{P_{\max}} \quad (8)$$

where $P_{\max}$ symbolizes the LED's maximum transmit power.

4. Multiple input multiple output (MIMO)

Multiserver Using beamforming for multiple users, communications been extensively investigated as a candidate technology for dramatic throughput benefits for the overall system [20]. In the case of downlink multiuser MIMO, a UE can be supported by one or more beams based on the available number of BS transmit antennas and total number of BS receive antennas at the UEs in a cell. We show that interbeam interference can be fully cancelled at the receiver when there are as many transmit antennas as there are receive antennae, or more. In this traditional multiuser In a MIMO system, a beamforming vector orthogonal to the channel gains serves each UE receiver of the other receivers [37].

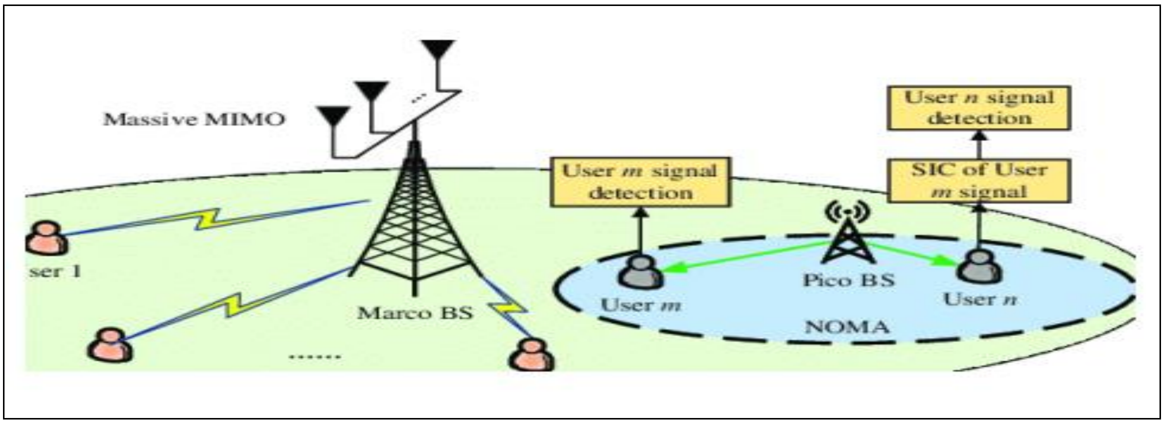

Fig 4: NOMA in Massive MIMO System [38].

The equations related to MIMO mentioned in [37]:

the transmitted superposed signal $\tilde{x} \in \mathbb{C}^{N\times 1}$ can be expressed as

$$\tilde{\mathbf{x}} = \mathbf{M}\mathbf{x}. \quad (9)$$

the received signal for k-th user of n-th cluster can be expressed as

$$y_{n,k} = d_{n,k}[\mathbf{h}_{n,k}\mathbf{M}\mathbf{x} + z_{n,k}] \quad (10)$$

Where $h_{n,k} \in C^{1\times N}$ is the radio channel gain column vector for k-th user of n-th cluster, and $z_{n,k} \in C$ represents circularly symmetric complex Gaussian noise with variance σ^2.

the received signal-to-intra-cell interference-plusnoise ratio (SINR) for k-th user of n-th cluster can be expressed as follows:

$SINR_{n,k}$=

$$\frac{|(d_{n,k}\mathbf{h}_{n,k})\mathbf{m}_n|^2 p_{n,k}}{\underbrace{|(d_{n,k}\mathbf{h}_{n,k})\mathbf{m}_n|^2 \sum_{j=1}^{k-1} p_{n,j}}_{\text{Intra-beam interference}} + \underbrace{\sum_{i=1, i\neq n}^{N} |(d_{n,k}\mathbf{h}_{n,k})\mathbf{m}_i|^2 p_i}_{\text{Inter-beam interference}} + \underbrace{d_{n,k} z_{n,k}}_{\text{Noise}}} \quad (11)$$

Where p_i is the total transmit power for i-th cluster, and we assume that $E[|s_{i,j}|^2] = 1 \ \forall_{i,j}$.

5. Signal input signal output(SISO)

For instance, let us consider a two-user SISO-NOMA system, where two users, a far user U1 and a near user U2, are served by the BS on the same resource block, using P1 > P2 transmit powers. U1 decodes its message as decoding U2 is just noise, while U2 first decodes the message of U1 and removes it completely and then decodes its own message. By doing this, both users exclusively occupy the entire resource block and the near user can decode its message without interference from the far user. At best, the rate being achievable by U1 and U2 via NOMA is expressed in (2) respectively [26]:

$$R_1 = \log_2\left(1 + \frac{P_1|h_1|^2}{1 + P_2|h_1|^2}\right) \quad (12)$$

$$R_2 = \log_2(1 + P_2|h_2|^2) \quad (13)$$

Where hi is the channel coefficient of U_i. In the case of K users, given a user order $U_1, \cdots, U_K$, SIC is applied such that U_i decodes the messages of $U_1, U_2, \cdots, U_i$ sequentially and while decoding U_j 's message ($j \leq i$), the interference from $U_1, U_2, \cdots, U_{j-1}$ is removed based on previous decoding results and the interference from $U_{j+1}, \cdots, U_K$ is treated as noise.

6. Empirical Fair Optical Power Allocation (EFOPA)

building on this observation, we propose a method for empirically equitable distribution of optical power (EFOPA), which not only guarantees maximum fairness but also has a low level of computational complexity, and dimming capability. EFOPA is based on a simple formula forequitable optical power distribution. As far as we are aware, there is no equivalent simplified fair optical power allocation formula in the literature that guarantees maximum fairness and customizable intensity levels for both static and dynamic receivers. The EFOPA method simplifies the power allocation process for users [25], meaning that this method does not require subsequent re-optimisation when either the levels of illumination change, or user locations shift (as long as they remain within the same light intensity settings). It gives the Shannon capacity expressions that can be found in Equations [25]:

$$R_k = B_k \log_2\left[1 + \frac{h_k^2 p_k}{\left(h_k^2 \sum_{l=k+1}^{K} p_l + \sigma^2\right)}\right] \quad (14)$$

$$R_k = \frac{B_k}{K}\log_2\left[1 + \frac{h_k^2 p_k}{\sigma^2}\right] \quad (15)$$

7. Cognitive Radio (CR-NOMA)

Cognitive Radio (CR) is the technique evolved to enhance the spectrum utilization by opportunistically using the available spectrum [24]. In a typical environment of a CR network, there exists M different types of primary radio (PR) networks and one or more CR networks that share the same geographic area. In addition, each PR network is ignorant of CR behavior and does not need special abilities to coexist with CRs [40]. In a CR network, there are two kinds of users i.e, PUs, and SUs. PUs are the users who received the license to use the spectrum band. SUs, on the contrary, are generally unlicensed and have access to the entire licensed PU spectrum [39] but must avoid causing interference to PU transmissions. Fig. Fig. 5shows a diagram of CR [41] :

Fig 5: CR-based NOMA network [40].

8. Intelligent Reflecting Surface (IRS)

To be used as a potential 6G wireless communications technologies, IRS has been used for the IRS [21]. In particular, IRS is a cost-effective 2D array with abundant of passive reflecting elements, which can reshape the wireless environment due to its usable facility through a reconfigurable controller. IRS and NOMA improves spectrum efficiency combined with energy efficiency of communication systems jointly [42]. Fig. Figure 6 is a diagram of IRS [42].

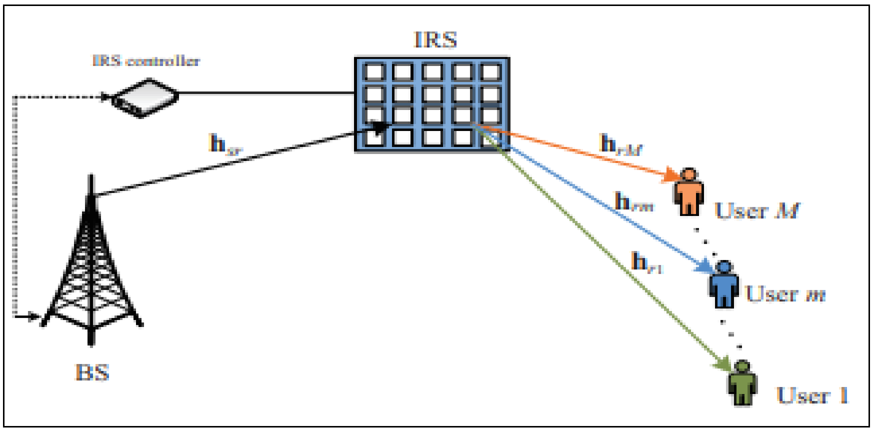

Fig 6: An IRS-assisted downlink NOMA network model in which IRS facilitates communications between the BS and terminal users [42].

How well IRS-NOMA processing uses energy [42]

$$\eta_{EE} = \frac{R_\Phi}{P_{total}} \quad (16)$$

Where $R_\Phi \in (Rm{,}dl, R_{\zeta,dt})$.

Here is a

Table 2: That includes the mentioned techniques with information about their Advantages, Disadvantages, SNR, SE, EE, Power, Data Rate, and Channel

S	Technique	Advantages	Disadvantages	SNR (dB)	SE (bps/Hz)	EE (bits/J)	Power (W)	Data Rate (Mbps)	Channel
1	Particle Swarm Optimization	Global search is effective in dynamic environments	Resource demanding, parameter sensitive	15- 30	2-6	0.5-1.5	0.5-2	20-100	Optimized
2	Gain ratio power allocation (GRPA)	Higher spectral efficiency,better power management improves overall system performance	Increased computational complexity,sensitive to channel conditions	30-40	4.5-6.5	80-100	0.3-0.15	120-250	Rayleigh fading
3	Enhanced gain difference power allocation (EGDPA)	Fairness, Efficient power allocation	Complexity, May not perform well in dynamic environments	25-35	3.5-6.0	70-90	0.25- 0.1	100-200	Rayleigh fading
4	MIMO	Greater capacity, improved spectral efficiency	The higher the complexity, the more hardware is required	20-40	20-40	1-3	1.5-5	50-200	Enhanced
5	SISO	Simple, lower cost	Small volume, less efficient	10-20	1-2	0.2-0.8	0.3-1	10-30	\
6	Empirical Fair Optical Power Allocation (EFOPA)	Equitable division, consistent output	Requires accurate identification of optical parameters	12-28	2-5	0.5-1.7	0.6-1.5	15-85	Fair Allocation
7	CR-NOMA (Cognitive radio NOMA)	Dynamic spectrum, spectrum sharing	Working with interference is another difficult task	18-32	2.5-6	\	0.7-2.5	20-95	Dynamic
8	IRS (Intelligent Reflecting Surface)	Limited range, inexpensive, expands coverage	Expensive to deploy, position sensitive	20-40	5-15	1-4	1-4	50-150	Optimized

5. Conclusion

Non-Orthogonal Multiple Access (NOMA), as a new paradigm of multiple access method, can remarkably enhance the spectral efficiency, Fairness to users, and system capacity of wireless networks as compared to the conventional Orthogonal Multiple Access (OMA) schemes. In contrast to OMA which avoids interference by orthogonally allocating resources, NOMA exploits power-domain multiplexing that let several Users should share the same time and frequency resources at varying power levels. With this method, whilst the Successful Interference Cancellation (SIC) at the receiver, signal separation is performed efficiently and it leads to a boost of network performance in particular conditions where the users have heterogeneous channels. Given NOMA has the property of supporting more users by fitting them within the same bandwidth, this is a significant advantage over OMA in terms of supporting larger cell-edge users who are usually suffering from the worse channel condition from the base station. NOMA supports its greater flexibility with its integration capability with new technologies such as Massive MIMO, Cognitive Radio (CR-NOMA) and Intelligent Reflecting Surfaces (IRS) targeting higher spectral and energy efficiency. Not to mention that the use of power allocation strategies consisting of Gain Ratio Power Allocation (GRPA) and Enhanced Gain Difference Power Allocation (EGDPA) presents another important aspect for maximizing the data rates while minimizing the degradation of adjacent channels, making basic procedures during dynamic network environments where wireless phenomena occur. However, NOMA also comes with some drawbacks such as the increase in computational complexity due to SIC processing and the requirement of accurate power allocation for efficient inter-user interference handling. But due to continuous research in the optimization strategies (such as PSO) and machine learning-based optimization techniques, these issues are progressively being tackled because of the fact that these approaches are highly efficient and scalable for NOMA implementation. Looking ahead to future wireless networks towards 6G, NOMA has the potential to be an important enabler in tackling the rising requests for a high rate of data, minimal latency, and massive connectivity. Due to its suitability for advanced wireless technologies and also for different channel conditions its a good contender for next generation communication systems. Considering the restrictions imposed by the traditional OMA and the potentialities of contemporary optimization techniques, NOMA is one of the significant enablers for the next-generation networks to achieve better resource allocation along with the user experience in a more connected world.

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