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RIS enabled NOMA for Resource Allocation in Beyond 5G Networks

Kirubakaran Namaskaram[1], Parijatham Rajagopal[2], Baby Munirathinam Rathinam[3], Amalorpava Mary Rajee Samuel[3,*], Sridevi Cheguri[4] and M. Fathu Nisha[5]

[1]*Chennai Institute of Technology, Chennai, India*
[2]*Sri Venkateshwara Engineering College,Bangalore, India*
[3]*Malla Reddy Engineering College for Women, Secundrabad, India*
[4]*St.Martin's Engineering college, Secundrabad, India*
[5]*Sethu Institute of Technology, Tamilnadu, India*

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Abstract

The cluster communication of the beyond 5G Heterogeneous Network (Hetnet) is dependent on multiple access techniques. Reconfigurable intelligent surface (RIS) is the potential benefit of 5G when it is combined with non-orthogonal multiple access (NOMA). Although NOMA has been suggested as a way to improve energy efficiency, wireless networks are now denser than before. As a result, the issue with distance, spectrum and energy use gets worse. Due to the limited energy supply, it is necessary to create control over the channel and revolutionary energy efficiency that maximises both total rate and power optimisation. We jointly optimize the transmit power and optimal phase shift to change the weak environment in order to increase the signal-to-noise ratio (SNR) and multiplex data streams in the spatial domain, RIS arrays are used to form beams in the required directions. By decoupling sub channel allocation, a low-complexity sub channel matching method is suggested in order to maximise energy efficiency. In the proposed work, It is demonstrated that the RIS-assisted NOMA system provides promising solutions for users at different scenarios and exhibit significant results in error performance and achievable data rates even in the presence of system imperfections.

Keywords: Heterogeneous Network, NOMA, SWIPT, RIS

1. Introduction

The widespread use of smartphones has led to a significant rise in both subscriber numbers and data traffic. Conversely, consumers find it challenging to fulfil their expectations for excellent service due to the wireless network's limited access to its resources. As a result, one of the potential approach is to use RIS assisted NOMA system. It can be programmed dynamically to reflect, refract and manipulate incoming electromagnetic fields. RIS elements come in sizes ranging from about 100 square centimetres up to about 5 square metres or even bigger. The placement and setup of the RISs have a significant impact on the performance of RIS-assisted NOMA (non-orthogonal multiple access) systems. Consequently, the effect of the RISs on the channel should be taken into account by the fading model.

By including sub-cells in the macrocell region, the system's spectral efficiency (SE) is improved in comparison to the conventional mobile network [1]. The number of antenna elements in the arrays of the 5G base stations (BS) and user equipments (UE) can be measured at the order of 100 and 10, respectively. Macrocells are used in Hetnets to assure coverage, while small cells can be used in conjunction with macrocells to increase throughput [2]. Small base stations (SBSs) are easy to deploy and have good adaptability to deploy.[3] The employment of the BSs increases the power consumption of the wireless network. As a result, reducing interference, increasing energy efficiency, and increasing sum rate are what will determine how well RIS assisted NOMA based Hetnets perform. [5]. In NOMA, Multiple number of users are allocated with same frequency and frequency resources in order to get the connectivity. This multiplexing is of either in code domain or in power domain. The suggested method divides RIS in order to improve NOMA gain and perform with the need for uplink (UL) power control and also optimising the channel conditions for NOMA users.

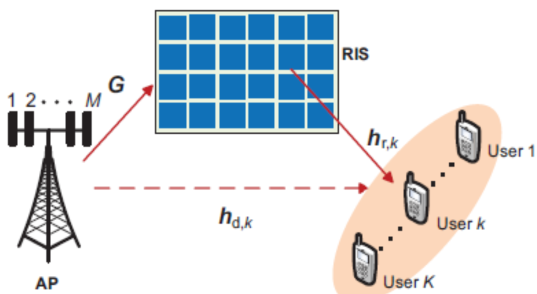

Fig. 1. RIS enabled Heterogeneous network structure [1]

Figure 1 is an illustration of RIS enabled Hetnet structure where K number of users are associated with the BSs through RIS link and direct link as well.

2. Related Work

The authors suggested to increase the attainable rate of a RIS-assisted NOMA system, a simultaneous power

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allocation and reflection optimisation approach. Simulation findings show that, in comparison to traditional NOMA and RIS-assisted systems, the suggested algorithm can greatly increase system performance. [6] The location and power allocation of aerial vehicle and the transmission beamforming of RIS based NOMA are jointly optimized in [7], The authors proposed a multiuser RIS-aided NOMA system with joint power allocation and channel estimation in [8]. The successive interference cancellation approach was employed to enhance the SE and EE NOMA. The signals are grouped according to their power. The NOMA convex function was used by the authors to suggest a game-theoretic technique for power control in Hetnet. Fair resource distribution is also used among the consumers. Nearly about one third of the energy used for operating by the radio access network components. For several methods, including orthogonal frequency division multiple access, the authors in [8] addressed the radio resource allocation problems. (OMA) Both the schemes are deliberated as the suitable technique to support network metrics of quality of service (QoS) requirements for the users, and exploit multi-path fading and achieved high spectral efficiency.

The power domain is used by NOMA to achieve multiple access. It uses the Successive Interference cancellation (SIC) method specifically. With the help of this SIC technology, many users are multiplexed using various power levels within the same frequency range. The OMA scheme is very different from this. The NOMA system allows for the removal of interference from other users who have less channel state information (CSI) by the user who has more CSI. This is the reasoning behind NOMA's ability to use fewer spectrums than the OMA plan. [9-11]

Because the NOMA precept permits several users to be superimposed at the same bandwidth, interference results for such systems. As a result of the inclusion of additional interference that this new era brings, existing useful resource control and interference mitigation strategies, particularly for ultra-dense networks, need to be reviewed. Although the NOMA strategy has several benefits, the increased statistics sensing capacity of more customers as a result of this approach leads to a better safety and privacy danger. Therefore, a series of security issues from the communication layers must be resolved in order to use this method to build a strong, environmentally friendly, and highly effective network. [12-14]

The interference alignment technique improves the sum rate in a Hetnet by avoiding interference among multiple users. For MU-MIMO systems based on NOMA, user-centring techniques like user-pairing and clustering are suggested.

In order to determine closed form equations for sum-rate,, outage probability, energy efficiency, and node power consumption under the NOMA up-link protocol, a mathematical approach is developed. These expressions in closed form can be used to create an optimisation issue that encapsulates the entire system. The difficulty of identifying the ideal parameters that maximise the amount of energy captured while maintaining reasonable system performance within the confines of communication is the impetus for this purpose.

The contributions are as follows

- We derive expressions the sum rate for the NOMA user of the proposed RIS-enabled NOMA Hetnet.
- Initially, we formulate the optimal phase shift and transmit power to calculate the received signal-to interference-plus-noise-ratio (SINR) and then deriving the closed-form expressions of sum rate and EE
- In addition, we illustrate the effect of the sub channel allocation and the power allocation ratio on network performance;
- Finally, the proposed RIS-assiated NOMA Hetnet is compared to its corresponding OMA counterpart and the case with RIS phase array elements.

3. System Model

The capacities, coverage, transmit powers, and Base Station (BS) densities that comprise up a Hetnet's n-tiers of BSs are what set them apart from one another. A two-tier heterogeneous uplink cellular network is modelled in this section. The macro base stations are accumulated with the tiny base stations in a two-tier Hetnet. The idea behind Hetnet is to layer small cells over macro cells in order to provide functionality that the macro cell cannot handle on its own, as well as to meet user traffic requirements and low latency requirements. Within a circular radius of this RIS enabled NOMA-based Hetnet, one MBS and n number of SBS are situated.

A set of "u1, u2, u3,... Un" users are connected to the BSs wherever the signal strength is possible. To prevent interference, the users are divided on the same channel. The number of sub channel shares the entire system bandwidth. users are assigned to specific subchannel as per requirements.

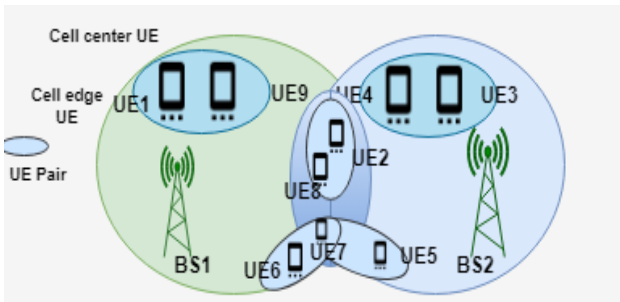

Fig. 2. Energy efficient NOMA based Hetnet

The users associated with SBS are denoted as SUE and users associated with macro base station is denoted as MUE. The adjustable phase shift coefficients of UEs and channel gain are assumed as $g = [g_{1,\ldots,}g_M]^H \in \mathbb{C}^{M\times 1}$ and $h = [h_1, \ldots \ldots \ldots h_M]^H \in \mathbb{C}^{M\times 1}$ The channel gain from the MUE to the RIS and from the RIS to the MBS is assumed as $[\Phi_1, \ldots \ldots \ldots . \Phi_M]^H$

The reflecting coefficients of the RIS is defined as $\Phi_M = \beta_m e^{j\theta_m}$ .where β is an amplitude coefficient of value $\beta_m \in [0,1]$ and θ_m is the adjustable phase shift coefficient of value $\theta_m \in [0,2\pi]$

The transmission of blocked links is carried out through RIS. The large number of low-cost reflecting elements reflects the incident signal with an adjustable phase shift or enables other unnatural environment functionalities. [6,7]. The SINR of the UE is

$$\gamma^{UE} = \frac{P|g^H \Phi h + g^{SS}|^2}{Ph^S + \sigma^2} \tag{1}$$

In this equation (1) σ^2 is the noise power at the receiver. The objective function is to optimize the transmit power. It is represented as

$$P^* = \frac{Ph^{MM} - \gamma^{min}\sigma^2}{\gamma^{min}\left|g^{SM} + f^H \Phi h\right|^2} \tag{2}$$

The optimal transmitted power represented as P^* and Φ_M stands for the controllable phase shift of the M^{th} reflecting element. β and x are the power allocation coefficient and data symbol selected from QAM constellations

The received signal is arranged in ascending order to refine the strongest signal in the cluster of uplink and weakest signal in the group. The sum rate of users of BS b on sub channel s is given by:

$$\sum_{i=1}^{4} R_i \le \log_2\left(1 + \frac{\sum_{i=1}^{4} P_i}{N_0}\right) \tag{3}$$

where Pi stands for the ith user's equivalent transmission power. N0 stands for the AWGN. It is assumed that there are four activated users in a multiple access scenario (1, 2, 3, 4). 4 users' equivalent transmission powers are estimated to range from 4 dBm to 20 dBm.

Although traditional direct superimposition scheme is capable of be most useful perspective of information, the development and deciphering complication is extraordinarily excessive whilst the wide variety of person is large. Therefore, a sub channel matching algorithm is proposed for uplink a couple of access.

As a result of RIS enabled NOMA assigning various users to a subchannel through SIC, it plays decoding on the receiver, where interference is minimised in a positive order according to the power or channel advantage of different customers. The phase shift coefficient is optimized and the rate maximization denoted as

$$\begin{aligned} &\max log_2(1 + \gamma^{UE}) \\ &s.t\ C_1: |\gamma^{UE}| \ge \gamma^{min} \\ &C_2: |\Phi_m| = 1. \forall m \\ &C_3: 0 \le P^* \le P^{max} \end{aligned} \tag{4}$$

There are maximum users expected to be assigned with each subchannel of the BS. The users are first decoded at the identical subchannel. The data rate is in proportion to its SINR and it can be formulated as follows, based on Dinkelbach's method,

$$\max R\ |g^H \Phi h + g^{SS}|^2 \ - \lambda |g^{SM} + f^H \Phi h|^2 \tag{5}$$

The achievable rate of NOMA user is denoted as

$$\gamma_k^{NOMA} = \frac{P_k\left|g_k^{SS} + g_k^H \Phi h\right|^2}{\left|g_k^{SS} + g_k^H \Phi h\right|^2 \sum_{i=1}^{k-1} P_i + \left|h_k^{MS}\right|^2 P + \sigma_k^2} \tag{6}$$

where the first term in the denominator is the interference from Macro base station. The total sum rate is obtained as

$$R = \sum_{k=1}^{K} log_2(1 + \gamma_k^{NOMA}) \tag{7}$$

A. Transmission Power Optimization with Φ

Resource allocation and sub channel allocation are done in an effort to cut down on system energy use. The successive convex approximation for low complexity (SCALE) algorithm in Ref [12], for any z > 0,

$$log_2(1 + z) \ge \alpha log_2 z + \beta \tag{8}$$

In equation (6) the auxiliary variables are $\alpha = \frac{z_0}{1+z_0}$ and $\beta = log_2(1 + z_0)$ these are approximation constants.

The elements required for network QoS are maximum power constraints, CSI and rate of uplink users. The relationship is close-fitting when $z = z_0$. All these parameters have an adequate impact on the sumrate maximization in RIS-NOMA primarily based totally Hetnets. The optimisation problem is complicated by the following restrictions, such as the power need and the QoS requirement on each subchannel, in order to maximise the sumrate and minimise cross-tier interference. As a result the following is optimized sumrate

$$R = \sum_{i=1}^{K} \alpha_k\, log_2 \gamma_k + \sum_{k=1}^{K} \beta_k \tag{9}$$

Where denoted as the minimal required transmission rate of each BS.

$$\begin{aligned} &max \sum_{k=1}^{K} \alpha_k log_2\left(\left|g_k^{SS} + g_k^H \Phi h\right|^2\right) \\ &\qquad - \sum_{k=1}^{K} \beta_k \\ &\qquad - \sum_{k=1}^{K} \alpha_k log_2\left(\sigma_k + \left|g_k^{SS} + g_k^H \Phi h\right|^2 \sum_{i=1}^{k-1} e^{P_i^*}\right) \\ &s.t\ \ C_4: \sum_{k=1}^{K} e^{P_k} \le P^{max} \\ &C_5: \sum_{k=1}^{K} e^{P_k} |g_n^{SS} + f_n^H \Phi h|^2 \le I_n^{th}, \forall n \end{aligned} \tag{10}$$

The optimization problem is a concave maximization since the log-sum-exp is convex [13]. The closed form solution is obtained by solving Lagrange dual theory. The solution can be solved as:

$$L(P_k^*, \mu, \delta_n) = \sum_{k=1}^{K} \alpha_k P_k + \sum_{k=1}^{K} \alpha_k log_2(\,|g_k^{SS} + g_k^H \Phi h|^2) - \sum_{k=1}^{K} \beta_k - \sum_{k=1}^{K} \alpha_k log_2(\sigma_k + |g_k^{SS} + g_k^H \Phi h|^2 \sum_{i=1}^{K-1} e^{P_i}) + \mu(P^{max} - \sum_{k=1}^{K} e^{P_k}) + \sum_{n=1}^{N} \delta_n (I_n^{th} - \sum_{k=1}^{K} e^{P_k} |g_n^{SM} + f_n^H \Phi h|^2) \tag{11}$$

The non-negative multipliers are μ and δ. Based on Karush-Kuhn-Tucker (KKT) conditions, the transmitted power is calculated by

$$P_k^* = \left[\frac{\alpha_k}{\mu + \sum_{n=1}^{N} \delta_n \left|g_n^{SM} + f_n^H \Phi h\right|^2}\right] \tag{12}$$

The objective function is non-concave since P_k^* and Φ_k are coupled each other. Hence we need to optimize the phase shift Φ_k in accordance with the solution (12) of P_k^*

B. Energy-Efficient Phase shift optimization

In order to achieve the maximization of transmission power and phase shift of RIS is getting optimized. In order to optimize Φ_k, optimized transmit power should be fixed.

$$\begin{aligned} &Max\ \sum_{k=1}^{K} \frac{\alpha_k P_k \left|g_k^{SS} + g_k^H \Phi h\right|^2}{\left|g_k^{SS} + g_k^H \Phi h\right|^2 \sum_{i=1}^{k-1} P_i + \sigma_k} \\ &s.t\ C2: |\Phi_m| = 1\ \forall\ m \\ &C6: \sum_{k=1}^{K} P_k |g_n^{SM} + f_n^H \Phi h|^2 \le I_n^{th} \end{aligned} \tag{13}$$

A less complex and more effective set multiple-ratio fractional programing is created to determine the non-convexity subjected to constraints C2 and C6.

C6 becomes

$$|g_n^{SM} + f_n^H \Phi h|^2 \le |g_n^{SM}|^2 + |\Phi^H f|^2 = |g_n^{SM}|^2 + \Phi^H f \Phi \le {I_n^{th}}\Big/{\sum_{k=1}^{K} P_k} \quad (14)$$

Thus the phase shits becomes

$$\Phi^H f \Phi \le I_n^{th}, \quad (15)$$

Where

$I_n^{th} = {I_n^{th}}\Big/{\sum_{k=1}^{K} P_k} - |g_n^{SM}|^2$ is the minimum interference for the macro UE.

$$\max \sum_{k=1}^{K} y_k$$
$$s.t.\, C_4: \Phi^H \cup \Phi = 1$$
$$C_7: f_k^H + f_k \le 0$$
$$C_8: \Phi^H F \Phi \le I_n^{th}, \forall n \quad (16)$$

Where

$$f_k = \Phi^H g_k g_k^H \Phi + 2Re\{g_k^{SS} g_k^H \Phi\}$$

The above problem is convex optimization with quadratic constraints.

Thus the Lagrange function is

$$L(\Phi . y_k, \vartheta, \rho, \omega) = -\sum_{k=1}^{K} y_k + \vartheta(\Phi^H \cup \Phi - 1) + \sum_{k=1}^{K} \omega(f_k^H + f_k) + \sum_{n=1}^{N} \rho(\Phi^H F \Phi \le I_n^{th}) \quad (17)$$

Where ϑ, ρ and ω are the non-negative Lagrange multipliers.

Based on KKT conditions,

The optimized phase shift becomes y_k^*

$$y_k^* = \frac{\alpha_k P_k + \sigma\sqrt{\omega, \alpha, \rho}}{\sum_{i=1}^{K-1} P_i} \quad (18)$$

The Lagrange multipliers are

$$\omega(l+1) = [\omega(l) + d_3(l) \times \{f_k^* + f_k\}]$$
$$\vartheta(l+1) = [\vartheta(l) + d_4(l) \times (\Phi^H \cup \Phi - 1)]$$
$$\rho(l+1) = [\rho(l) + d_5(l) \times (\Phi^H F \Phi - I_n^{th})] \quad (19)$$

Where $d_3(l)$, $d_4(l)$ and $d_5(l)$ are the step sizes.

Uplink users on BSs and subchannels are assigned through the use of matching technique. This collection of guidelines covers two main methods. The consumer is first assigned to the subchannel in accordance with the channel's exceptional status. If not, the relevant subchannel is allotted to the users with the highest CSI. Second, users who can increase the channel's EE are chosen.

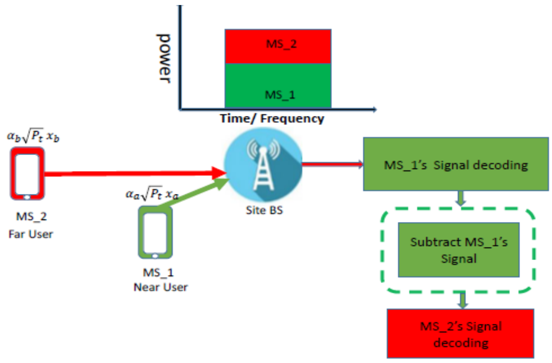

Fig. 3. Uplink NOMA subchannel allocation

The subchannel allocation plan for each BS will then be provided. Because the exhaustive technique, the most effective subchannel allocation strategy, seeks for all possible customer combinations and selects the consumer mixtures from them to maximise the power efficiency of the system which significantly will increase the complexity. The suggested subchannel allocation algorithms fall short of expectations. However, the suggested subchannel allocation methods are less complicated and may distribute the subchannel more quickly than the conventional subchannel allocation system.

Table 1. Nomenclature

Symbol	Notation
M	Reflecting elements in RIS
K	Total No. of User Equipments
P^{max}	Maximum Transmitted power
I_n^{th}	Interference
σ_k^2	Noise Power
g_k	Channel gain
h	The channel gain from the MUE to the RIS
f_n	Interference gain
g_n^{SM}	The channel gain from RIS to MUE
α_k, β_k, l	Auxiliary variables
$d_3(l) d_4(l)\ d_5(l)$	Step size
$\delta(0), \vartheta(0)\ \rho(0)\ \omega(0)$	Lagrange Multipliers
$\Phi(0)$	Phase shift of RIS
y_k	Optimized Phase shift

RIS-NOMA based Resource Allocation Algorithm

Input:
M,K, $P^{max}, I_n^{th}, \sigma_k^2, g_k, h, f_n, g_n^{SM}$

Initialize: $\alpha_k, \beta_k, l = 0, P_k(0) = \frac{P^{max}}{K}, \delta(0) > 0, \vartheta(0) > 0, \rho(0) > 0, \omega(0) > 0, d_3(0) > 0, d_4(0) > 0, d_5(0) > 0\ \Phi(0) = \frac{\pi}{2} I_M$

While $l < L_{max}$ do

Update $P_k, \forall k$: (eqn)

for $i = 1{:}1{:}L_1$ do

Update Lagrange multipliers μ and δ by problems

Update auxiliary variable $\alpha_k(i+1) = \frac{\gamma_k^{UE}(i)}{1+\gamma_k^{UE}(i)}$

and $\beta_k(i+1) = log_2(1 + \gamma_k^{UE}(i)) - \alpha(i) log_2(\gamma_k^{UE}(i))$

6 Check if all the users are assigned with optimal power
$\|P(i+1)-P(i)\|^2 < \varepsilon$ then
Obtain the next optimal $P^* = P(i+1)$
7 end if
8 end for
9 Update Φ for given P^*
for $j = 1{:}1{:}L_j$ do
Update the auxiliary variable y_k and the Lagrange multipliers
Until $\|y(j+1)-y(j)\|^2 < \varepsilon$
Obtain y_k, ω, α and ρ
If $\|\Phi(j+1)-\Phi(j)\|^2 < \varepsilon$ then
$\Phi^* = \Phi(j+1)$, break;
else
j=j+1;
end if
10 end for
Output P^* and Φ^*

The power performance parameter t is initialized, along with the maximum iteration range and their error tolerance. Iteratively, the power matrix and subchannel allocation matrix are updated in accordance with the signal strength, and the total EE, or parameter t, is determined. The energy efficiency restrictions are taken into consideration when updating the subchannel allocation matrix. The equivalent transmission power matrix is arranged in ascending order as a result. The system's EE converges as a result of the increased repetition of iterations. The iterative strength optimisation set of rules' specific phases are enumerated in Algorithm.

In terms of fundamental structure and functionality, energy-efficient NOMA performs similarly to SIC. According to the working theory of the SIC, the users with strong channel conditions perform the decoding, therefore the messages of the weak user would be decoded first by the users with superior channel circumstances. In order to help other users with weak channel states and increase their reliability, users with good channel conditions use this knowledge to act as relays for other users. The following flowchart illustrates the fundamental functioning when there is just one SC and two or more users.

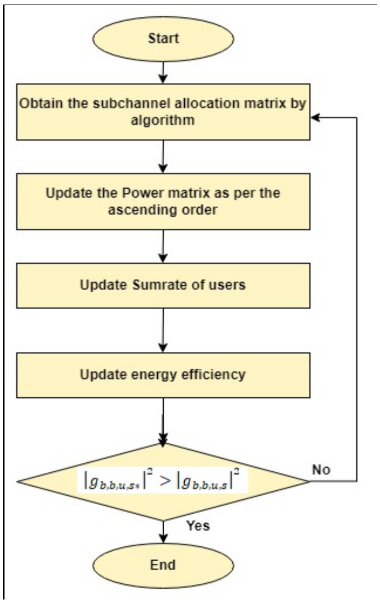

Fig. 4. Flow chart of energy efficient RIS-NOMA based Hetnets

Table 2. Simulation parameters

Parameters	Values
Radius	500 m
System Bandwidth	1 MHz
Number of subchannel	10
Small cell radius	15 m
Transmission power of MBS	46 dBm
Transmission power of SBS	20 dBm
Noise power spectral density	-174 dBm/Hz

The suggested RIS assisted NOMA implementation also made it possible for a sizable rise in sum-rate. Similarly, the power allocation factor for near user is β = 0.25 while for far user is β=0.5. The proposed algorithm is converged within 100 iterations. The optimal phase shift is attained while ensuring QoS constraint

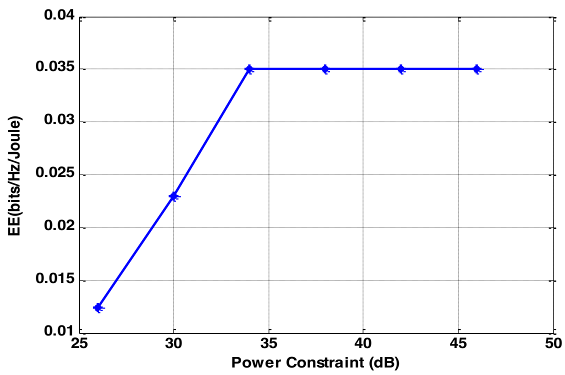

Fig. 5. Energy efficiency of NOMA based Hetnets over different power constraint

4. Numerical Evaluation and Simulation Results

This section comprises of analytical results with MATLAB simulation where we consider a circular area 500 m in which MBS located in center and the FBS are surrounded. The proposed sub channel allocation algorithm and power control in terms of EE is verified with the simulation. The simulation parameters are listed in table 1.

Four users are supposed to be served by the small cell. Power control and subchannel allocation are derived simultaneously. We first derived the power control matrix, then the subchannel allocation matrix. As a result, the strategy suggested in this paper is not the best. We were successful in using the suggested approach to simultaneously enhance several performance measures in an ultra-dense Hetnet that was randomly deployed. For instance, when compared to the standard NOMA scheme, the system capacity and throughput gain increased by 18 and 27%, respectively, and by 82% and 67%, respectively, when compared to the conventional OFDMA scheme

There is a list of the transmit power and coverage range of macrocells and femtocells. There is also a list of the total number of macro and femto CUEs. However, we have assessed the scenario by adding more UEs. Based on the distance between the near user and the BSs, the effect of the power allocation factor is assessed on the performance of the hybrid NOMA system, accordingly. The suggested Subchannel algorithm's average energy efficiency is shown in Fig. 5, and this configuration is simulated using random channel realisations. According to the data, the EE gradually increases in the low transmit power zone, from 26 dBm to

34 dBm, and then converges once it enters the high power range. The combination of RIS and NOMA, provides opportunities to optimize the overall system power consumption. This could involve adjusting the power allocation strategy for NOMA users in conjunction with the capabilities of the RIS.

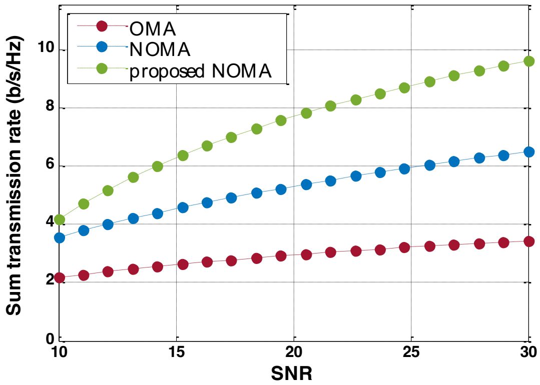

Fig. 6. Sum transmission rate of NOMA based Hetnets over different Transmit SNR

Utilizing NOMA, the effectiveness of the suggested subchannel allocation and fair power allocation methods is assessed, and the results are contrasted with those of the NOMA and OMA techniques.

It is obvious that boosting transmitted power results in higher sum rate capacities that can be attained at lower SNRs. Fixed power allotment cannot be increased arbitrarily due to co-channel interference. Sum transmission rate (b/s/Hz) for various transmit SNRs is shown in Fig. 6. A comparison is made between the proposed sub channel NOMA scheme and other modulation techniques like OMA and NOMA without power restriction. It is obvious from Fig. 4 that raising SNR enhances this sub channel NOMA scheme's total transmission capacity in perfect interference cancellation mode. The fact that it functions well in many channel conditions contributes to this improvement in performance, but OMA still outperforms it in terms of total rate. When compared to the intended NOMA, the SC-NOMA falls short. This is a result of the same carrier being overloaded with users.

Fig. 7 illustrates how the energy efficiency performance of the proposed NOMA system is used to assess the impact of the power constraint.

It demonstrates that when the number of UEs rises, EE rises as well—up to a point, that is, when the maximum system capacity is reached—and then, if the number of UEs rises further, EE declines. But in Hetnets, MBS fares better than SBS. The result shows that the throughput and EE in both Hetnets and the MBS-only network rise when we increase the number of UEs up to a specified level. However, throughput rises but EE slightly drops as the number of UEs in the network rises. Additionally, this graph shows how RIS assisted NOMA based Hetnets outperforms other networks in terms of throughput and EE.

The proposed NOMA system produces a 6.1 dB increase in SNR for a BER of 10^2. The ability of the proposed NOMA strategy to remove both the AWGN effect and cross-tier interference is what causes this increase in SNR. In terms of sum-rate performance,

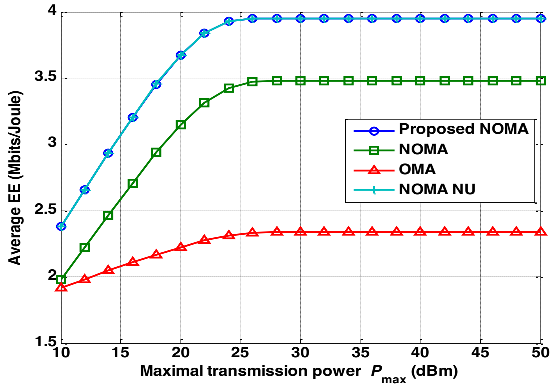

Fig. 7. Average EE of NOMA based Hetnet over different Transmit power

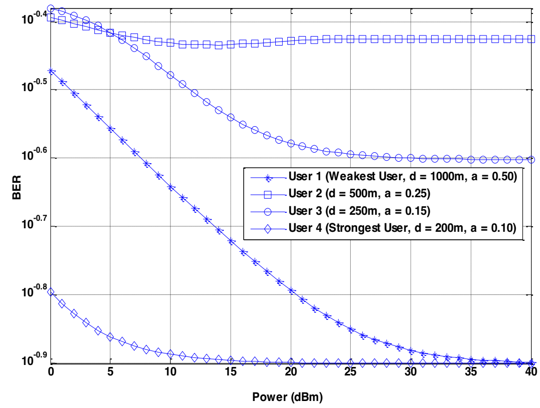

Fig. 8. BER of RIS-NOMA based Hetnet over different Transmit power

Fig. 8 shows that the proposed NOMA scheme works better than the SIC-based method [10] with a comparative improvement of roughly 24%. It should be noted that the SIC-based NOMA system requires extra processing and signalling overheads to carry out user pairing and power control operations and to communicate this information to ultra-dense network. Achieving a low BER is generally desirable because it indicates a high level of reliability in data transmission.

It has been discovered that the proposed NOMA approach significantly improves the fairness measures. Additionally, the sum rate and outage for the proposed NOMA technique are calculated and illustrated in figures 9 and 10, which make use of the enhanced power allocation coefficients and time length. The numerical results indicate an increase in the system's EE as well as a strengthening of user fairness.

As per the the proposed results, the signal from far end is considered as interference. The likelihood of a failure, known as an outage, is the rate at which a message will be correctly decoded. The increase in target data rates for users depends on the outage probability. Hence by using this sub channel allocation with power coefficients, we can mitigate an outage by adjusting channel coefficients and power coefficients. In scenarios where the channel conditions are not distinctly different or where interference is significant, the gains of NOMA may be limited.

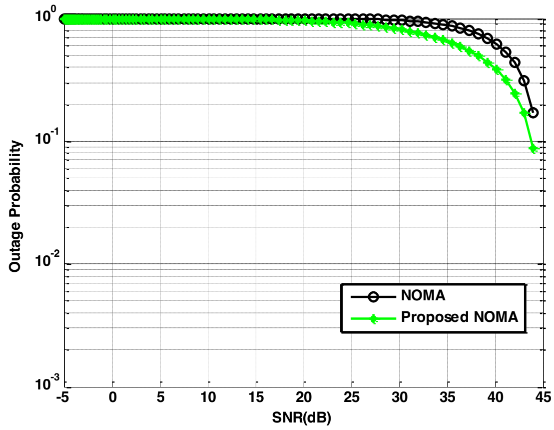

Fig. 9. Outage Probability of RIS-NOMA based Hetnet

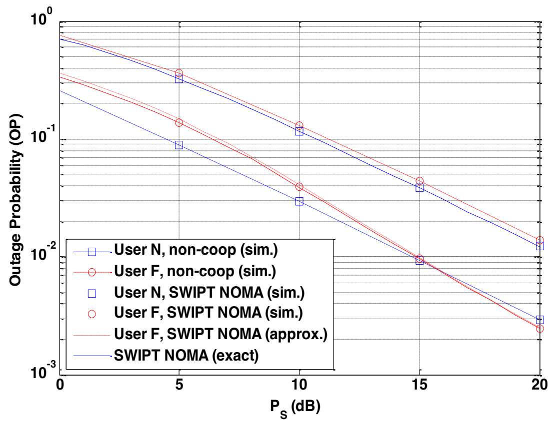

Fig. 10. Outage Probability comparison

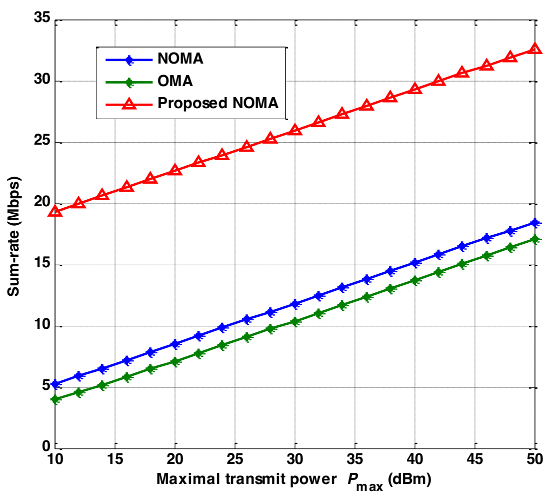

Fig. 11. Sum-rate of RIS-NOMA based Hetnet over different Transmit power

The compression ratio for individual near and far user can be calculated using

$$k_a = \left(1 - \frac{N_a}{L_a}\right) \times 100$$

$$k_b = \left(1 - \frac{N_b}{L_b}\right) \times 100 \tag{20}$$

L_a and L_b are the original length of signal. N_a and N_b are the number of no-zero samples.

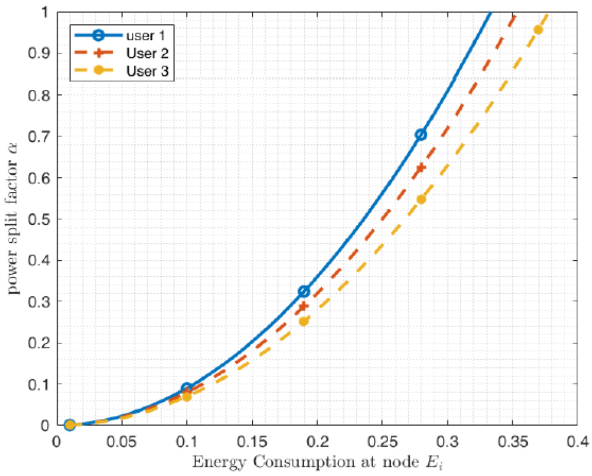

Fig. 12. Energy consumption for users

Figure 12 depicts the energy consumption ratio during decoding and encoding steps. The higher the power factor coefficients, the higher the consumption. The maximum power consumption will have the impact on the energy performance. This system can be applied for smart as well as efficient data transmission under NOMA uplink. The near and far NOMA users are trying to adjust their transmitted signal using their power factors. Using SWIPT and subchannel allocation algorithm the original signal is retrieved by decoding the message from near user first and simultaneously as per power order. NOMA relies on proper power allocation among users to maximize system throughput. If the power allocation strategy is not optimized for the specific channel conditions and interference environment, the expected gains may not be realized. The primary function of data compression in our proposed system is to conserve energy at the NOMA smart users.

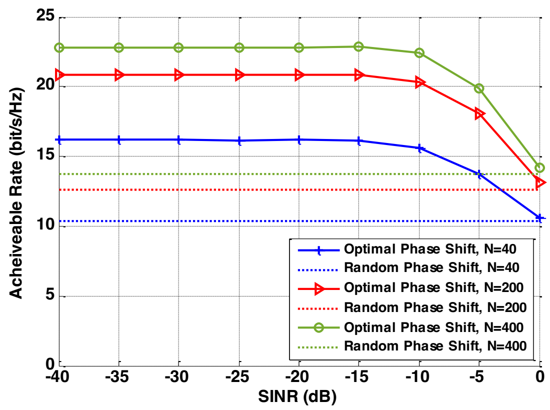

Fig. 13. Achievable Rate of RIS assisted NOMA users

The power of a RIS in the planning and development of the next-generation heterogeneous network is demonstrated using the numerical data provided. In three different array element scenarios, the possible data rate and spectral efficiency in the presence of random phase shift and optimal phase shift are compared.

5. Conclusion

In this work, the investigation of sub channel allocation and energy optimisation in NOMA-based Hetnet with a focus on power limitations and cross-tier interference reduction.

Power optimisation through energy harvesting is suggested due to a limited power restriction. Since the non-convex aim characteristic has a fractional shape, it can be transformed into an equivalent subtractive shape. The suggested and tested sub channel-matching algorithm is mostly dependent on the channel circumstances. The idea of wireless information and power transfer occurring simultaneously is examined, and the current trade-off between information rate and transferred energy at the receiver is illustrated. The proposed problem was able to adjust the user's transmission power and achieving the maximum data rate.

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