ANALYSIS AND SYNTHESIS OF ENERGY EFFICIENT POWER ALLOCATION FOR NOMA-MIMO IN 5G

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Abstract

Millimetre Wave (mm Wave) Massive Multiple Input Multiple Output Beam Space MIMO, the required Radio Frequency (RF) chain systems can be reduced without loss of performance. However, the basic limit of the number of users supported by MIMO speeds in existing beams cannot be larger than the number of RF chains in the frequency resource. To eliminate the limitation, the concept of non-orthogonal multiple access (NOMA) has been proposed for the energy efficient mm wave and new spectrum transmission scheme that integrates with the beam space MIMO. Using NOMA in the Beam Space MIMO system, the number of RF chains may be lesser than the number of supported users in concurrent frequency resources. MIMO-NOMA analysed the achievable rate of the proposed beam space MIMO NOMA, which surpasses the existing techniques. The proposed beam space MIMO-NOMA can achieve higher energy efficiency compared to the existing beam space MIMO.

Keywords: *EE (Energy Efficiency), NOMA, OFDMA, SE (Spectral Efficiency). MIMO, Radio Frequency*

1. Introduction

Multi-Input Multi-Output (MIMO) communications that generate multi-user beam are a potential technology to achieve significant gains in overall system performance. Downlink Multiuser MIMO [9] provides one or more beams for each user in the cell, depending on the number of base station (BS) transmit antennas and the total number of antennas received by the user. To avoid the inter beam interference the transmission antenna is greater than or equal to receiving antenna. Non-Orthogonal Multiple Access is the key radio access techniques that are promising for performance improvement in future cellular communications. NOMA offers desirable benefits including high spectrum performance compared to the orthogonal frequency segment multiple accesses (OFDMA) [6]. As with conventional Orthogonal Multiple Access (OMA), each user is allocated exclusive spectrum resources, and users can exploit their respective channel gains whenever NOMA monitors the message signals of multiple users in the power domain at the transmitter nodes. Successive Interference cancellation (SIC) is used for multiuser detection at receiver and decoding.

Power allocation for NOMA with optimal solution provides maximum efficiency in both uplink and downlink NOMA system. However, the requirement of power allocation among NOMA users at transmitter end and the use of SIC application at receiver end potentially bound scheduling in NOMA. In existing OMA schemes, users had to share either time (TDMA) or frequency (FDMA and OFDMA). This share of resources is what limits the OMA schemes, because it limits the bandwidth that such schemes are able to offer, to each individual user. The users are superimposed in power domain at same time and frequency. Superposition Coding (SC) and decoding is done in the power domain. NOMA does not require spreading codes in power domain.

NOMA is used to achieve high SE and energy efficiency on Orthogonal Multiple Access (OMA). The introduction of 5G has led to the development of new technologies that improve network efficiency, reduce end-to-end delay and increase reliability. For all users NOMAs entire interest rests on the channel allocation of power and channel. In the present system, the power allocation is only detected for fewer instances, the joint optimization of the power allocation and the channel allocation is a common requirement. In [2] the author has considered both maximum and minimum integrity, the increase in the weighted sum rate, the incremental rate with the Service Quality constraints, and the energy efficiency increase with the weights or QoS constraints in the NOMA system.

The combination of NOMA and MIMO technologies demonstrates significant potential for improving spectral performance and providing services to a large number of users. In [16] the author has investigated the problem creation, beamforming, user clustering and power allocation of MIMO-NOMA with their limitations. The critical issue of the sustainability of SIC interrupt cancellation arising from the use of achievable rates as performance metrics. NOMA with a massive MIMO / millimetre-wave MIMO that can be used the use of Non-Orthogonal Multiple Access with SIC in downlink multicore Multi-Input Multi-Output (MIMO) cellular systems is explored. The total number of antennas that end up in a user cell (UE) is greater than the number of transmit antennas at the base station (BS). Dynamic power allocation solutions to increase the overall cell capacity for inter-cluster and intra-cluster power allocation were offered.

2. Related work

In paper [1] the author has proposed an optimal power allocation scheme for MIMO NOMA systems, based on CSI criteria which can achieve the capacity portion of the MIMO broadcast channel as dirty paper code. A less complex sub-optimal scheme is proposed for all CSI channel conditions. The numerical results show that the NOMA projects significantly outperform the traditional time segment based single-user MIMO program and the multi-user MIMO. In paper [2] the author has proposed explicitly taking into account the regulatory constraints on the powers of users in each channel, they are ignored in their existing works and they show that they have a significant impact on SIC in NOMA systems. Then, we provide the optimal power allocation for the criteria considered in either closed or semi-closed form. We also propose a less complex and efficient method to jointly improve channel allocation and power allocation in NOMA systems by combining optimal power allocation.

In paper [3] the author has proposed with the explosive growth of high-data-rate applications, more power is being used in wireless networks to ensure service quality. Therefore, energy-efficient communications have been given more attention in the context of low energy resource and environmentally friendly transmission behaviours. In paper [4] the author aimed at increasing the quality of user’s service needs and the energy efficiency under each cluster power constraint. Based on RF chains to obtain the optimal power allocation. The simulation results show that the proposed NOMA scheme achieves better EE performance than the conventional OMA scheme.

In paper [5] the author has proposed Explore the most efficient 3-D resource allocation for massive MIMO-NOMA systems. Due to the complexity of the hardware and the channel variation in the massive MIMO-NOMA system, efficient antenna selection and user scheduling algorithms have been proposed to increase the cost rate. A joint NOMA-Assisted Relaying (CNAR) system is proposed to serve multiple cell-edge users through the use of 3-D resource. To minimize the relaying problem in the CNAR system, the Simplified-CNAR (S-CNAR) system has been proposed as an alternative NOMA-enabled relaying strategy.

In paper [6] the author has proposed primarily on the power-domain NOMA Uses Super Position Coding (SC) in Transmitter and Subsequent Interrupt Cancellation (SIC) Receiver. Various researchers have demonstrated that NOMA can be used effectively to meet Network-level and user-experience data rate requirements of the fifth generation (5G) Technologies. In paper [7] the author has proposed the optimization problem, for NOMA resulting the better data rate and energy efficiency than the conventional orthogonal frequency segments multiple access schemes. The Cluster-Head Selection (CHS) algorithm for selecting a user for each beam is proposed in [8].

In paper [9] the author has proposed investigated the trade-off between data rate efficiency and energy consumption in NOMA. The simulation results show that the resource allocation schemes for both the perfect CSI and the imperfect CSI can significantly increase the energy efficiency of the NOMA multilateral networks. In paper [10] the author has proposed an EE-optimized power allocation strategy that maximizes EE. The numerical results show that NOMA has better EE performance compared to conventional orthogonal multiple access. In paper [12] the author has proposed a new design of prediction and detection metrics for MIMO-NOMA is proposed and its performance is analysed with a constant power allocation coefficient. In paper [13] the author has investigated the performance of an internal 2×2 MIMO-NOMA-based multi-user VLC system.

3. Proposed Work

Beam Space Multiple Input Multiple Output (MIMO), the proposed method that can significantly reduce the number of radio frequency (RF) chains required in millimetre wave (mm wave) massive MIMO systems without loss of performance. To overcome the limit of existing beam space MIMO, a new spectrum and energy-efficient mm wave transmission scheme that integrates the concept of Non-Orthogonal Multiple Access with beam space MIMO, is used to simultaneously increase the number of supported RF chains in frequency resources.

The energy efficiency problem is explored in a massive MIMO system with millimetre wave (mm wave) with Non- Orthogonal Multiple Access. Many two-user clusters are designed according to their channel interaction and gain differentiation. We propose a hybrid analog or digital briquetting scheme for low radio frequency (RF) chain structure at the base station (BS). Based on the above, users' service quality (QoS) requirements and the power allocation problem are created to maximize the EE under each cluster of power constraints. An operational mechanism is proposed to obtain the optimal power allocation. The simulation results show that the proposed NOMA achieves better EE performance than conventional OMA.

Due to its ability to improve system spectral performance in wireless communications, Non-Orthogonal Multi-Access relies on the latest technologies. Using

NOMA on a multichannel network will meet the high data traffic needs of users. The interplay between data rate efficiency and energy consumption in NOMA, energy-efficient user planning and power optimization in NOMA multichannel networks were explored. The simulation results show that the resource allocation schemes for both the perfect CSI and the imperfect CSI can significantly increase the Energy Efficiency of the NOMA heterogeneous networks

3.1 Beam space MIMO

Beam Space MIMO systems, the received signal vector can be can be expressed as

$$y = H^H \text{WPs} + \text{v} \tag{1}$$

where s indicates the signal vector

P - Maximum transmitted power at the BS

W - Precoding matrix for k = 1, 2,...... K

v - noise

H = $[h_1, h_2, \ldots. h_k]$ of size $N \times K$ channel gain matrix

3.2 Saleh-Valenzuela channel model

This statistical model whose basic assumption is that the multipath elements arrive in clusters, resulting from multiple reflections from objects near the receiver and transmitter.

$$h_k = \beta_k^{(0)} \ (\text{a}\ \theta_k^{(0)}) + \sum_{l=1}^{L} \beta_k^{(l)} \ (\text{a}\ \theta_k^{(l)}) \tag{2}$$

Where $\beta_k^{(0)}$ (a $\theta_k^{(0)}$) - LoS component of the k^{th} user

$\beta_k^{(0)}$- Complex gain

$\theta_k^{(0)}$- Spatial direction

$\beta_k^{(0)}$ (a $\theta_k^{(0)}$)for $1 \le l \le L$ is the l^{th} NLoS component of the k^{th} user

For a typical Uniform Linear Array, the array steering vector a**(θ)** can be expressed as

$$\text{a}\ (\theta) = 1/\sqrt{N}\ [e^{-j2\pi\theta_m}]_{m\in J(N)} \tag{3}$$

where $J(N) = \{i - (N - 1)/2, i = 0, 1, \cdot \cdot \cdot , N - 1\}$ is a symmetric set of indices centred around zero

The spatial direction is defined as

$$\theta = \text{d}/\lambda \sin(\varphi) \tag{4}$$

where φ - physical direction

λ - Signal wavelength

d - antenna spacing

φ- Physical direction satisfying $-\pi/2 \leq \varphi \leq \pi/2$

λ- Signal wavelength

$$\theta n = 1/N\ (n - N+1/2) \tag{6}$$

3.3 Proposed Beam space MIMO-NOMA

To further improve the spectrum performance and connectivity, NOMA is recommended in the Beam Space mm wave MIMO systems. Unlike existing beam space MIMO systems, each beam selected in the proposed beam space MIMO-NOMA can serve more than one user simultaneously.

Achievable Sum Rate

m^{th} user detects i^{th} user signals $1 \leq m < i \leq |S_n|$ and then removes detected signals from received signals.

The achievable rate at the m^{th} user in the nth beam is given by

$$R_{m,n} = log_2(1+ \gamma_{mn}) \tag{7}$$

Where γ_{mn} - SINR at the m^{th} user in nth beam

S_n for $n = 1, 2, \cdots, N$RF denote the set of users served by the *n*th beam

Spectrum Efficiency

The spectrum performance against the SNR of the proposed beam space MIMO-NOMA scheme can be defined by a strong user-based equivalent channel for iteration 10 and K = 32.

Energy Efficiency

$$R_{sum} = \sum_{n=1}^{N_{RF}} R_{m,n} \tag{8}$$

The energy efficiency ε is given by,

$$\varepsilon = R_{sum} / P + N_{RF}P_{RF} + N_{RF}P_{SW} + P_{BB} \tag{9}$$

Where P is the maximum power transmitted, P_{RF} is the RF chain consumed power Consumed by each RF chain, P_{SW} is the power consumption of switch, and P_{BB} is the baseband power consumption.

Simulation Specification and Results

The specifications of the MIMO-NOMA of the energy-efficient beam space for the millimetre wave mm wave system are given in Table 1.

Table 1. Specifications for Energy-efficient beam space MIMO-NOMA

PARAMETERS	**EXPRESSION**
N = 256 K = 32 L = 3	transmit antennas Number of users paths per user
N_{RF}	Number of RF chains
K	Single antenna users
λ= 1	Wavelength
D	d = λ/2 , antenna array spacing
SNR = 10 dB	Signal to Noise Ratio
P = 32	total transmitted power
Imax = 30	iteration times of power allocation
a(Θ)	a(Θ) = $1/\sqrt{N}\ [e^{-j2\pi\theta_m}]_{m\in J(N)}$, **a(Θ)** is the array steering vector
H = [h_1, h_2, · · · , h_k]	Beam space channel matrix

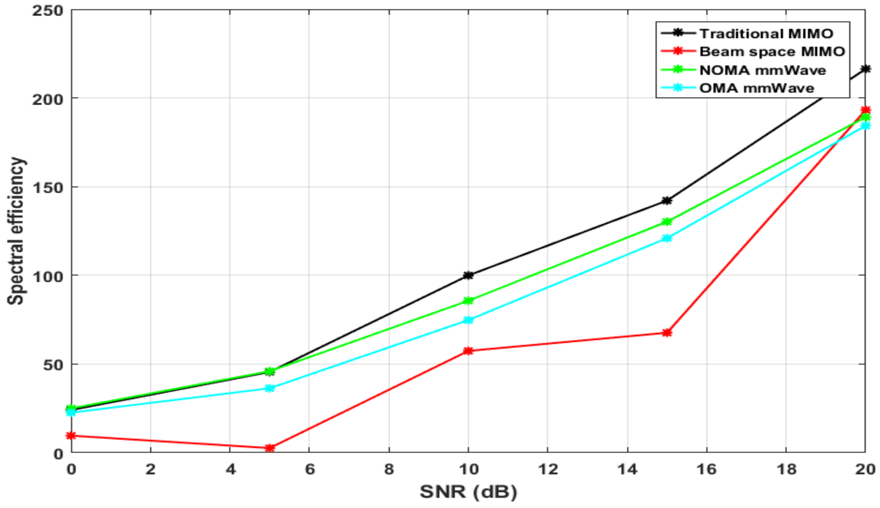

Figure 1. Performance of SE Vs SNR

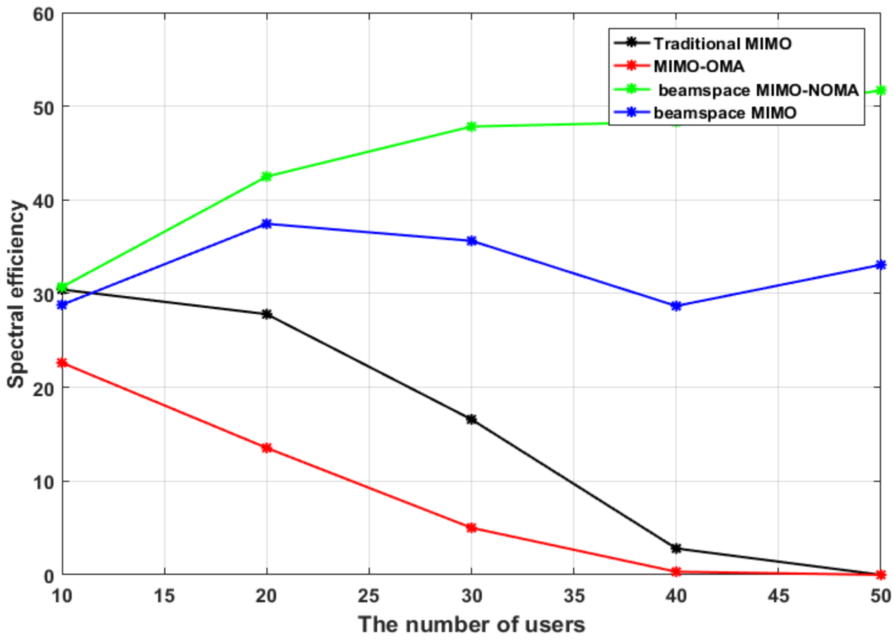

Figure 2. Spectrum performance Vs Users K

In Figure 1, Spectrum performance against SNR of the four schemes is considered. It has been found that the proposed beam space MIMO-NOMA scheme can achieve higher spectrum performance than the beam space MIMO and MIMO-OMA**.** In Figure 2, Performance of spectrum efficiency against the number of K users, when SNR = 10 dB and with increasing users K, the performance gap between the beam space MIMO and the proposed beam space MIMO-NOMA increases.

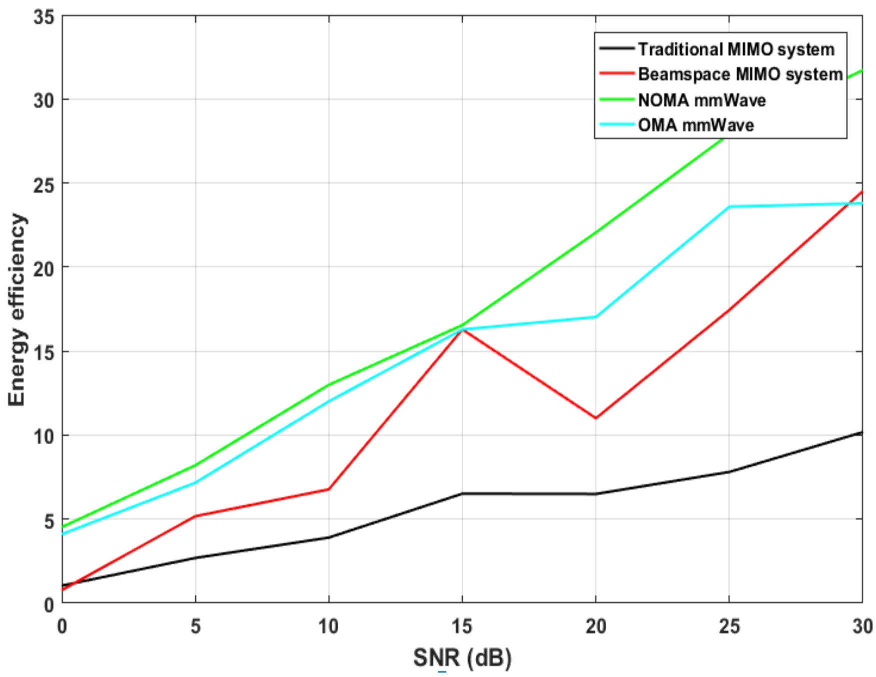

Figure 3. Energy Efficiency Vs SNR

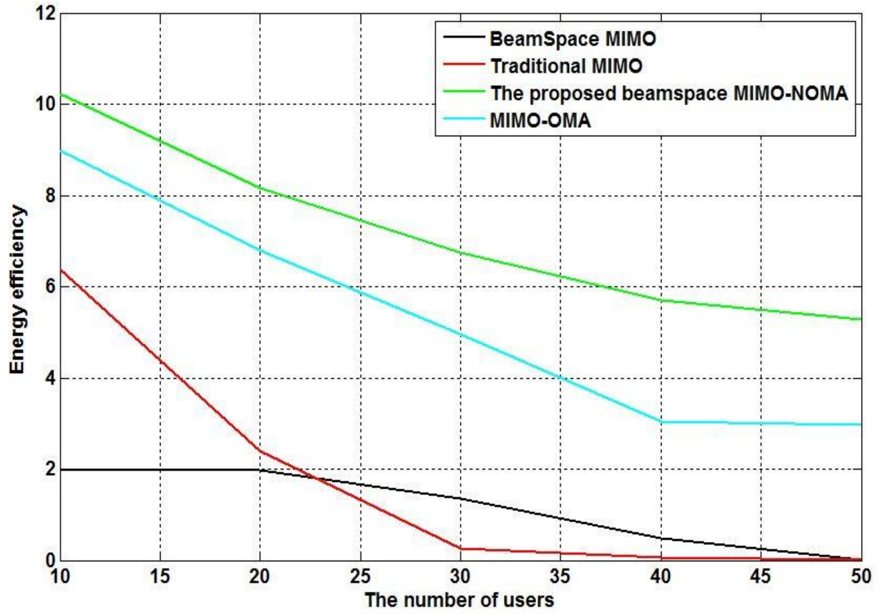

Figure 4. Energy efficiency Vs Users K

In Figure 3, Energy efficiency against the SNR of the four schemes are considered. It has been found that the proposed beam space MIMO-NOMA scheme can achieve higher energy efficiency. In Figure 4, Energy efficiency against the number of K users, where SNR = 10dB. The potential of the proposed beam space MIMO-MOMA project is greater than the other three projects, and the number of users is also very large (e.g., 50 users are disconnected simultaneously).

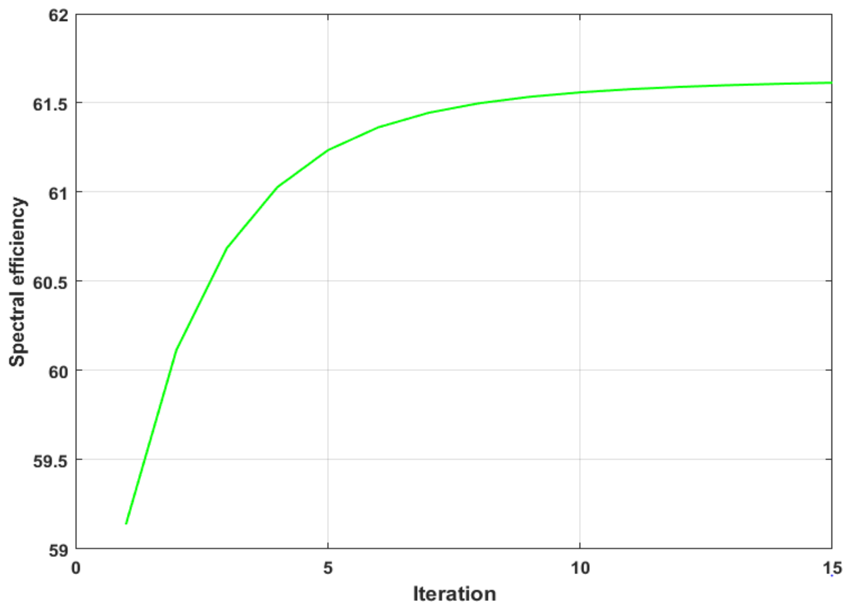

Figure 5. Spectrum performance in the number of iterations

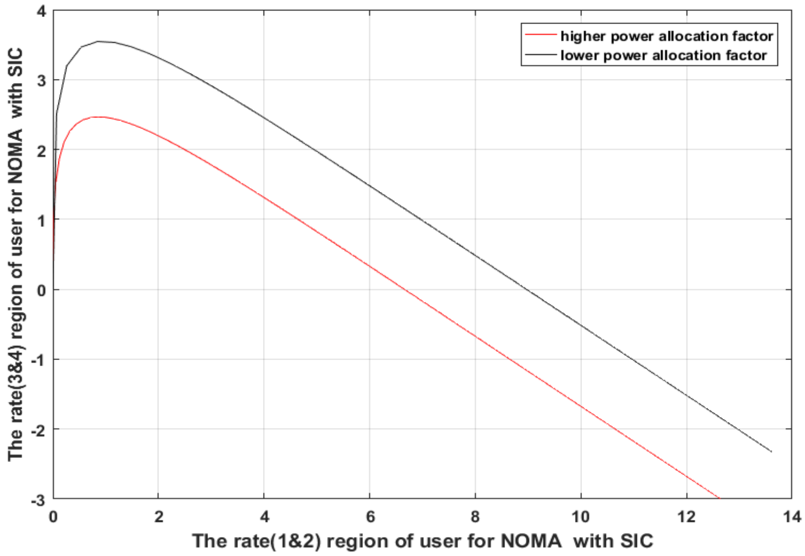

Figure 6. Rate Areas for SIC in NOMA

In Figure 5, the plot of the spectrum performance against the number of iterations for power allocation is plotted. After 10 iterations Spectrum performance is found to be stable, this verifies the integrity of the proposed power allocation. In Figure 6, the rate region for SIC is plotted in NOMA with varying power allocation factor. With a lower allocation factor and lower transmission power, the achievable rate area is lower. With higher allocation factor and higher transmission power, the achievable rate area is higher.

4. Conclusion

To break the existing limit of the existing beam space MIMO, the beam space MIMO-NOMA is proposed. Beam Space MIMO, in which a user can use each beam simultaneously on frequency resources. The number of users is larger than the number of RF chains in the proposed beam space MIMO-NOMA. The use of NOMA enhances the ability of the beam space MIMO in massive merger. All users' power allocation is optimized by increasing the achievable rate and a functional optimization algorithm has been developed to suppress inter-beam and intra-beam interference. The simulation results show that the proposed beam space MIMO-NOMA can achieve better spectrum and energy efficiency.

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