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Energy-aware Power Allocation approach using hybrid optimization in MIMO-NOMA with Multiple Users

Ramchandra Kisan Gurav[1*], Dr. Sanjay Arjunsing Pardeshi[2]

1. Research Scholar, Department of Electronics Engineering,
Shivaji University, Kolhapur, Maharashtra, India
Email:- ramgurav1987@gmail.com

2. Principal, Government Polytechnic, Tasgaon, Dist- Sangli,
Maharashtra, India
Email:- sapardeshi@rediffmail.com
*Corresponding Author: Ramchandra Kisan Gurav

Abstract

Normally, power allocation is a technique, which is used to supply the power to user with various antennas. Power-domain Non-Orthogonal Multiple Access (NOMA) has been broadly deliberated as a research topic in next generation of wireless communication schemes. NOMA multiplexes the numerous users by applying the Successive Interference Cancellation (SIC) at the transmitter as well as receiver. NOMA has several advantages in terms of ergodic sum rates, achievable rate and sum rate. However, the power allocation in NOMA failed to consider the Multiple-Input Multiple-Output (MIMO) channel. Hence, this research considers the MIMO-NOMA with multiple users for establishing the energy aware power allocation using hybridized optimization algorithm, namely African Vulture Lion Optimization Algorithm (AVLO). Here, the devised AVLO is modeled by incorporating the advantage of African Vulture Optimization algorithm (AVOA) and Lion Optimization algorithm (LOA). Moreover, the analysis is carried out by validating its efficiency based on sum rate, energy efficiency and achievable rate. Here, the invented AVLO scheme attained the better sum rate, energy efficiency and achievable rate of 131723.7Mbps, 0.166 MbpJ and 5.987 Mbps. corresponding.

Keywords: African Vulture Optimization algorithm, Lion Optimization algorithm, Multiple-input multiple-output, Non-orthogonal multiple access, Orthogonal Frequency Division Modulation.

1. Introduction

Due to the tremendous development of internet-of-thing assisted large scale heterogeneous networks and the development of fifth generation (5G) wireless networks, the communication necessities become extremely strict in terms of high speed, minimum latency, immense connectivity and so on [13]. For fulfilling this adequate communication necessities and attain the better quality communication services, NOMA has been provide a proper solution. In 5G network system, NOMA behaves as one of the auspicious multiple access technologies [14]. The dissimilar users in NOMA system provides the frequency time resources as similar to the frequency time resources of traditional orthogonal multiple access (OMA) through the code-domain or power-domain multiplexing such that the network capacity is increased with better network requirements, such as high throughput, massive connection and low latency [15][5]. For further improving the supported users count and attain the maximum spectrum efficiency, NOMA system has established in multi-input multi-output (MIMO) [16][17]. Besides, the NOMA system is more precise than the OMA system with respect to minimal spectral usage and improved power efficiency [4]. Generally, Massive MIMO and NOMA system are the two major communication approaches in the 5G communication networks, which communicate together for fulfilling the biggest demands of communication service [18] [19][2].

The major key performance indicator (KPI) of 5G involves massive connectivity for Internet of Things (IoT), spectral efficiency (SE), diverse compelling services, energy efficiency and low latency [2]. Among these, the Energy efficiency (EE) is the primary performance evaluation parameter for 5G communication system, which provides an excessive attention recently. The EE system is expressed as the proportion among attainable sum rate of users as well as the overall power consideration. Though, only limited investigators have examined the EE concert of NOMA system [11]. Moreover, simultaneous wireless information and power transfer (SWIPT), which assists the parallel broadcasting of information and energy. Moreover, the SWIPT technique is considered as a feasible approach for utilizing the energy resource, while assuring the QoS. One of the most effective receiver models for SWIPT is power allocating approach. By the assistance of power splitter, the Radio frequency (RF) signal is subdivided into two sections for information detection (ID) and energy harvesting (EH) that have been adapted the fundamental concept of SWIPT. Indeed, SWIPT technique has an enormous potential for the multi-user communication models [4]. The energy efficient aware allocation for a MIMO NOMA model with numerous users in a cluster is examined to guarantee a least rate for every user [9].

Recently, there are various power allocation approaches have been invented by the researchers in MOMO NOMA. In [12], two-step iterative EE scheme with dual antennas and user selection is devised in single cell MIMO models [9]. In [20][21], the researchers have been investigated the EE analysis on allotting the sub-channel resources under the consideration of perfect channel state information (CSI). Moreover, this method optimized the power allocation and sub-channel assignment for maximizing the EE in downlink NOMA network [11]. An effective power allocation approaches in MIMO NOMA mainly considers the user matching [23] and power allocation [22]. In addition, these approaches have been deployed for enhancing the spectrum efficiency, energy efficiency and users' fairness [24]. Generally, the earlier power-domain NOMA system offers the multiple users with similar time slots. However, due to the progression of 5G technology, various power levels have been allocated to the dissimilar users in order to attain the multiple access [5]. MIMO-NOMA has been hypothetically established to afford a greater capacity and data rate than the MIMO-OMA in 4th generation (4G), and power allocation policies have been explored in a number of previously modeled works [10]. In power-domain NOMA, superposition coding is utilized in transmitter side and the SIC is employed in receiver side, and it permits the users to communicate the similar resources by multiplexing the signals of various users with dissimilar allocated powers. Here, the powers are assigned to users based on their channel gains [5]. Furthermore, most power allocation problems are resolved by optimizing the sum data rate of MIMO NOMA, which is referred to as NP-hard problems [10].

This paper devises the AVLO assisted energy aware power allocation scheme, which includes various blocks, such as QAM modulation, OFDM modulation, preamble insertion, power allocation, transmitter, channel estimation, Cyclic Prefix (CP) removal, Discrete Fourier Transform (DFT) and Quadrature Amplitude Modulation (QAM) demodulation. In this research, the power allocation is carried out using hybridized optimization, namely AVLO. The invented AVLO is the crossbreed of AVOA and LOA, which processes based on the energy efficiency and sum rate such that the appropriate users are determined for allocating the power.

The major contribution of this research is,

- ***Proposed AVLO assisted energy aware power allocation scheme***: In this research, the power allocation is carried out with optimal model, namely AVLO, which is the incorporation of AVOA and LOA. Moreover, the power allocation is carried out based on the fitness function, which includes sum rate and energy efficiency.

The design of this paper is explained in this section. Section 2 portrays the literature survey of power allocation methods, section 3 deliberates the MIMO-NOMA model, section 4 explains the proposed methodology, section 5 discusses the results of invented scheme and section 6 concludes the devised model.

2. Motivation

Generally, NOMA acts as an important function in succeeding generation of wireless communication systems. NOMA has numerous advantages; however, they work only with single-input single-output (SISO) channels. Hence, by integrating the NOMA with MIMO channel, users are typically paired into clusters for diminishing the complexity of SIC in the receiver. This inspires the researcher for selecting MIMO-NOMA as a research topic.

2.1 Literature review

The literature review of various energy-aware power allocation approaches is elucidated in this section. Zeng, M. *et al.* [1] developed a Spectral efficiency (SE) maximization power allocation method to assure quality of service for users. This technique outperformed OMA and offered the equivalent power NOMA based on both EE and the admitted users count. Though, it was not sufficient to recompense the energy necessary to admit the supplementary user. In order to compensate the sufficient energy, Liu, P. *et al.* [2] developed an energy efficient power allocation process in MIMO-NOMA system where the dissimilar users are designated in every beam. This method had gotten the higher energy efficiency than the prevailing methods. Though, it required excess number of RF chains to improve the system performance. The system performance gets improved in [3] where Khaleel Ahmed, S. and Venkateswara Rao, N. developed a Salp Particle Swarm optimization for Power allocation (SPPA) model for assigning the user with respect to the spectral efficiency as well as energy efficiency. Its effectiveness was revealed in terms of energy, achievable rate and Bit error rate (BER). However, it failed to utilize the system in ultra-dense network (UDN) for progressing the performance. In order to enhance the performance of network, Chen, L. *et al.* [4] developed an Alternating optimization (AO)-based iterative model to resolve the converted optimization issues at the inner layer. Moreover, it provided higher performance, but did not suppress the interference of inter-beam and the EE performance.

For attaining the better EE performance, Jo, S. *et al.* [5] developed a multi-agent deep reinforcement learning for resolving the issues in power allocation strategy of MIMO system. It expressively upgraded the energy efficiency, but it had several issues in investigating thejoint subchannel selection. For resolving the issues in joint subchannel selection, Zhu, J. *et al.* [6] introduced a two suboptimal low-complexity user grouping as well as beam selection approaches for establishing the power allocation strategy in MIMO. It outperformed the traditional designs in dissimilar system condition. However, the spectral energy gets affected,while extending the power to peak point. In order to avoid the destruction of spectral energy, KhaleelahmedSk, and Venkateswara Rao N [7] introduced a Fractional Salp Particle Swarm Optimization (FSPSO) algorithm for allocating the power in MIMO system. This method acquired sophisticated energy efficiency, better sum rate as well as spectral power. Moreover, it did note liberate numerous bandwidths for the power allocation in MIMO-NOMA system. For utilizing the multiple bandwidths in MIMO-NOMA power allocation, Khaleel Ahmed, S. and Venkateswara Rao, N. [8] developed a Particle Swarm Optimization (PSO)-based priority scheduling to schedule the users in power allocation based on QoS as well as power constraints. It exhibited the superior performance in energy and achievable rate. Though, it faced the issues in aggregating the sum rate of MIMO-NOMA system.

2.2. Challenges

The challenges of various energy-aware power allocation approaches are explained in this section.

- In [4], the power allocation method was achieved the higher energy efficiency and attainable sum rate. The challenge of developed method in [4] is to analyze the advanced precoding model for overwhelming the inter-beam interference as well as progress the energy efficiency performance.
- For attaining the better result with the interference of inter-beam, the multi-agent deep reinforcement learning (DRL)-based power allocation approach can expressively discover the EE of MIMO-NOMA system with numerous transmit power,but it failed to resolve the joint subchannel selection as well as power allocation issue for multiple practical situations of MIMO-NOMA systems [5].
- In order to achieve the better joint subchannel selection with power allocation scheme in MOMO NOMA, FSPSO algorithm was designed in [7]. The power allocation approach attained the least BER and improved spectral power, energy efficiency, allocation of power and achievable sum rate, but it failed to consider numerous bandwidths.
- For achieving the better outcome with numerous bandwidths, PSO-based priority-based scheduling algorithm in [8] was devised in allocating the power with theoptimal QoS and energy, but did not progress a system with layered broadcasts for maximizing the sum rate of MIMO-NOMA system [8].
- However, the usage of enormous antennas significantly attained the high energy consumption as well as hardware cost, while utilizing the fully digital signal processing in massive MIMO system since the amount of essential RF chains is similar to that of antennas, and RF chains consume more power as well as costly at mm Wave frequency.

3. System model

This research considers the multi-user MIMO system in which the BS is fortified with U antennas, and is capable of transmitting the data to numerous receivers, each fortified with K antennas [27]. Thus, the overall user count in the considered system is $U \times Y$, which are merged into U clusters arbitrarily with $Y(Y \geq 2)$consumers per cluster. NOMA is subjected amongst the various consumers in the similar cluster. The channel matrix among BS and the y^{th} user in the u^{th} cluster is indicated as $W_{u,y} \in \Re^{K \times U}$, the precoding matrix of BS is represented as $D \in \Re^{U \times U}$ and then the detection vector of (u, y)user is illustrated as $b_{u,y} \in \Re^{K \times 1}$. For the deliberated MIMO-NOMA, the BS multiplexes the anticipated signals for every user at the similar frequency as well as time resource. Thereby, the consistent broadcasted signals from BS is articulated as,

$$d = Dm$$

where, m

indicates the information bearing vector, and is illustrated as,

(1)

$$m = \begin{bmatrix} \sqrt{D_{\max}\alpha_{1,1}} m_{1,1} + \dots + \sqrt{D_{\max}\alpha_{1,1}} m_{1,Y} \\ \sqrt{D_{\max}\alpha_{U,1}} m_{U,1} + \dots + \sqrt{D_{\max}\alpha_{U,Y}} m_{U,Y} \end{bmatrix} \tag{2}$$

where, $m_{U,Y}$ and $\alpha_{U,Y}$ indicates the coefficient of signal and power allocation for user (u,y), which satisfies $\sum_{u=1}^{U}\sum_{y=1}^{Y}\alpha_{u,y}\leq 1$ and $D_{\max}$ represents the overall transmit power of BS. Moreover, the observed signal of (u,y) user is illustrated as,

$$q_{u,y}=W_{u,y}Dm+v_{u,y} \tag{3}$$

where, $v_{u,y}$ is indicated as identically and independent distributed additive white Gaussian noise vector. Moreover, the analytical model of applying detection vector $b_{u,y}$ on observed signal is portrayed as,

$$b_{u,y}^{W}q_{u,y}=b_{u,y}^{W}W_{u,y}du\sum_{y=1}^{Y}\sqrt{D_{\max}\alpha_{u,y}}m_{u,y}+\underbrace{\sum_{g=1,g\neq u}^{U}b_{u,y}^{W}W_{u,y}d_{g}m_{g}}_{\text{interference from other clusters}}+b_{u,y}^{W}v_{u,y} \tag{4}$$

where, m_g defines the g^{th} row of m. Here, if $b_{u,y}^{W}W_{u,y}du=0$, $g\neq u$, then the equation is signified as,

$$b_{u,y}^{W}q_{u,y}=b_{u,y}^{W}W_{u,y}du\sum_{y=1}^{Y}\sqrt{D_{\max}\alpha_{u,y}}m_{u,y}+b_{u,y}^{W}v_{u,y} \tag{5}$$

The expression for effective channel gains without losing the generality is modeled as,

$$\left|b_{u,1}^{W}W_{u,1}du\right|^{2}\geq\ldots\geq\left|b_{u,Y}^{W}W_{u,Y}du\right|^{2} \tag{6}$$

In the receiver side, the interference from user is eliminated by applying the SIC. Furthermore, the attained data rate of user (u,y) is established as,

$$I_{u,y}=\log_{2}\left(1+\frac{\beta\alpha_{u,y}\left|b_{u,y}^{W}W_{u,y}du\right|^{2}}{1+\beta\sum_{g=1}^{y-1}\alpha_{u,g}\left|b_{u,y}^{W}W_{u,y}du\right|^{2}}\right) \tag{7}$$

where, $\beta=D_{\max}/\sigma^{2}$ specifies the transmit signal-to-noise ratio (SNR). Figure 1 displays the system model of cluster-based MIMO-NOMA.

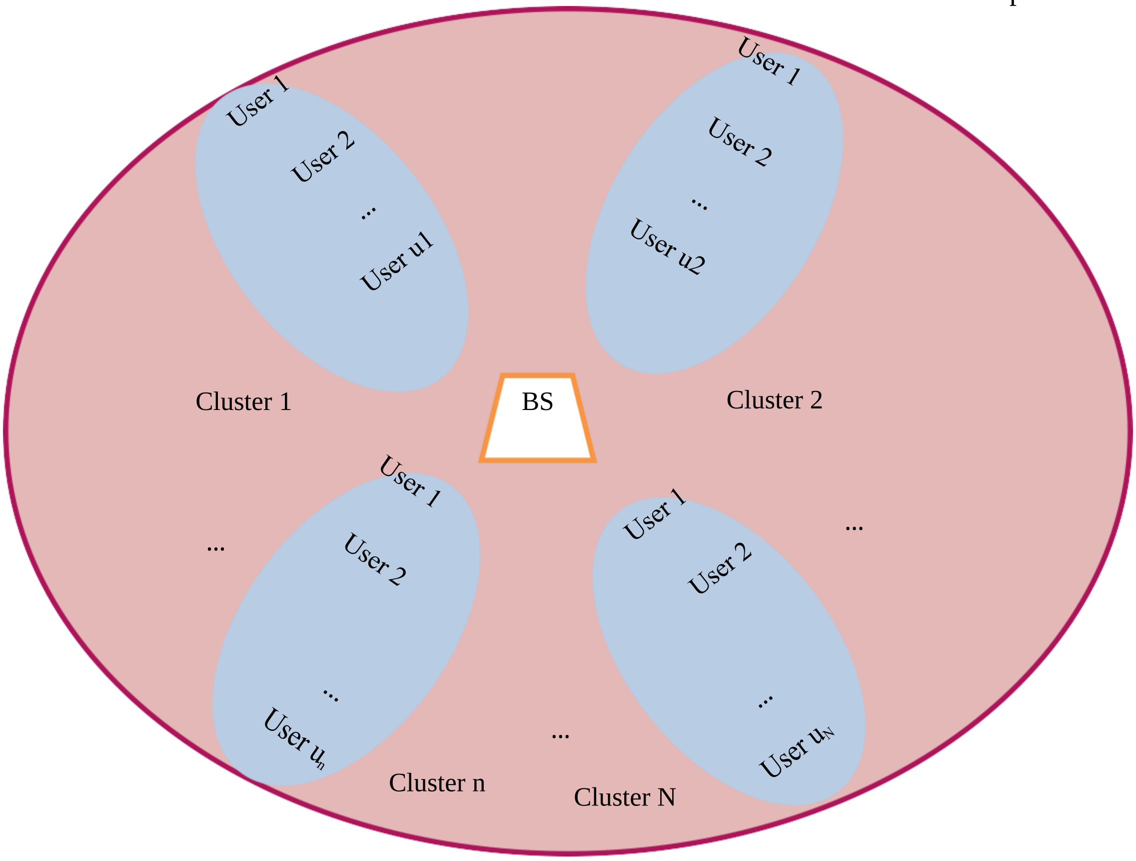


Figure 1. System model of cluster-based MIMO-NOMA

4. Proposed AVLO-assisted energy aware power allocation scheme in MIMO-NOMA with multiple users

The AVLO-assisted energy aware power allocation approaches in MIMO-NOMA with dissimilar users are explained in this section. Figure 2 illustrates the proposed optimal energy aware power allocation scheme. Here, the projected model contains multiple users in which each user is subjected to the QAM, such that the user data is mapped into the QAM formatand is transformed OFDM for modulating the mapped data. In order to synchronize the frames, the preamble is applied on each frame. While establishing the power allocation, the OFDM signals is combined with the transmit power using invented AVLO-assisted energy aware power allocation scheme by considering the power requirement and QoS constraint. Moreover, the signal coming out from the estimated channel is passed to the CP removal. After that, the DFT is applied on the signal and then the optimal signal is attained based on the response of channel estimation. At last, the transmitting signal is recovered after the completion of demapping using QAM demodulation module. Therefore, the optimal power allocation is accomplished in the MIMO-NOMA environment with the criteria deliberated by the AVLO algorithm such that every user in the system can broadcast effectively with minimum rate of energy.

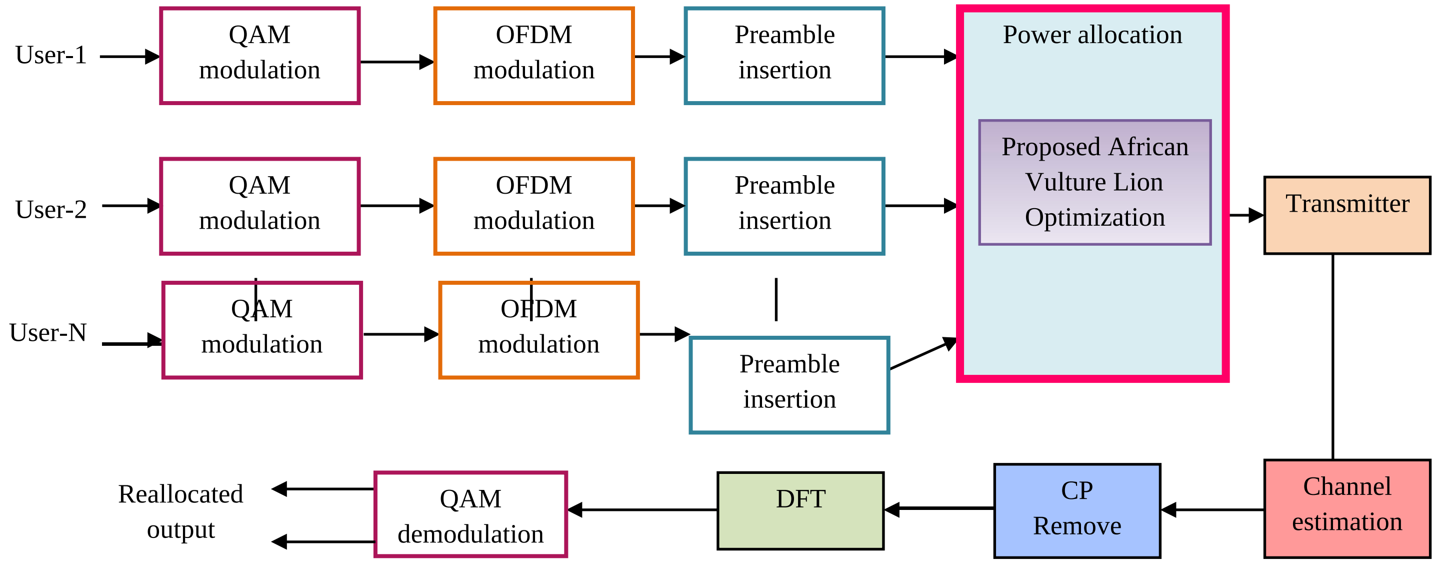


Figure 2. Block diagram of proposed AVLO-assisted energy aware power allocation scheme

4.1 Basic requirements of MIMO-NOMA communication system

The AVLO-assisted energy aware power allocation approaches contain various communication requirements, and is explained in the below section.

i) QAM modulation

QAM is referred to as Quadrature Amplitude Modulation, which combines the two amplitude modulation (AM) signals into a unique signal. The QAM modulation helps to twice the bandwidth, and is broadly used in modulation applications, like telecommunication. Moreover, QAM modulation increases the spectral efficiencies by limiting the noise level, linearity of communication channel and so on. In this research, QAM is used to map the user data into the QAM format.

ii) OFDM modulation

OFDM is an auspicious approach in the upcoming generation of wireless communication systems. In OFDM, it partitions the bandwidth of entire transmission into numerous orthogonal sub-channels. In multiuser OFDM, it augments the multiple accesses to OFDM by permitting the number of users to communicate an OFDM symbol. Here, the OFDM modulation is performed to modulate the mapped signal, and is sent to the preamble insertion block.

iii) Preamble insertion

This block inserts the preamble on the modulated signal for channel estimation. Generally, in fast varying channel, the channel estimation is completed by injecting pilot symbol into the modulated signal, which is termed as pilot-dependent channel estimation. However, the pilot-based channel estimation reduced the transmission rate, while inserting huge quantity pilot symbol on the modulated signal. In order to avoid this, preamble symbol is designed for avoiding the transmission rate loss, such that the accuracy of channel estimation is enhanced.

In addition, the preamble insertion is used to detect the channel response at receiver side. Moreover, preamble is designed to synchronize each frame.

iv) Power allocation

Power allocation is the process of allocating power to the user through the antennas. In this research, the power allocation is carried out using AVLO algorithm, which is the incorporation of AVOA and LOA.

v) Transmitter

The transmitter is accountable for conveying the input signal. In this research, the transmitter sends the modulated signal for channel estimation.

vi) Channel estimation

Channel estimation is the process of estimating channel, which acts as a significant function in communication receiver. For avoiding the channel effects of received signal, the channel estimation is necessary for providing the information. In this research, MIMO-NOMA system utilizes multiple antennas for transmitting and receiving the signal.

vii) CP remove

After the channel estimation, CP removal is carried out to avoid the interference of transmitted signal in the communication channel.

viii) DFT

After the CP removal, the DFT is applied on the attained signal such that the equivalent frequency domain symbols are acquired.

ix) QAM demodulation

After that, every component signal is then demodulated using QAM demodulation in order to attain the reallocated output in the receiver side.

4.2 Optimal power allocation using AVLO

Power allocation is the process of allocating power to the corresponding user through the antenna. Here, the power allocation is carried out using AVLO algorithm where the optimization algorithm is modeled by the incorporation of AVOA [25] and LOA [26]. The developed optimization algorithm is utilized to allocate the power to the employers in the network. In the invented algorithm, the fitness function is used to analyze the sum rate as well as energy efficiency of various users such that the users with maximum value of sum rate as well as energy efficiency are selected as best solution. However, the user with smaller values of sum rate and energy efficiency is not suitable for data communication such that the sufficient power is allocated to the corresponding user for making it suitable for data communication. AVOA is modeled by inspiring the lifestyle of African vultures. The lifestyle of African vulture includes navigation and foraging characteristics. In AVOA, the number of vultures is subdivided into two solutions. Here, the optimization algorithm initially computes the fitness values of entire solution. The first best solution relies on the first best vulture as well as the second solution relies on the second-best vulture. The advantage of AVOA is it offers the superior performance on most of the engineering case scenarios. Likewise, the LOA is a nature inspired optimization algorithm, which is modeled by inspiring the special characteristics of lions. In LOA, the lions are updating its position in the hunting process, and they are shifts towards the safest location based on the fitness value, Here, the invented AVLO algorithm is modeled by taking the highlights of both AVOA and LOA. Here, the updated equation of LOA is added on the updated location of AVOA. Thus, the algorithmic flow of invented AVLO algorithm is given below.

4.2.1 Objective function

The objective function is normally used to choose the optimal solution. In this research, the power allocation is carried out using optimal power allocation algorithm based on the fitness computation, Thus, the expression for fitness function is considered as,

$$Z = \frac{1}{2}\left[\kappa_{EE} + G^{sum}\right] \tag{8}$$

where, κ_{EE} signifies the energy efficiency, and G^{sum} specifies the sum rate.

Energy efficiency: The energy efficiency is framed as,

$$\kappa_{EE} = \frac{G^{sum}}{N_c + N_t} \tag{9}$$

where, N_c indicates the power consumption, and N_t indicates the transmit power.

Sum rate: The maximum value of sum rate is deliberated as best solution, and is indicated as G^{sum}.

4.2.2 Encoding of optimal vultures

In this research, the selection of optimal vultures is considered as an optimal solution. Figure 3 displays the solution encoding of invented scheme for power allocation. Here, the best solution is selected relies on the fittest vultures. From figure 3, each solution indicates the power allocated to the specific user. For instance, Φ_{11} be the power allocated to the 1st user, Φ_{12} indicates the power allotted to the 2nd user and so on. Moreover, Φ_{st} indicates the power allotted to the s^{th} user in t^{th} cluster.

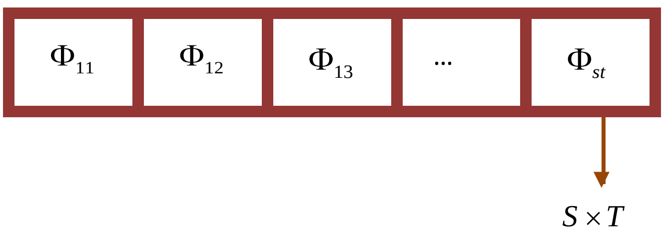


Figure 3. Solution encoding

4.2.3 Algorithmic processes of AVLO

The processing flow of AVLO algorithm is explained in this section.

1. Initialization

The first step is initiate the L number of vultures in an environment, which calculates the similar number of population and the number relies on the overall problem count.

2. Fitness measure

The fitness measure is employed to select the best solution, and the expression is already elucidated in section 4.2.1. For every iteration, the overall population is re-estimated based on the fitness value.

3. Starvation rate of vultures

Vultures can search food with high energy while they are satiated. Likewise, when the vultures are in hungry, then the vultures do not have appropriate energy such that they are not able to move other place for searching the food. This behavior is analytically portrayed as,

$$J = \left(2 \times k_1 + 1\right) \times h \times \left[1 - \frac{p_s}{p_{\max}}\right] + t \tag{10}$$

$$t = w \times \left(\sin^r\left(\frac{\psi}{2} \times \frac{p_s}{p_{\max}}\right) + \cos\left(\frac{p_s}{p_{\max}}\right) - 1\right) \tag{11}$$

where, the satiated vultures are represented as J, p_s indicates the s_{th} iteration, $p_{\max}$ specifies the maximum iteration count, h and w specifies the random number.

4. Exploration stage

In this stage, the vultures are searching for food based on two conditions. In order to explore the food, the vultures investigate two dissimilar locations based on the parameter M_1, which is employed to choose the strategy, and is illustrated as,

$$M(s+1) = \begin{cases} B(s) - Q(s) * J & if\ M_1 > k_{M_1} \\ B(s) - J + k_2 \times \left((\eta - \sigma) \times k_3 + \sigma\right) & if\ M_1 < k_{M_1} \end{cases} \tag{12}$$

In order to improve the performance, the above expression can be modified to update the location of vultures. From AVOA,

$$M(s+1) = B(s) - Q(s) * J \tag{13}$$

$$Q(s) = \left|E * B(s) - M(s)\right| \tag{14}$$

Substitute equation (14) in equation (13),

$$M(s+1) = B(s) - \left(\left|E * B(s) - M(s)\right|\right) * J \tag{15}$$

Assuming $B(s) > M(s)$,

$$M(s+1) = B(s) - \left(E * B(s) - M(s)\right) * J \tag{16}$$

$$M(s+1) = B(s) - E * B(s) * J + M(s) * J \tag{17}$$

$$M(s+1) = B(s)\left[1 - E * J\right] + M(s) * J \tag{18}$$

From LOA [26], the location update expression for female lion is given by,

$$female\,lion' = female\,lion + 2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\} \quad (19)$$

$$female\,lion' = M(s+1) \quad (20)$$

$$female\,lion = M(s) \quad (21)$$

$$M(s+1) = M(s) + 2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\} \quad (22)$$

$$M(s) = M(s+1) - 2Q * \Im(0,1)\{B_1\} - U(-1,1) * \tan(\delta) * Q * \{B_2\} \quad (23)$$

Applying equation (23) in equation (18),

$$M(s+1) = B(s)[1 - E * J] + [M(s+1) - 2Q * \Im(0,1)\{B_1\} - U(-1,1) * \tan(\delta) * Q * \{B_2\}] * J \quad (24)$$

$$M(s+1) - M(s+1) * J = B(s)[1 - E * J] + [-2Q * \Im(0,1)\{B_1\} - U(-1,1) * \tan(\delta) * Q * \{B_2\}] * J \quad (25)$$

$$M(s+1)[1 - J] = B(s)[1 - E * J] + [-2Q * \Im(0,1)\{B_1\} - U(-1,1) * \tan(\delta) * Q * \{B_2\}] * J \quad (26)$$

$$M(s+1) = \frac{1}{1-J}\left[B(s)[1 - E * J] - [2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\}] * J\right] \quad (27)$$

where, Q specifies the distance among the location of female lion, J indicates the rate of solution being satiated, E specifies the coefficient vector, $M(s+1)$ specifies the location of solution at iteration $s+1$, $M(s)$ indicates the location of solution at iteration s and $B(s)$ specifies the best vulture in s^{th} iteration. This is the final updated expression for exploration phase.

5. Exploitation phase

The exploitation phase is executed based on M_2 and M_3. When the value of $|J|$ is between 1 and 0.5, then the developed algorithm enters into the exploitation phase. The selection of suitable strategy is done based on M_2 and M_3. The constraint M_2 selects the policy exists in 1st phase, whereas the constraint M_3 selects the policy exist in 2nd phase.

First phase of exploitation process

The exploitation process contains two phases, such as rotating flight and siege-fight. If the value of M_2 is larger than or equal to k_{M_2}, then the siege-fight is activated, whereas if the value of M_2 is smaller than or equal to k_{M_2}, then the rotating flight is activated, and is portrayed as,

$$M(s+1) = \begin{cases} Q(s) * (J + k_4) - d(t) & if\ M_2 > k_{M_2} \\ B(s) - (X_1 + X_2) & if\ M_2 < k_{M_2} \end{cases} \quad (28)$$

1) Food completion

In some cases, numerous vultures tries to get the identical food source at same time while they are in hungry, which consequences more conflicts among the vultures. This character is formulated as,

$$M(S+1) = Q(s) * (J + k_4) - d(t) \tag{29}$$

$$d(t) = B(s) - M(s) \tag{30}$$

Applying equation (30) in equation (29),

$$M(S+1) = \left|\left(E * B(s) - M(s)\right|\right) * (J + k_4) - B(s) + M(s) \tag{31}$$

Assuming $B(s) > M(s)$,

$$M(s+1) = E * B(s)(J + k_4) - M(s)(J + k_4) - B(s) + M(s) \tag{32}$$

$$M(s+1) = B(s)[E * (J + k_4) - 1] - M(s)[(J + k_4) - 1] \tag{33}$$

Applying equation (23) in equation (33),

$$M(s+1) = B(s)[E * (J + k_4) - 1] - [M(s+1) - 2Q * \Im(0,1)\{B_1\} - U(-1,1) * \tan(\delta) * Q * \{B_2\}] [(J + k_4) - 1] \tag{34}$$

$$M(s+1) + M(s+1)[(J + k_4) - 1] = B(s)[E * (J + k_4) - 1] + [2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\}] [(J + k_4) - 1] \tag{35}$$

$$M(s+1)[1 + J + k_4 - 1] = B(s)[E * (J + k_4) - 1] + [2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\}] [(J + k_4) - 1] \tag{36}$$

$$M(s+1) = \frac{1}{[J + k_4]} \left[B(s)[E * (J + k_4) - 1] + [2Q * \Im(0,1)\{B_1\} + U(-1,1) * \tan(\delta) * Q * \{B_2\}] [(J + k_4) - 1] \right] \tag{37}$$

This is the concluded updated expression for invented AVLO algorithm. Here, k_4 specifies the random number among 0 to 1 and $\Im(0,1)$ specifies the random number.

2) Rotating flight of vultures

If the value of M_2 is smaller than or equal to k_{M_2}, then the rotating flight is activated. This is designed as,

$$M(s+1) = B(s) - (X_1 + X_2) \tag{38}$$

where,

$$X_1 = B(s) \times \left(\frac{k_5 \times M(s)}{2\psi} \right) \times \cos(M(s)) \tag{39}$$

$$X_2 = B(s)\times\left(\frac{k_6 \times M(s)}{2\psi}\right)\times \sin\left(M(s)\right) \tag{40}$$

Here, the function of cosine and sine is indicated as $\cos$ and $\sin$, k_5 and k_6 indicates the random number among 0,1.

Second phase of exploitation process

When the value of $|J|$ is fewer than 0.5, then the invented algorithm enters into the second phase of exploitation step. In the starting stage, k_{M_3} is generated. If k_{M_3} is larger than M_3, then various kinds of vultures are accumulated over the food source, this is modeled as,

$$M(s+1) = \frac{C_1 + C_2}{2} \tag{41}$$

where, C_1 and C_2 implies the movement of vulture. If $k_{M_3} < M_3$, then the aggressive siege-fight process is completed, which is assumed by,

$$M(s+1) = B(s) - |d(t)| \times J \times \xi(d) \tag{42}$$

Here, $d(t)$ specifies the distance amongst the vulture to best vultures of two batches and $\xi(d)$ is utilized to gain the effectiveness of AVLO.

Step6. Re-calculation of solution

The best location of vulture is figure din entire iterations relies on fitness function. Here, the final solution is linked with the prior solution hence the optimal one is selected as a concluded solution.

Step 7: Termination

All the pre-described processes are done endlessly till all vultures are processed. Algorithm 1 displays the pseudocode of invented AVLO.

Algorithm 1. Pseudocode of developed AVLO

Pseudo code of devised AVLO
Initialization of arbitrary population
While(ending condition is not arrived) ***do***
Estimate the objective function with Equation (8)
Assign $M_{BestVulture_1}$ as the locus of 1st best vulture
Assign $M_{BestVulture_2}$ as the locus of 2nd best vulture
for (every vulture (M_s)) ***do***
Choose $B(s)$
Update J with Equation (10)
if $(\lvert J \rvert \geq 1)$ **then**
if $(M_1 \geq k_{M_1})$ **then**

Update the location of vulture by Equation (27)
else
Update the location of vulture
if $(\lvert J \rvert < 1)$ **then**
if $((\lvert J \rvert_2 \geq 0.5))$ **then** ***if*** $(M_2 \geq k_{M_2})$ **then**
Update the location of vulture with Equation (37)
else
Update the location of vulture with Equation (38)
else ***if*** $(M_3 \geq k_{M_3})$ **then**
Update the location of vulture with Equation (41)
else
Update the position of vulture by Equation (42)
Return $M_{BestVulture_1}$
End

Here, the devised AVLO scheme is utilized to allot the power to the user based on the energy efficiency and sum rate. Here, the AVLO scheme is modeled by integrating AVOA and LOA.

5. Results and discussion

The experimental outcome of invented AVLO-assisted energy aware power allocation scheme is explained in this section.

5.1 Experimental setup

The newly invented AVLO scheme is executed on MATLAB tool using PC with windows 10 OS and intel i3 core processor. Moreover, the simulation metrics of the invented method is notified in Table 1.

Table 1. Simulation requirements

Simulation metrics	Range
Transmitter power	43
Antenna	64
Frequency	450
Antenna height	180

5.2 Performance metrics

In this research, the newly designed power allocation scheme is investigated with three metrics, such as sum rate, energy efficiency and achievable rate, and these three metrics are briefly elucidated as below.

Sum rate: The sum of achievable rate of various simultaneous transmissions is termed as sum rate. The description of sum rate is already explained in section 4.2.1.

Energy efficiency: The description of energy efficiency is already explained in section 4.2.1.

Achievable rate: The data rate, which is lower than the capacityis termed as achievable rate.

5.3 Comparative methods

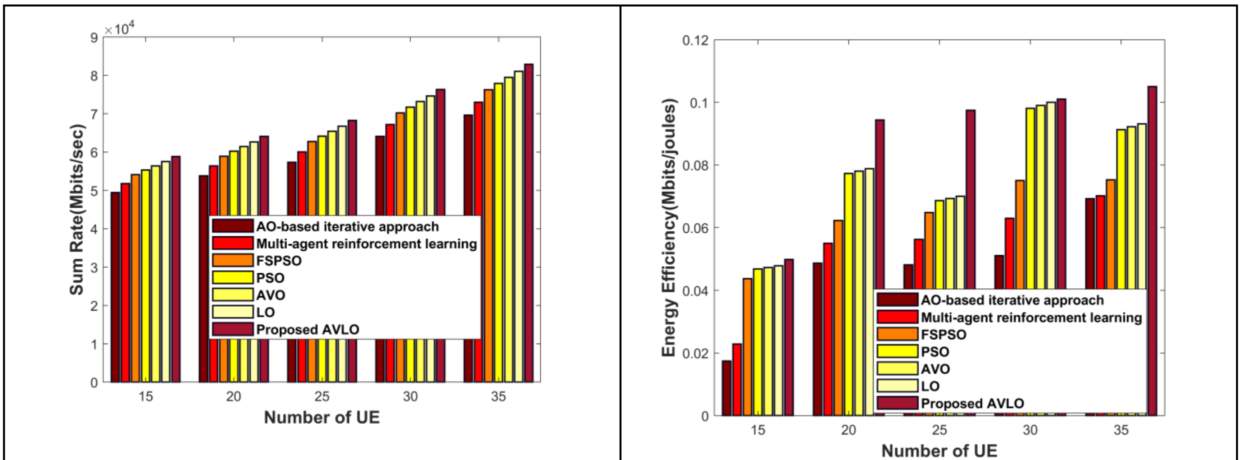
The attained outcome of invented AVLO scheme is compared with some previously modeled approaches, namely AO-based iterative approach [4], Multi-agent reinforcement learning [5], FSPSO [7], PSO [8], AVOA [25] and LOA [26].

5.3.1 Comparative analysis

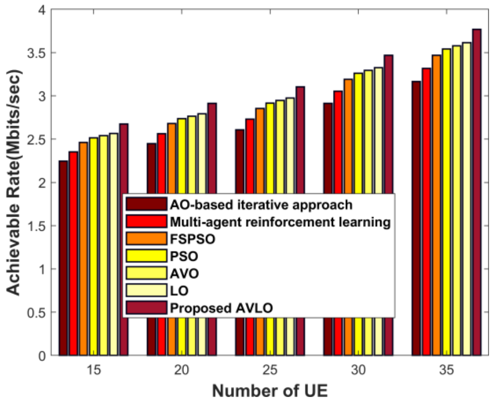
The comparative assessment of AVLO is done by adjusting three different scenarios, such as 64 transmitting antennas, 128 transmitting antennas and 192 transmitting antennas. Moreover, the assessment is carried out based on the metrics, namely sum rate, energy efficiency and available rate with respect to the number of user equipment (UE).

i) By varying 64 transmitting antennas

The comparative assessment of sum rate based on the number of UE for AVLO is portrayed in figure 4 a). Here, when the number of UE is 35, then the sum rate of AO-based iterative approach is 69646.84 Mbps, Multi-agent reinforcement learning is 72963.36 Mbps, FSPSO is 76279.87 Mbps, PSO is 77938.13 Mbps, AVO is 79496.6, LO is 81086.86, and the AVLO is 82912.91 Mbps. The percentage improvement of AVLO is 16%, 12%, 8%, 6%, 4.3%, and 2.2%. The energy efficiency graph of invented AVLO is portrayed in figure 4 b). The energy efficiency of AO-based iterative, Multi-agent reinforcement learning, FSPSO, PSO, AVO, LO and AVLO is 0.069MbpJ, 0.070MbpJ, 0.075MbpJ, 0.091MbpJ, 0.09221MbpJ, 0.093132MbpJ, and 0.105MbpJ for the number of UE is 35. Figure 4 c) illustrates the comparison of achievable rate of AVLO based on number of UE. Here, the invented scheme attained the achievable rate of 3.768 Mbps, whereas the achievable rate acquired by the previously designed techniques is 3.165Mbps, 3.316Mbps, 3.467Mbps, 3.542Mbps, 3.578Mbps, and 3.614Mbps when the number of UE is 35. The percentage improvement of AVLO is 16%, 12%, 8%, 6%, 5.31%, and 4.26%.



(a)	**(b)**

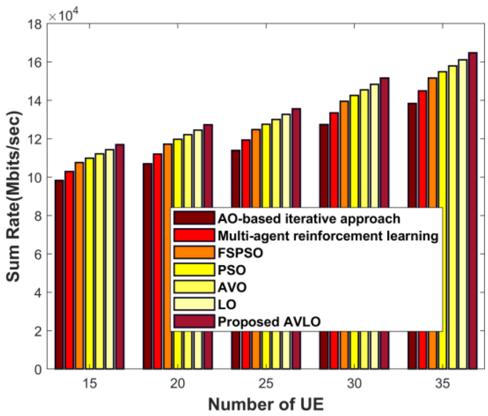


(c)

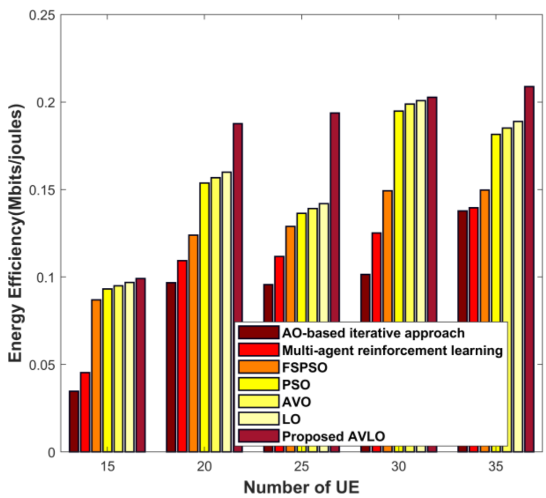
Figure 4. Comparative assessment based on a) Sum Rate, b) Energy efficiency, c) Achievablerate

ii) By varying 128 transmitting antennas

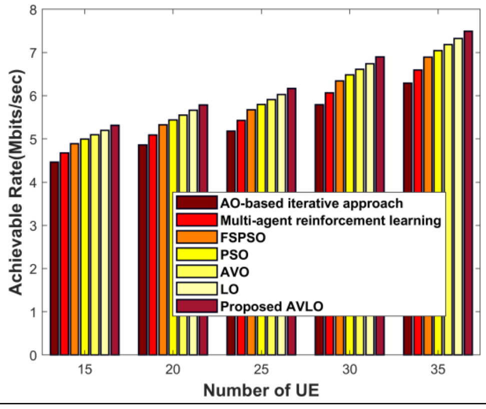
The comparison of sum rate based on number of UE for the invented AVLO is explained in figure 5 a). The sum rate attained by the various present power allocation approaches is 138430.07 Mbps, 145021.98 Mbps, and 151613.88 Mbps, 154909.84 Mbps, 15801Mbps and 16117Mbps, whereas the sum rate of AVLO power allocation scheme is 164797.70 Mbps when the number of UE is 35. Figure 6 b) shows the comparative graph of devised AVLO for energy efficiency. The energy efficiency values, such as 0.137MbpJ, 0.139MbpJ, 0.149 MbpJ,0.181MbpJ, 0.185MbpJ, 0.188MbpJ and 0.208MbpJ is attained by the conventional and invented scheme for the number of UE is 35. Figure 6 c) illustrates the achievable rate of devised AVLO scheme with number of UE. While the UE count is 35, then the invented AVLO achieved the achievable rate of 7.490 Mbps, whereas the traditional approaches gotten the achievable arte of 6.292 Mbps, 6.591 Mbps, 6.891 Mbps, 7.041 Mbps, 7.182Mbps and 7.325Mbps.



(a)



(b)

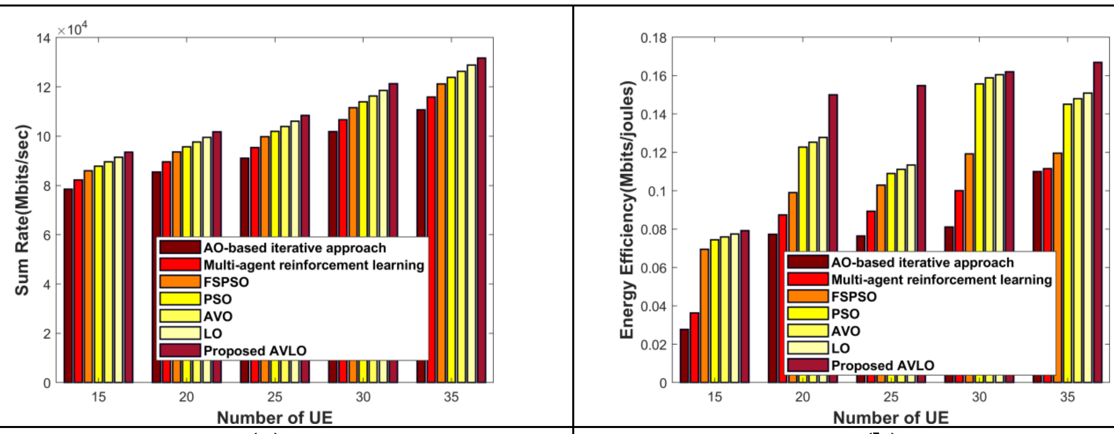


(c)

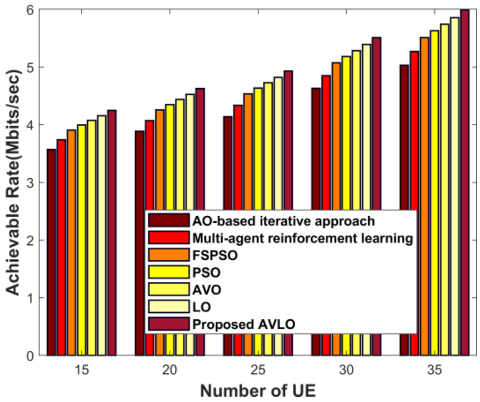
Figure 5. Comparative assessment based on a) Sum Rate, b) Energy efficiency, c) Achievable rate

iii) By varying 192 transmitting antennas

The sum rate graph of invented AVLO is portrayed in figure 6 a). The sum rate of AO-based iterative, Multi-agent reinforcement learning, FSPSO, PSO and AVLO is 110647.94 Mbps, 115916.89 Mbps, 121185.84 Mbps, 123820.32 Mbps, 12629Mbps, 128822Mbps, and 131723.74 for the number of UE is 35. Figure 6 b) illustrates the energy efficiency of devised AVLO scheme with number of UE. While the UE count is 35, then the invented AVLO achieved the energy efficiency of 0.166MbpJ, whereas the traditional approaches gotten the energy efficiency of 0.110MbpJ, 0.111MbpJ, 0.119MbpJ, 0.145MbpJ, 0.147MbpJ, and 0.151MbpJ. The comparative assessment of achievable rate based on the number of UE for AVLO is portrayed in figure 4 a). Here, when the number of UE is 35, then the sum achievable rate of AO-based iterative approach is 5.02 Mbps, Multi-agent reinforcement learning is 5.268, FSPSO is 5.508 Mbps, PSO is 5.628 Mbps, AVO is 5.74Mbps, LO is 5.85Mbps, and the AVLO is 5.987 Mbps.



(a) **(b)**



(c)

Figure 6. Comparative assessment based on a) Sum Rate, b) Energy efficiency, c) Achievable rate

5.4 Comparative discussion

In this research, the comparison is done based on varying the number of transmitting antennas in the count of 64, 128 and 192 is given in table 2. Among these, the AVLO assisted power allocation scheme attained the better values based on the sum rate, energy efficiency and available rate of 131723.7Mbps, 0.166 Mbps and 5.987 Mbps. Likewise, the conventional approaches gotten the sum rate of 110647.94 Mbps, 115916.89 Mbps, 121185.84 Mbps, 123820.32 Mbps, 12629Mbps, and 128822Mbps, energy efficiency of 0.110MbpJ, 0.111MbpJ, 0.119MbpJ, 0.145MbpJ, 0.147MbpJ, and 0.151MbpJ, and the available rate of 5.029 MbpJ, 5.268 MbpJ, 5.508 MbpJ, 5.628 MbpJ, 5.74MbpJ and 5.85MbpJ.

Table 2. Comparative discussion

Variations	Metrics	AO_based Iterative Approach	Multi_agent Reinforcement Learning	FSPSO	PSO	AVO	LO	Proposed AVLO
64 transmitting antennas	Sum rate (Mbps)	69646.85	72963.36	76279.88	77938.14	79496.6	81086.86	82912.91
	Energy efficiency (MbpJ)	0.069	0.070	0.075	0.091	0.0922	0.093	0.105
	Available rate(Mbps)	3.165	3.316	3.467	3.542	3.578	3.614	3.768
128 transmitting antennas	Sum rate(Mbps)	138430.1	145022	151613.9	154909.8	15801	16117	164797.7
	Energy efficiency (MbpJ)	0.137	0.139	0.149	0.181	0.188	0.208	0.208
	Available rate(Mbps	6.292	6.591	6.891	7.041	7.182	7.325	7.490

	)							
192 transmitting antennas	Sum rate(Mbps)	110647.9	115916.9	121185. 8	123820 .3	12629	12882 2	**13172 3.7**
	Energy efficiency (MbpJ)	0.110	0.111	0.119	0.145	0.147	0.151	**0.166**
	Available rate(Mbps)	5.029	5.268	5.508	5.628	5.74	5.85	**5.987**

6. Conclusion

This paper presents the newly modeled AVLO assisted energy aware power allocation scheme based on the fitness function, which include the energy efficiency and sum rate. The hybrid AVLO algorithm is modeled by joining the AVOA and LOA. Here, the AVOA method familiarized the lifestyle of vultures, whereas the LOA is relying on the hunting style of lions. In this research, the MIMO-NOMA with multiple users is utilized to transmit thedata in communication medium. Here, the devised algorithm computes the ability of user to communicate the data based on the energy efficiency and sum rate. The user with maximum value of sum rate and energy efficiency is deliberated as an optimal solution. Moreover, the minimum value of energy efficiency and sum rate with the user is selected to allocate the power for transmitting the information. Moreover, the analysis is done based on varying the transmitting antennas. Furthermore, the devised AVLO scheme attained the better performance based on the sum rate, energy efficiency and available rate of 131723.7Mbps,
0.166 MbpJ and 5.987 Mbps. In future, the effectiveness of devised model can be extended by including some other communication network.

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