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Review and Analysis of Beamforming's Power Allocation Studies for (5G) Networks

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ABSTRACT

The necessity to investigate viable spectrum areas for satisfying the anticipated needs has been prompted by the rising cellular data traffic demands. As a result, the scientific community has given (mmWave) communication a lot of attention. In (5G) wireless networks, massive (mmWave MIMO) communications are often accomplished using hybrid transceivers that combine lower and higher as a digital and analog processing units phase shifters and power amplifiers respectfully. This hybrid beamforming (HB) architecture lowers costs and power use, which is consistent with the (5G) network's objective for (EE) of design. In this work, using system models of hybrid transceiver architectures, both digital (DB) and analog (AB) beamforming arrays with possibilities for antenna design, and hybrid beamforming (HB) in heterogeneous wireless networks, they trace the development of (HB) for massive MIMO connections. Authors widen in discussion by focusing on hybrid beamforming to solve resource management issue and examine the applicability of hybrid beamforming (HB) techniques while also highlighting the fascinating difficulties that lie ahead for this field. The main aim of this work is to analyse the many studies and show the advantages and weak points of each single study based on the general and famous parameters as well as explaining the efficiency of all studies. We got an overview of the hybrid beamforming, which covers topics such as application areas; In order to reduce upfront costs and continuing operating costs, the fully-connected architecture can achieve full beamforming gain per RF chain, but at the expense of increased hardware complexity. On the other hand, the low-complexity sub-connected architecture offers reduced beamforming gain.

1. Introduction

The research on (5G) wireless networks, which strives to fulfill and address a variety of technological needs and obstacles, has, as of late, gained a significant amount of interest from both academic institutions and commercial organizations. According to research published via Wireless World Research [1] smartphone data transfer is more than doubling annually and is projected to surpass wired-device traffic by the year 2018. In addition, the volume of bandwidth demanded by users has skyrocketed over the course of the last few years. This is due to the introduction of a

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plethora of applications require a large amount of bandwidth, 3D games, car-to-everything (Car2X) connections, and high-resolution augmented reality video feeds [2-4]. Furthermore, it is projected that by the year 2020, there will be something in the vicinity of 50 billion gadgets serving the community [5], which equates to more than six gadgets per person. We're talking about both human and device-to-device or vehicle-to-vehicle communication here. Main aim is to create a setting in which electronic devices such as sensors, home appliances, vehicles, and drones may interact with one another through mobile networks. In order for the mobile network to support these types of communications, the capacity of the network has to be significantly increased [131].

In this respect, it is anticipated that capacity of the (5G) network would need to be one thousand times larger than that of the fourth generation (4G) system [6]. This will allow the network to support such huge communications. This ambitious objective will inevitably become an issue related to a lack of energy, and as a result, it is of the utmost importance to create solutions that are both (EE) and compliant with the technical standards. More than seventy percent of the mobile operator's monthly electrical expenditures are contributed by the radio section. In addition to this, the expansion of mobile network coverage has resulted in a considerable rise in the production of carbon dioxide, which is a serious worry in the modern world [7]. It is anticipated that hybrid beamforming (HB) for (mmWave) will be an essential component of (5G) in order to fulfill demanding criteria of the (5G) standard while also preserving the design's capacity to save energy. The main objective and purpose of this work is the analysis of many studies and show the advantages and weak points of each single study based on the general and famous parameters as well as explaining the efficiency of all studies.

2. Technologies of Power Allocation Services

2.1 Technology Works on 300 MHz to 3GHz Band

The spectral efficiency (SE) and bandwidth are two factors that have a significant impact on the ever-increasing demand for wireless communication systems. At this time, all wireless technologies are functioning in the band that ranges from 3x102 MHz to 3x103 MHz [8]. Since the technologies of the physical layer have successfully arrived at the Shannon capacity [9], choice one and only that has not been fully investigated is the system bandwidth. Examining the mmWave frequency range at high intensities, which ranges from 3x103 MHz all the way up to 3x105 MHz, is therefore the central focus of (5G) wireless networks. On the other hand, (MIMO) technology, which involves the utilization of multi-antennas at both sender and receiver sides, is seen as one of the potentially fruitful ways for enhancing signal efficiency [10]. MIMO offers two potential avenues for the improvement of SE:

i. (BS) can connect with numerous user equipment (UE) using same time-frequency space resources.
ii. Second, many information flows might potentially exist between the BS and each UE. Massive MIMO is the next stage in the evolution of the MIMO concept, when hundreds or thousands of antenna components were used at a base station (BS). Large-scale MIMO might cut down on transmission power needs and small-scale fading [11]. Since massive MIMO employs beamforming gain to get sufficient (SNR) by compensating for substantial the route missing, it is essential for mmWave frequencies. That's why mmWave frequencies absolutely need enormous MIMO. Thus, the use of massive (MIMO) communications provides additional access to the 3x103 to 3x105 MHz channels and boosts SE [12,13].

As demonstrated in Figure 1, 5G wireless networks will include MmWave massive MIMO into a plethora of applications, such as vehicle-to-vehicle (V2V), Internet-to-vehicle (I2V), device-to-device (D2D), backhaul, small cell, and vertical virtual sectorization. These technologies put a substantial amount of strain on the mobile network to satisfy the communication needs of its users, and massive MIMO has the opportunity to improve capacity, signal enhancement, and (EE). On the other hand, the frequencies that are meant to be transmitted have larger the route missing [12]. Usage of the multi-level systems may help mitigate the issue of the route missing by providing a potential (LoS) or less multiple pathways to target [14]. Beamforming in mmWave massive MIMO systems involves the use of a big antenna matrix to compensate for the route missing via the use of directed broadcasts. Traditional baseband (DB) calls for only one unique (RF) chain to be used for each antenna in massive MIMO systems [11,15,16].

Alternatively, since mixed-signal and RF chains (ADC/DAC, data converters, mixers, etc.) are notoriously power-hungry and expensive, they are seldom used. [17] The decision was made for hybrid beamforming (HB) that operates in both baseband and analog domains. Therefore, a number of researches have presented various designs with the objective of decreasing the number of RF chains via mixing analog and digital beamformer. These approaches are collectively referred to as hybrid beamforming (HB) techniques. Ways or manners of hybrid beamforming (HB) were created with the intention of jointly optimizing the analog and digital as hybrid beamformers in order to achieve the highest possible rate. Since RF beamforming is performed in the analog domain, it is possible to link many beamformer sets to a single or a few digital-to-analog converters (ADCs or DACs), (HB) architecture appears to be more applicable to mmWave than conventional microwave architecture [18].

This is due to fact that beamforming performed in analog domain at RF. Beamforming is a process that directs the vast majority of signals produced by a collection of transmit antennas in the desired angular direction [19]. To be more specific, beamforming distributes the identical symbol over all of the transmit antennas while applying a weighted scale factor. In order to achieve the highest possible received (SNR), all of the received signals are coherently merged at the RX using a distinct scale factor. This improvement in (SNR) is referred to as beamforming gain in antenna array systems. The modification that occurs in the slope of the error probability as a direct consequence of the gain in beamforming is referred to as the diversity gain [20]. It explained number of RF chains that has a lower bound equal to total number of data streams that are being broadcast as one of the driving forces behind the growing interest in hybrid beamforming. On the other hand, Number of antennas affects beamforming gain and diversity order [21].

In purely (DB), a digital signal processor is used to perform the beamforming operations, which offers more degrees of freedom and better flexibility to develop effective beamforming techniques. DB approach calls for a distinct (RF) chain to be used for all elements of the antenna, which leads to a complicated design and a high level of power consumption. When doing (AB), the antenna weights may be applied in one of two ways: either by utilizing elements of time delay, alternatively, by equivalently phase-shifting of the signal either before or after the RF up-conversion step [22]. Table 1 provides a comprehensive analysis of the differences and similarities between DB and AB. On the basis of the benefits and drawbacks of analog and (DB), there were an interest increased that hybrid beamforming (HB) is an appropriate design It is capable of using massive mmWave antenna arrays whilst having a smaller architectural footprint [23,24].

The availability of an appropriate architecture that can take advantage of hybrid beamforming (HB) is a major factor fueling this interest. In a fully connected hybrid beamforming (HB) system, all of the RF chains are linked together and directed to their respective antennas, where partially connected hybrid beamforming (HB) architectures only connect each RF chain to a subset of the antenna elements. These two types of hybrid beamforming (HB) architectures make up the bulk of the available options. Both of these designs involve a certain level of complexity in exchange for the benefits they provide. In a sub-connected design, the number of signal processing paths is Nt x N2RF, whereas in a completely connected architecture, it is Nt x NRF. This is because fully connected architectures have more transmit antennas than sub-connected architectures do. However, the fully linked design has a beamforming gain that is NRF times bigger than partial connected approach [22,23]. Entire hybrid beamforming (HB) designs have the same overarching goal, which is to lessen the complexity of the underlying hardware and signal processing while yet delivering close to ideal performance, or performance that is comparable to that of pure (DB).

2.2 Gradient Boosting Aided Deep Q-Network (DQN) GBDT in C-RANS

C-RANs, have potential to allow an increase in the amount of data traffic carried by 5G systems. However, because of the intricate states, allocating resources in C-RANs is a computationally intensive and time-consuming process.

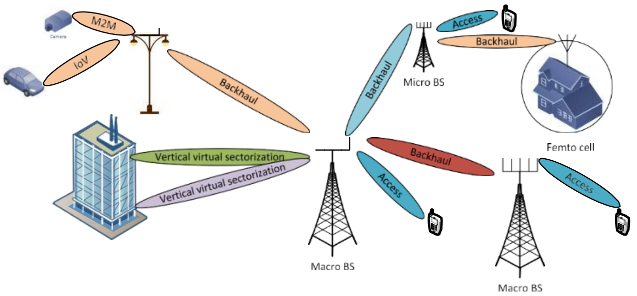


Fig. 1. Applications of massive MIMO on millimeter waves in (5G)

As a result, it is difficult to fulfill the needs of real-time wireless applications for (EE) and low latency. This research presents the (DQN) based technique for addressing the (DRA) problem in a real-time C-RAN. By greatly reducing amount of computing needed to solve second order cone programming (SOCP) problems, this paradigm allows for substantial savings in terms of energy. In order to get a rough idea of how to solve the (SOCP) problem that emerged during beamforming design, the researchers first applying the GBDT to the regression task. When solving this issue using standard computer methods, a lot of time and memory is used. Researchers then create (DQN) based on a common deep reinforcement learning to provide the robust policy that controls the online/offline state of remote radio heads (RRHs) and reduces energy allocation. Due to the infinite possible states in a real-time C-RAN system, the (DQN) employs (DNN) to deal with this problem. The GBDT then refines its policy as it observes the state and the resulting reward. The developed strategy is robust in the face of errors, such as when the gradient boosting regression is not fully constrained by the starting problem. Results from the simulation show significant advantages over existing manners in terms of performance and the computational complexity needed to reduce energy usage. This is in comparison to existing methods.

As more and more wireless devices, such as smart phones and tablets, enter the market, there has been a concomitant increase in the demand for mobile data services as well as the development of these services [24]. (C-RANs) [25]. Are often considered to be the most promising mobile network design to address the aforementioned problem. In particular, centralized (C-RANs) partition (BSs) into radio units, also known as (RRHs), and (BBU Pool). Within a C-RAN, the BBU may be positioned at an area that is both handy and straightforward to reach, and the RRHs can set up atop poles or on roofs on demand. In order to keep performance at an acceptable level in C-RANs, (DRA) is an absolute need. Several studies have attempted to use convex optimizations in the hopes of obtaining the best allocation method possible. Some of these works are (SOCP) [26], (SDP) [27], and (MIP) [28]. Although, in real-time C-RANs, where environment is in a constant state of flux, the effectiveness of the aforementioned methodologies in determining the best course of action is confronted with significant obstacles. In the field of reinforcement learning (RL), there have been efforts made to improve the effectiveness of the solution technique described in [26,29] and shown in Figure 2.

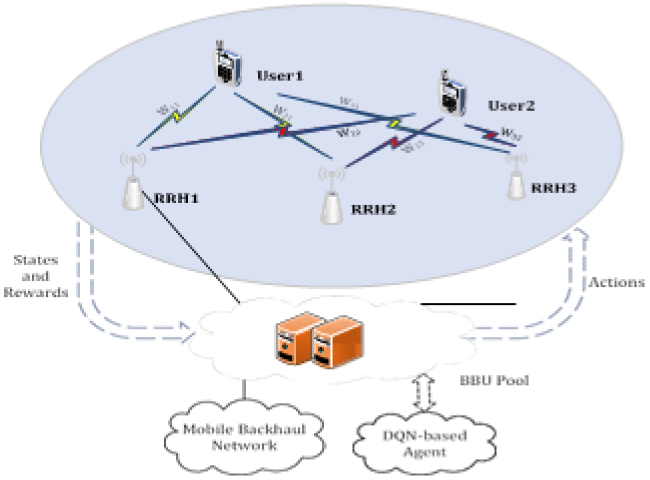


Fig. 2. DQN-based DRA in cognitive radio access networks

RL has demonstrated its significant benefits by successfully resolving DRA issues in wireless communication networks. The problem of DRA in RANs is often modeled as an RL problem in the existing approaches [24,29,30], which involves establishing various parameters as the reward. In contrast, the research presented in [30] determined that the reward should be the average summation of (QoS) and the averaged resource utilization of the slice. However, as difficulty of allocation issues rises, the search space for potential solutions has a tendency to become endless, making it difficult to find a solution to the problem. Deep reinforcement learning, often known as DRL, is a method that was developed using combination of RL and deep neural networks (DNN) [31].

DRL was suggested and used to solve the challenges listed above in [32-34]. DRL is able to conduct end-to-end RL [31] because it makes use of DNN's ability to directly collect useful features from its high-dimensional state space. The issues of a huge search space and continuous states are no longer the insurmountable hurdles they once were thanks to the aid of DNN. In order to apply the DRL paradigm to DRA issues, it is necessary to design the reward, the action, and the state. In the majority of cases, it is necessary for the action set to be enumerable. In the research described in [26], a double-step decision framework was utilized to ensure the enumerability of the system. This was accomplished by altering the state of one RRH at each epoch. This framework functions very well in models that have an endless number of states. In addition, in DRA issues, the question of how to get the best allocation strategy will, in the majority of instances, be ultimately transformed into a different optimization problem, namely, a convex optimization problem [35], which is a problem that can be addressed mathematically. Traditional methods [36-38] for tackling the convex optimization issue, as SOCP, still have major restrictions, look likes being time consuming, which makes it difficult to produce a policy for large scale systems. Unfortunately, this is the case. The DNN approximation [39-42] has been applied to DRA issues in recent studies, and these efforts have resulted in considerable improvements to the computing efficiency of the problem. However, due to DNN's very erratic performance in the regression phase, good performance is notoriously difficult to attain [43]. When there are a huge number of hyper-parameters, precisely tuning a practical system becomes much more difficult. In the fields of computability theory and information theory, there have been scholars who have explored and researched this subject [21].

The gradient boosting machine, often known as GBM [45], is a type of algorithm that belongs to the family of boosting algorithms [46,47], which is a subfield of ensemble learning [48-50]. As a result of its rapid training and excellent performance, it has been a frontrunner in several data mining and machine learning contests [51], establishing itself as one of the most cutting-edge methods in the ML field. Although, to the best of the researchers' information, only a handful of papers have attempted to apply this manner or strategy to the DRA issue, much alone other regression problems in communication systems. At that study, one frequent kind of DRL known as (DQN) is utilized in order to efficiently handle the DRA problem in C-RANs that include an endless number of states. In addition, a tree-based GBM, also known as (GBDT), it utilized to approximate the solution of SOCP in order to combat the challenges associated with obtaining the reward in (DQN) in a low amount of time. This is done in order to reduce the amount of latency experienced. Then, the researchers show that our technique is superior to the standard ways by contrasting it with the results of simulations using the standard methods. The following is a list of the primary contributions that this work made:

i. In the beginning, they provide the model of (DRA) problem that exists in C-RAN system. After that, researchers provide a regressor that is based on GBDT to approximate SOCP solution of the suggested issue. This regressor will serve as the instant reward that is required in (DQN). When this is done, it is not necessary for the proposed system to solve the original SOCP issue each time; as a result, significant savings in computing cost can be realized.
ii. Following this, the researchers presented a unique (DQN)-based architecture for the generation of the optimum policy to regulate the states of RRHs. In this design, the immediate reward is acquired through a GBDT-based regressor rather than SOCP solution.
iii. They demonstrate the improvement in performance and decrease in complexity that our suggested solution offers in comparison to the solutions that are already in use.

2.3 Energy Efficient (EE) Full Duplex (FD) in mmWave Backhaul Networks

MmWave wireless communication systems in (5G) era are distinguished by their dense deployment of small cells and their applications of (FD) technologies, both of which provide the chance to keep up with the exponential increase in demand for data services. Beamforming, together with improvements in analog and digital self-interference (SI) cancellation methods, are what increase capacity in mmWave wireless backhaul networks. The researchers suggest using the (FD) concurrent transmission method in a mmWave backhaul network to save energy and improve the network's overall performance. Constraints on multiuser interference (MUI), spectral integrity (SI), and forward error correction for (FD) transmission are taken into account during the construction of the contention graph. The contention graph is then used to suggest methods for grouping flows and regulating power. The researchers analyze the efficiency, throughput, and power use of the proposed method in a network setting. The researchers also examine how changing the number of BSs, the volume of traffic, and the strength of transmissions affects system performance at various interference thresholds. In comparison to (TDMA), half duplex (HD) and full duplex (FD) concurrent transmission without power control, the results of the simulation reveal that the concurrent method that was developed produces higher performance with the appropriate SI cancellation and interference threshold.

It has been suggested that mmWave communications, also known as mmWave communications, will be a crucial component (5G) mobile network. This is so that these networks will be able to accommodate the skyrocketing growth of data rate and bandwidth requirements necessitated by new technologies like (IIoT), (AI), and big data analytics. The line of sight (LOS) characteristic of communication, which contributes to interference control [54], is one of the advantages of the mmWave band. This advantage is in addition to the availability of underutilized spectrum at gigahertz frequencies, which is one of the benefits of the mmWave band. However, the usage of standard optical fiber networks among (BSs) in mmWave backhaul networks is prohibitively expensive [55]. This is because of the dense deployment of (BSs) in mmWave backhaul networks. In contrast, wireless backhaul networks that make use of beamforming and directional antennas offer considerable benefits over their wired counterparts in terms of throughput as well as the costs associated with deployment [56,57]. When used in wireless backhaul networks, the placement of directional antennas may effectively resist the attenuation of mmWave transmission, while beamforming technology can assist to boost throughput and expand the propagation range.

During the course of last decade, a significant amount of research has been conducted on the subject of the (EE) of wireless backhaul networks. These studies have included a comparative study of network topologies and frequency bands, which may be found in [58]. Although it has been shown that simultaneous data transmissions result in increased network performance, the quantity of energy that is used continues to be at a very high level. This is due to the fact that it is directly connected to the extreme interference that takes place during parallel transmission. Various research, which can be found in [59-64], have been conducted on this matter. As a result of these investigations, substantial progress has been achieved in the design of mid-access control (MAC) protocols, frame scheduling, and interference cancellation. As displayed by researchers in [62], when they introduced an adaptive channel super frame allocation method that was based on a newly constructed super frame structure.

This algorithm achieved superiority in (QoS), and it is described in further detail in [62]. A unique link scheduling technique for concurrent transmissions based on the feedback beamforming information in mmWave networks was described in reference [64]. This strategy was developed for use in mmWave networks. However, the majority of existing scheduling algorithms in mmWave bands can only operate in (HD) mode. Because of this, spectral efficiency is limited, and the algorithms are unable to supply a rising data rate [65]. When compared to HD mode, (FD), which is a technique to send/receive data, flow simultaneously, practically duplicate's system capacity, which is highly outstanding for a mmWave communication system. Full-duplex (FD) is the method to transmit/receive data flow simultaneously. In addition, FD mode demonstrates superiority in both the reduction of bit error rate and the management of outage probability, which offers the possibility for the advancement of current state-of-the-art technologies in 5G [65]. On the other hand, FD systems are susceptible to the issue of (SI), which is seen in Figure 1. When both receiving and transmitting signals are sent across the same channel at the same BS, the SI is produced because the sent signal causes interference with the received signal [66]. Even though a number of innovative and cost-effective methods for SI cancellation have been presented in [67-71], there is (RSI) that exists, which has a detrimental effect on the performance of the concurrent transmission and the overall system. Therefore, taking into mind SI throughout the design process of concurrent scheduling in FD mode should be done so as to increase (EE).

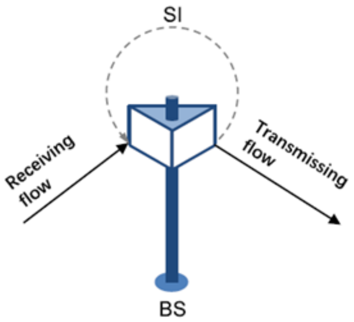


Fig. 3. Diagrammatic representation of the SI that results from (FD) transmissions.

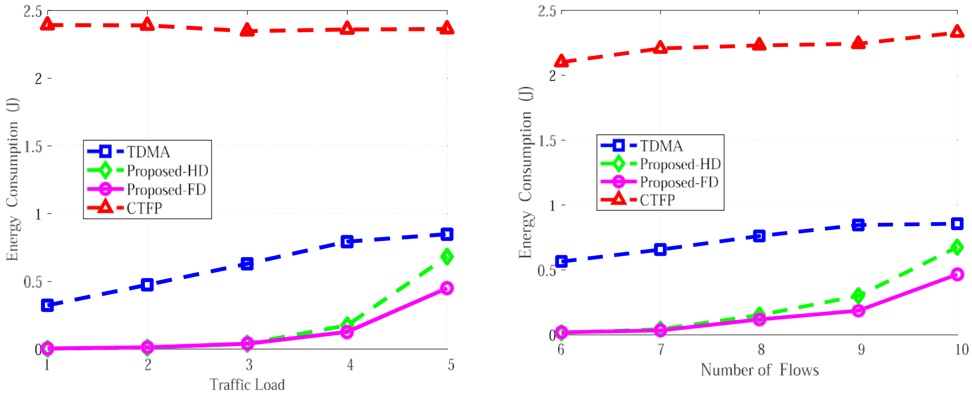
Improvements have been achieved in a variety of areas, including beamforming design, channel estimates, signal identification, the implementation of multiple access schemes, and the assessment of capacity [72-79]. This is despite the fact that the military, industry, and academic institutions all show a significant amount of interest in mmWave communication technologies. It is essential to have a reliable package detection mechanism in place before beginning the process of establishing communications in burst mmWave wireless networks. Additionally, mmWave antennas that have strong directional emission patterns and a broad bandwidth have been suggested [80]. In addition, Zhu *et al.,* examined the use of (NOMA) in mmWave communication with the intention of increasing the total number of customers who are serviced. In point of fact, communications at such high frequencies not only call for the implementation of a reliable not only represent a paradigm change in the administration of networks and their resources, but also in signal detecting mechanisms, multiple-access schemes, and the use of strengthened directional antennas.

This is due to the fact that communications at such high frequencies necessitate the use of enhanced directional antennas. The assessment of the performance of backhaul wireless networks should place equal emphasis on the amount of energy used and the throughput of the network. In light of these considerations, they offered a method for concurrent scheduling that is both (EE) and effective in FD mmWave backhaul networks. With this approach, the researchers hope to achieve higher performance in terms of both network throughput and energy usage. The following is a synopsis of the primary contributions that this paper makes.

i. Authors integrate FD into the concurrent transmission scheduling used for the mmWave backhaul network. Also, they built a combined optimization model to improve (EE) of system by combining the transmission characteristics of standard (TDMA) and FD modes in mmWave bands. This allows us to better use the available bandwidth.
ii. After careful consideration of the parallel transmission principle, the benefits of FD, and the constraints imposed by practice, a power control method and a flow grouping technique are proposed as part of a concurrent scheduling system. The substantial interference is much reduced by the flow-grouping approach, which is built on top of a preexisting contention graph. The power control algorithm is dedicated to reducing unnecessary energy consumption and increasing network throughput.
iii. They analyze the influence that a variety of scheduling strategies, traffic loads, and flow numbers have on the amount of energy that is used, as well as the efficiency with which energy is used. When traffic volumes, BS placement, and maximum transmission power are all in flux, they also investigated how to correctly establish the interference threshold,

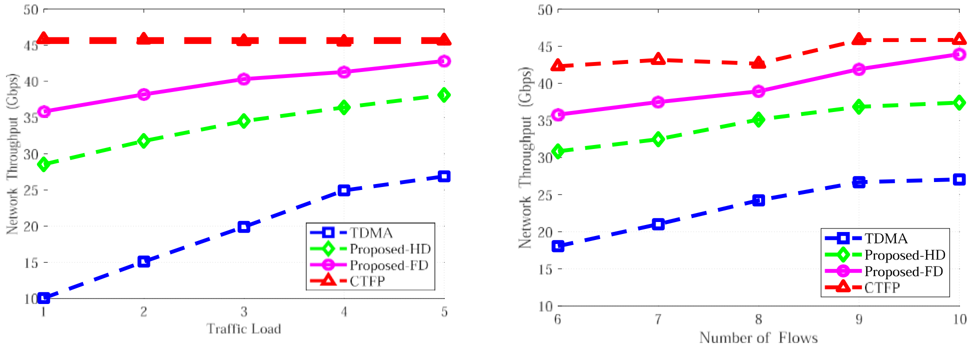
denoted by. The remaining parts of this work are structured as described below. The super frame construction, antenna model, and various transmission modes are going to be discussed in the next portion of this article.

The simulation is going to take place on a mmWave wireless backhaul network operating at 60 GHz, and it will use actual directional antennas. The route missing exponent is calculated to be 2 [95], when line-of-sight transmission is assumed. Based to [90], the standard FD systems provide SI cancellation that is about equivalent to 120 decibels. As a result, SI cancellation factor that was employed in the simulation may be equally distributed anywhere between 2 and 4 times 1011.5. In the beginning, there are ten (BSs) enabling FD transmission that are randomly dispersed over a range of one hundred by one hundred m2, and each BS have same amount of transmitted power (Pt). The transmission distance is unknown due to the fact that each flow chooses its transceivers in a random fashion. They test out how well the FD works that is being considered concurrent scheduling algorithm and compare it with the performance of three schemes, namely, TDMA, the HD concurrent transmission scheme with power control, and the FD concurrent transmission scheme without power control. In order to make the performance comparison more clearly, they have been used two different traffic load models. In traffic model A, the number of flows is always set to 10, but the required throughput for each flow can range anywhere from [0.5 to 1.5] Gbps, [1 to 2] Gbps, [1.5 to 2.5] Gbps, [2 to 2.5] Gbps, and [2.5 to 3.5] Gbps. These throughput ranges are indicated by the traffic load, which can range from 1 to 5 at any given time. In traffic model B, the number of flows varies from six to ten, which is shown by the x-axis in Figure 4 (b), Figure 5 (b), and Figure 6 (b), while the needed throughput of each flow is equally distributed in the range between two and three and a half gigabits per second.



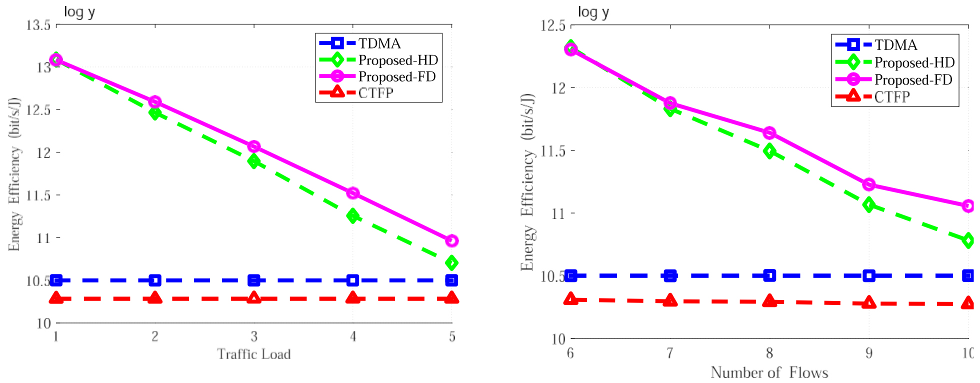
(a)Traffic model A (b)Traffic model B

Fig. 4. The analysis of the differences in energy usage (J)



(a) Traffic model A (b) Traffic model B

Fig. 5. The analysis of the differences in network throughput (Gbps)



(a) Traffic model A (b) Traffic model B

Fig. 6. The comparison of (EE)

In this study, authors presented an FD concurrent transmission method for the mmWave backhaul network that is built on a contention graph. This was done so that they can make use of more powerful SI cancellation techniques. The design of a contention graph offered a unique way for flow grouping transmission scheduling, and the suggested power management algorithm delivered both power savings and an increase in throughput. Both of these goals were accomplished. The findings of the simulation demonstrated quite clearly that (EE) of the Proposed-FD system was much higher than that of the current TDMA, CTFP, and Proposed-HD schemes. The selection of interference thresholds was also shown to be connected to traffic loads, BS distributions, and maximum transmission powers, all of which had a significant impact on the functioning of the system, based to extensive numerical calculations.

In a mmWave wireless backhaul system, the power consumption model should take into account not only the transmission power and modes, but also the circuit power and interface power. Transmission power and modes are obvious factors. Only the (EE) of a mmWave backhaul network under varying levels of transmission power and modes is the focus of this particular piece of study. In the future, they were worked together to optimize the amount of power that the system consumes in order to uncover more optimization solutions.

2.4 Energy Efficient of Energy Consumption for Beam Space MIMO-NOMA Systems

Massive MIMO is being considered as a potential game-changing technology for the next generation of communication networks (5G). Massive MIMO, on the other hand, creates a challenge for meeting the (EE) requirements of 5G because of the amount of power that is needed to run the high number of (RF) links. In this research, they offered a strategy for the allocation of power that is both (EE) of and effective for mmWave beam space MIMO (NOMA) systems. In these systems, there may be several users in each chosen beam. First, using the zero-forcing (ZF) beamforming approach, they were able to get the precoding matrix in accordance with the beam selection (BS) findings. Second, they used a fractional programming approach to describe the issue of optimizing (EE) to get the greatest possible gain. It is possible to convert the initial optimization issue into a convex optimization problem using sequential-convex approximation (SCA) and second-order cone (SOC) transformation. They were able to get the outcomes of the power allocation by using an iterative optimization procedure. After that, they did an analysis on the convergence of the iterative optimization approach that authors had presented and discover that the answer at each iteration is a solution that is less than optimum when compared to the initial non-convex optimization problem. When the transmitted power is greater than power threshold, the results of the simulation reveal that the suggested (EE) of power allocation system has superior EE performance in comparison to the current techniques.

It is anticipated that the volume of data traffic would rise by a factor of one thousand by the year 2020 [96,97] due to the fast expansion of mobile Internet and (IoT). Massive MIMO and (NOMA) are two fundamental strategies for the advent of (5G), which function together for the purpose of providing the future huge demands for communication service [98-101]. (EE) of 5G is greater than one hundred times the EE of 4G. This is in addition to 5G's spectral efficiency (SE), huge connectivity for (IoT), decreased latency, and numerous appealing services. The power allocation of MIMO-NOMA systems may be decreased by relay [102] and network densification [103,104] in accordance with the propagation characteristics of (mmWave).

The electromagnetic efficiency (EE) performance of systems may be hindered, however, by the power allocation of circuits, which is proportional to the number of (RF) chains. In other words, the large-scale antenna array has a negative impact on the EE need of 5G, despite the fact that it is capable of providing greater SE by producing directed beams that have a high gain. Due to large-scale antenna array is more difficult to control.

In conventional wireless communication research, the metrics of sum rate maximization, spectral efficiency maximization and sum power minimization (SEMax) (SRMax) (SPMin) respectfully have been the most widely adopted metrics for the purpose of matching the requirements of a tremendous increase in the amount of data [125]. In order to solve the issue of the downlink SRMax, the researchers [105-110] took use of the algorithms for user pairing and power allocation, both of which are NP-hard optimization issues. [105-111] presented a comprehensive review of the resource allocation (RA) methods for downlink NOMA. This paper's primary focus was on user pairing and power allocation. In addition to the criteria for SE, EE has lately attracted a large amount of attention because to the enormous amount of energy that is used by information and communication technologies. In [112], the EEMax issue was presented as a non-convex fractional programming model while the NOMA scenario was being considered. An EE-optimal energy consumption technique was developed, and it was based on the possible range of transmitting power that had previously been determined.

In order to investigate (EE) of dynamic power allocation (DPA) in NOMA networks, the Lyapunov optimization approach [113] is used. In doing so, they wanted to accommodate both the highest allowed transmission power and the minimum required level of service for our users. The design of EE of beamforming approach for downlink transmission in the context of a multiuser multi-input single-output (MISO) NOMA system was explored by Haitham *et al.,* [115], in contrast to the (EE) of power allocation for MIMO-NOMA with multiple users in a cluster [114]. This was accomplished within the framework of a MISO (multi-user, multi-input, single-output) system. The initial optimization problem posed by non-convex fractional programming was reformulated as, using sequential convex approximation (SCA) and Dinkelbach's technique. Both of these methods are based on sequential approximation of convex functions. For the purpose of resolving the issue of downlink beamforming for the multiuser MISO-NOMA system, two brand-new algorithms have been presented. [116-118] investigated the issue of (EE) of user scheduling and power distribution in NOMA heterogeneous networks, which is distinct from the single-cell EE analysis (HetNets).

Discrete lens arrays (DLAs) [119] may help minimize the energy allocation of a large-scale antenna array so that the EE can be improved further; the SE performance degradation is minimal in comparison to the typical antenna selection procedures. [120] suggested an interference-aware beam selection (IA-BS) technique with maintaining just one user in one beam by categorizing users into two groups: interference-users (IUs) and noninterference-users (NIUs).

The maximum number of users in a traditional beam space MIMO setup is limited by the available RF channels. Using NOMA and DLA together, Wang *et al.,* [121] presented a beam space MIMO-NOMA for mm-Wave communications that makes effective use of both spectrum and energy. Joint power optimization issue, which encompassed intra-beam and inter-beam power allocation, was solved, and the result was a proposal for (DPA) to maximize the possible SR. (DPA) issue for mmWave massive MIMO-NOMA with concurrent wireless information and power transmission was addressed using the Sherman-Morrison-Woodbury formula and iterative optimization technique [122]. The authors highlighted the fact that the number of users in each chosen beam is the key distinction between the BS MIMO-NOMA approach [121] and the IA-BS method [120]. The former approach allows for concurrent usage of each chosen beam, whereas the latter simply ensures that only one user is using each beam at any one time. Specifically, in the user dense circumstances, it is more probable that there are several users matching to one chosen beam.

The aforementioned references lead us to believe that some articles have been written on the (EE) performance of mmWave MIMO-NOMA communication systems. [115] addressed an (EE) of beamforming design for MISO-NOMA systems. This was done without the use of DLA. (EE) of mmWave beam space MIMO-NOMA was investigated in Reference [121]. However, the technique of power allocation was developed using SEMax as the measure of choice. [123] examined the joint beamforming and antenna selection (JBAS) issue within the context of standard OMA systems. This was done in the absence of NOMA and DLA. It does not make any sense to pursue SRMax without first ensuring that (QoS) requirements of the users are met. Especially in light of this prerequisite. In this research, they investigated a strategy for allocating power in mmWave beam space MIMO-NOMA systems that is efficient with respect to the use of energy. The following is a condensed summary of the contributions that this work makes:

i. Using BS method for mmWave beam space MIMO-NOMA [121] and the ZF beamforming technique, the researchers formulate the problem of (EE) of power allocation as a non-convex fractional programming problem. This problem takes into account the constraints that are placed on each user, limitations on the available power, the allowed pace, and the number of iterations of the SIC algorithm are all included. Particularly intricate SIC limitations were not taken into account in [121].
ii. The optimization issue that was given to us to begin with is a fractional programming problem. The EEMax optimization issue may be rewritten as a tractable convex (SOCP) by transforming it using SCA and SOC. This will make the problem easier to solve. In order to address the newly framed issue, they selected for an iterative optimization approach in order to get the power allocation outcomes. The convergence of the suggested algorithm is next subjected to our scrutiny.
iii. They tested our suggested strategy for allocating power in a way that is efficient with energy. The findings from the simulation demonstrate that the iterative optimization strategy that was developed may converge fast. When the power budget is more power threshold, the newly created approach has a higher efficiency index (EE) in comparison to the current methods for allocating power.

To control the goal function, unlike Dinkelbach's method [123,124], they introduced a slack variable. This transforms the original goal function into a linear one. SCA [124,126] and SOCP [126,127] are used to handle the non-linear constraints. Allocation of power may be determined by resolving the SPMin issue [125]. Then, they use an iterative optimization method to solve the problem of power distribution in an energy efficient (EE) fashion. The authors leverage previously shown results from SPMin as an initial starting point for our iterations.

To solve the initial optimization problem, an iterative optimization method was proposed [123]. which investigated the convergence of its suggested SCA based beamformer design for EEMax. Concerning the optimality, [115] compared the suggested algorithm to the Dinkelbach's approach to ensure its superiority; [123] shown via simulations that the iterative algorithm's solutions adhere to the Karush-Kuhn-Tucker requirements.

In this part, the capabilities of the suggested (EE) of energy consumption approach for mmWave beam space MIMO-NOMA scheme are analyzed by means of numerical simulations in order to provide an assessment of the method's performances. In this particular piece of research, they were only concerned with a single-cell downlink communication system. (BS) in question has $N = 256$ as number of antennas, and the distance between each antenna is equal to half the wavelength. They defined $\epsilon = 1$. It is possible to pick a varied number of (RF) chains using one of many transmission strategies, all of which are predicated on a variety of beam selection techniques. For instance, if they use a (FD) transmission, the number of chosen RF chains is $NRF = N = 256$. On the other hand, if use a BS approach, the number of selected RF chains is $NRF \leq K$, which is something that was covered in the part that came before this one. They assumed that (BS) has complete control over the beam space and CSI of all users.

Using $k = 20$ and $Ptr = 25dbm$ as inputs, they tested the convergence of the proposed iterative approach, and they made the SNR value$10db$. This allowed us to determine whether or not the proposed power allocation technique would converge. Particularly, in order to demonstrate the convergence feature, they simply determined that $Tmax$ should equal 30 as the termination condition. This is where they just show the outcomes of the eleven iterations that came before it. The convergence of our suggested approach is shown in Figure 1. In the case where is less than 0.01103, they are able to determine that the iteration will end after the $11th$ iteration.

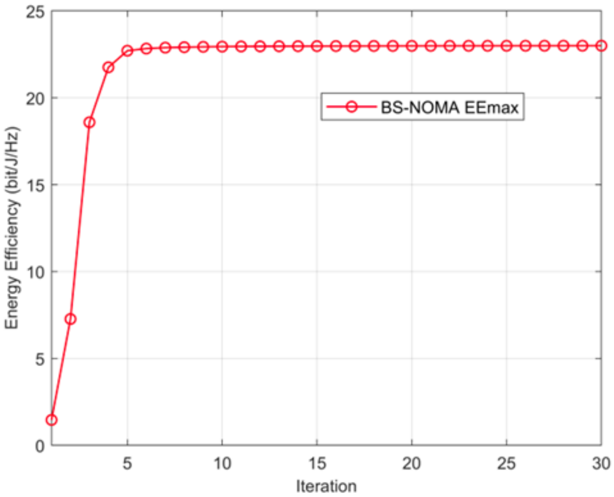


Fig. 7. For the suggested iterative optimization technique to converge, where $K = 20$, $Ptr = 25dBm, SNR = 10dB$

Energy consumption findings of BS-NOMA SRMax and BS-NOMA EEMax are what the researches were focusing. Based on Table 2, the BS-NOMA SRMax utilizes the whole of the sent power in order to achieve the maximum SR, while the BS-NOMA EEMax only makes use of a fraction of the total broadcast power. This is due to the fact that the transmitted power is more power threshold, which can be shown to be 30 dBm in Figure 5; yet, the transmitted energy shown in Table 2 is $40\ dBm$. User 2 and User 3 are located in the same beam space inside the BS-NOMA schemes (BS-NOMA SRMax and BS-NOMA EEMax), and there is an energy value gap between the users listed above and the users located above them.

In this research, they reach the conclusion that the energy consumption for mmWave beam space MIMO-NOMA communication systems may be done in an environmentally responsible manner. According to the findings of the BS, they might get the precoding matrix by using (ZF) beamforming method. The difficulty of EEMax is expressed as a fractional programming issue in its current form. The initial fractional optimization issue is changed into a convex optimization problem by the use of SCA and SOC transformation, and this problem is then addressed through the utilization of an iterative optimization technique. After that, researchers examined whether or not the iterative optimization technique that was devised has converged. The results of the simulation show that the proposed method of energy allocation achieves the same level of EE performance as the BS-NOMA SRMax when the transmitted energy is less than the energy threshold; however, the proposed method achieves a higher level of EE performance when the transmitted energy is greater than the threshold.

Table 1
Analog and digital beamforming compared

Beamforming	Degree of freedom	Implementation	Complexity	Power consumption	Cost	Inter-user interference	Data stream
Digital	High	ADC/DAC, mixer	High	High	High	Low	Multiple
Analog	Low	Phase shifters	Low	Low	Low	High	Single

Table 2
Energy consumption values (mW), where $K = 20, SNR = 10dB, Ptr = 40dBm$

Sytems	User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10
BS-NOMA SRMax	494.123	345.505	616.247	770.529	480.056	351.55	748.712	588.414	359.369	600.788
BS-NOMA EEmax	55.153	2.702	67.513	56.429	60.055	61.678	61.699	61.863	62.052	62.013
Sytems	User 11	User 12	User 13	User 14	User 15	User 16	User 17	User 18	User 19	User 20
BS-NOMA SRMax	355.538	598.450	350.948	383.682	464.413	535.259	728.652	381.091	343.906	503.195
BS-NOMA EEmax	62.061	61.992	62.070	62.061	61.952	61.953	61.994	61.987	61.534	61.241

3. Conclusions

In-depth analysis of hybrid beamforming, a crucial element of mmWave large MIMO systems, is provided in this paper. This article concentrates on power allocation understanding with diverse employed algorithms and technologies, in contrast to the four earlier studies on beamforming [129,130] which concentrated on mmWave channel characteristics and parameters and indoor usage.

Hybrid beamforming (HB) hardware designs, Resource management, various antenna counts at TXs and RXs, and the corresponding hybrid beamforming matrices; and Hybrid beamforming (HB) in small cells and HetNets. The researchers provided a review of current literature research for each of these subjects, beside explored the difficulties, outstanding concerns, and potential following studies for (HB) research in mmWave massive MIMO systems.

The main contributions in this work is the analysis of many studies and show the advantages and weak points of each single study based on the general and famous parameters as well as explaining the efficiency of all studies. After complete the entire comprehensive, we have got some lessons leads us to know the headlines of this work such as learned is an overview of the hybrid beamforming, which covers topics such as application areas, resource management, signal processing, and hardware design. In order to reduce upfront costs and continuing operating costs, hybrid beamforming (HB) is being used in response to the ever-increasing demand for mobile data. This change is being driven by the availability of more bandwidth in the mmWave frequency range and the usage of more antennas. The different hybrid beamforming (HB) designs are tailored to specific applications. For instance, the fully-connected architecture can achieve full beamforming gain per RF chain, but at the expense of increased hardware complexity. On the other hand, the low-complexity sub-connected architecture offers reduced beamforming gain. In terms of the amount of power that is used, the most important factor is the bit resolution of the ADC in DB and the PS in AB. This work covers the fact that the mmWave huge MIMO system can only be implemented using hybrid beamforming, which consists of both low-dimensions for digital and analog beamformers. Phase-shifters, switches, and antenna lenses are viable possibilities for (AB) [129] but (DB) may use proven methods to support multiple data streams by using them on the effective channel. According to the review of signal processing methods for hybrid beamforming (HB) from the perspective of the system model, On the topic of combining uplink precoding and downlink channel estimation for optimum (HB) design, there have been very few papers published. This was discovered through the examination of the hybrid beamforming (HB) process. Due to the inherent tiny cell size of mmWave frequencies (100–200 m), interference control for multi-cell inter-cell and multiuser intra-cell must be considered while building analogue and digital beamformers. Also, there are numerous areas of resource management that can have a substantial notwithstanding the fact that they are not directly connected to (HB); these factors have an influence on the performance of the hybrid beamforming, especially at the architectural level. This is because effective (HB) requires a wide variety of components. Potential study subjects for further improving the overall performance of (HB) include aspects of resource management such user clustering, beam managing, MAC changes both for in and out door use, and initial searching and tracking. Finally, we will learn that it is anticipated that the ultra-dense HetNet will be an essential component of the (5G). Because of this, the difficulties associated with hybrid beamforming (HB) become more difficult as a result of the increased density of HetNet in the 5G network. When the densification of HetNet is taken into consideration, problems with hybrid beamforming (HB) on a number of fronts, including the architectural level, signal processing, and resource management become considerably more crucial than they were before. This is true both at the access and backhaul levels. Also, the mmWave band is a possible contender for the backhaul component of the (5G). However, there are still many issues that need to be researched, include things like interference control, dual access small cells, the optimization of an antenna array, and time frequency space scheduling.

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