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Downlink massive full dimension-multiple input multiple output downlink beamforming analysis at 3.5 GHz using coordinated ON-OFF switching

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ABSTRACT

The long-term evolution and advancement (LTE-A) of the 5G wireless network depends critically on energy consumption. Many existing solutions focus on limiting power constraints and consequently system coverage. So, improving the antenna array elements of the base station (BS) can solve this issue. In this paper, introduce a coordinated ON-OFF switching method in the massive full dimensional multiple input multiple output (massive-FD-MIMO) system. It enhances the radiation pattern of the antenna array element by adjusting the angular power spectra at the BS. By the way, it allows to select the minimum number of antennas for effective beamforming toward specific user equipment's (UEs). In this context, part of antenna element should be active mode and remining should be sleep mode at the time of signal beamforming. The multipath spatial profiles are decided the beamforming frequency band with minimize energy consumption. As part of the method, we used a conjugated beamforming with power optimization scheme to determine the individual antenna potential and fading channel condition, power optimization is performed. This method quality of service, reliability, energy consumption and data rate can all be evaluated by experimenting with different-sized antenna arrays such as 16×16, 32×32, 64×64 and 128×128.

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1. INTRODUCTION

Accessibility of user equipment (UE) for data transmission is extended in the 5th generation cellular network [1]. However, the number of UEs interested in connecting to the 5G network has increased nearly 100 times over 4G, resulting in a huge demand to retain system capacity in terms of data rate (speed >10 Gbps) and energy efficiency (EE) [2]. In order to meet this requirement, the 5G cellular network must use at least 50% of total electrical energy for communication [3]. In order to find a new method to optimize power, many researchers devote more time to it. Over-connected UEs, in particular, should be prioritized in order to maximize data rates and maintain acceptable quality of service (QoS) levels under heavy data traffic. Furthermore, massive multiple-input multiple-output (massive MIMO) technology can provide the highest data rate, low latency and scaled robustness against interference [4]. Because of this, a significant amount of power is required to maintain the system's capabilities without sacrificing its overall performance [5]. Therefore, to address this issue an antenna muting principle is developed. This means that only a portion of the antenna element is in use while the rest remains dormant. Energy consumption is therefore reduced, but the method of turning on and off a minimum number of antenna elements is an open task for any research community. The frequency bands for 5G communication have been set at 3.4 and 3.8 GHz by IMT-2020. Antenna array design is heavily influenced by the channel characteristics in this band in terms of both energy consumption and transmission capability [6]. In this work, a coordinated ON-OFF switching concept in which spatial channel estimation is used to evaluate the energy efficiency of the massive-full dimension MIMO system under two important conditions are i) comparing power consumption with respect to the number of UEs for different antenna array sizes and ii) comparing power consumption along with different percent of traffic conditions with respect to the number of UEs. This model's antenna array radiation pattern can be improved by adjusting the base station (BS) power spectrum angularly [7]. In order for beamforming to be effective, a minimum number of antennas must be selected for desired UEs. Thereby, some antenna elements are activated, whereas others are deactivated. With the use of multipath spatial profiles, beamforming is performed, which reduces energy consumption while providing services to the desired UEs. Conjugate beamforming with optimistic power allocation is used to measure azimuth and elevation power spectra for reliable antenna element selection [8].

The proposed coordinated ON-OFF switching model is improved the energy efficiency of the selected minimum number of antenna element in the massive-FD-MIMO system. It takes spatial channel estimation in which analysis the signal interference between UEs through the measured channel coefficients. The experimental results are conveyed that the power optimization is reached in the IMT-2020 frequency band around 3.5 GHz. Furthermore, minimum number of active antenna element is measured for effective data transmission over the available UEs. The following sections frame the remainder of the paper: section 2 reviews to the recent study, 5G wireless networks in the 3.5 GHz frequency band facing more energy inefficiency than current 4G networks. System model and its spatial channel estimation, coordinated ON-OFF switching model and conjugate beamforming with optimistic power allocation scheme are described in section 3. In terms of QoS, reliability, energy efficiency, data rate, and power consumption, the proposed model's experimental results are summarized in section 4. Section 5 concludes with a look toward the future.

2. RELATED WORKS

The massive MIMO and spectrum sharing are the important 5G technologies that have had their energy efficiency examined [7]. The energy and spectral efficiency of D2D devices will be improved by this new technology. In order to achieve maximum energy efficiency [8], a multi-objective optimization problem (MOOP) was used to develop a power control system in [9]. For beamforming and spatial multiplexing in a multi-user large MIMO system, antenna grouping and selection were studied in [10]. Using a low-complexity binary search technique, the number of transmitting antennas was found. In addition, the impact of combining two or more energy-saving technologies on network performance, such as UDN with massive MIMO [11], has been studied. Antenna muting was presented in [12] as a way to improve user experience while also reducing energy usage. Dynamic antenna muting can be used to transform the MIMO-capable sector coverage mode to a single transmitting antenna psi-omni mode. Savings of 24.9% are possible with this plan. It was discovered in [13]–[15] that radio units might be adaptively enabled and deactivated under low load conditions, resulting in a self-optimizing antenna muting technique. New sleep-based resource allocation strategies have been proposed in [16], [17] as well. This tactic creates an interference map from which to select the femtocells that have been turned off. When femtocells are turned off, this map is not updated, which leads to sub-optimal solutions. Heterogenous networks (HetNets) that use densely deployed femtocells may benefit from an additional mechanism presented in [18]. The femtocells are put into sleep mode so that they do not interact with other femtocells. Each femtocell must allow the hybrid access mode in order for UEs in sleep mode to be connected to another neighboring cell within the cluster using the mechanism. According to [19], an efficient way to deactivate single-carriers (SCs) that are in undesired interference locations is presented for HetNets, allowing them to operate more efficiently. In [20], an energy-efficient SC resource allocation technique is discussed. The algorithm ensures a minimum QoS for multicarrier (MC) UEs while allowing SCs and MCs to use the same spectrum.

Distributed techniques are investigated [21] for multi-cell beamforming and power allocation without data sharing between base stations. There is no such thing as a single antenna element in our job. For example, zero-forcing (ZF) beamforming with a user-selectable selection approach has been studied in terms of data rates and system performance. ZF beamforming in an frequency division duplex (FDD) system is examined in [22] to see how it affects the data rate. For massive MIMO systems in uplink transmission, the average data rate performance of dispersed antennas is studied while all UEs transmit at the same power [23]. When studying downlink performance of cell-free systems employing time-division duplex (TDD), the maximum-minimum power allocation technique is applied [24]. There are upper and lower transmission capacity constraints for a multi-cell massive MIMO system [25]. The asymptotic rate performance of downlink multi-user systems was investigated using dispersed antennas and perfect channel state information (CSI). However, the ramifications of a CSI with fewer access points (APs) and users were addressed [26], [27] for large-scale dispersed antenna designs. However, in order to deliver consistently satisfactory service to all, or nearly all, customers from a massive MIMO standpoint, much research is required [27].

3. METHOD

The system paradigm for 5G cellular network beamforming is introduced in this section. Then, to improve power spectra at the BS and choose the fewest possible antenna array components for effective beamforming towards the selected UEs. Conjugate beamforming with optimistic power allocation and spatial channel estimates is an efficient utilization of power based on multipath spatial profiles.

3.1. System model

To illustrate the study, consider a 5G macro cell-centered BS, which can connect to a wide range of UEs. As shown in Figure 1, the linearly polarized antenna array element is responsible for beamforming to UEs in both azimuth and elevation directions. The uniform spacing between adjacent elements in the antenna array is kept at half the carrier wavelength (i.e., $d_{space} = \lambda_{carrier}/2$). The beamforming can be made larger or smaller depending on the distance, and thus the bandwidth of the transmitting signal is assigned between the BS and the UEs [28]. The row element in the matrix is in charge of azimuth beamforming, which involves adjusting the angular direction based on the UE's location. Similarly, the column element is in charge of elevation beamforming, which involves adjusting the angular direction based on the UE's location. The linearly polarized antenna array is appropriate for generating multiple beams with respect to different UEs distributed within the macro cell [29]. In this study, focus on minimum number of active antenna elements selection on different antenna array sizes includes 16×16, 32×32, 64×64 and 128×128 to achieve a reasonable data rate using conjugate beamforming with optimistic power allocation to respective UEs for beamforming from BS [30].

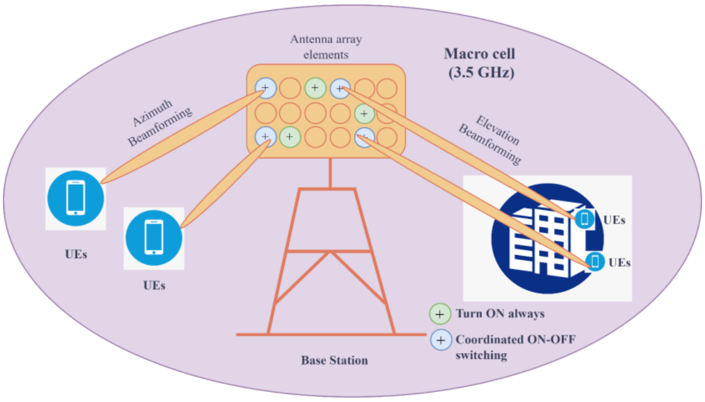


Figure 1. System model of coordinated ON-OFF switching model for single macro cell (3.5 GHz)

3.2. Spatial channel estimation

Multipath spatial (MPS) profile is the foundation of the beamforming. To achieve the lowest energy utility while still offering grantee services to the intended UEs, beamform direction is assessed in channel coefficient using (1). The downlink of the m^{-th} antenna element, where *m=1, 2, ..., M*, and CIR is given by (1):

$$h_s(\tau, \theta) = F_{loss} * \sum_{i=1}^{p} \alpha_i e^{j\phi_i} S(\theta_i) \delta(\tau - \tau_i, \theta - \theta_i) \quad (1)$$

where $\alpha_i e^{j\phi_i}$ represents the complex gains, τ_i represents the long-time delay, and θ_i adjusts the angular directivity of the i^{-th} path. Multi-path fading is frequently caused by shadow effects in signal transmission, which is denoted as F_{loss}. The term $\delta(\tau, \theta)$ indicates that the impulse response of the long-time delay exists in the time domain at $\theta = 0^0$. The MPS's normalized power is defined as $\sum_{i=1}^{p} |\alpha_i|^2 = 1$. Subsequently, $S(\theta_i)$ is the angular adjustment of the m^{-th} antenna element with respect to the first antenna element (reference point), from which the long-time delay between adjacent UEs of the signal beamforming is computed. It is stated in (2).

$$S(\theta_i) = exp\left(j \frac{2\pi}{\lambda_{carrier}} m d_{space} cos(\theta_i)\right) \quad (2)$$

Likewise, all M antenna array elements are combined and represented as a vector form, which is given as (3).

$$S^M = \left[1 \quad exp\left(j\frac{2\pi}{\lambda_{carrier}} md_{space}cos(\theta_i)\right),.. \quad exp\left(j\frac{2\pi}{\lambda_{carrier}}(M-1)d_{space}cos(\theta_i)\right)\right] \tag{3}$$

Therefore, the angular adjustment of the power spectra at the BS is entirely dependent on CRS in order to improve the antenna array radiation pattern for the UEs downlink.

$$P_{downlink}(\theta) = \sum_{\theta_i=\theta}\left|\alpha_i e^{j\phi_i} S(\theta_i)\right|^2 = \sum_{\theta_i=\theta}|\alpha_i|^2 (4)$$

For beamforming to desired UEs, all antenna elements have the same angle of adjustment and power distribution.

3.3. Coordinated ON-OFF switching concept

The macro cell capacity is extended up to maximum limits and utilizes the carrier frequency band (3.5 G Hz) to specific UEs for entire 5G cellular network. Moreover, the signal interference between UEs is estimated by (1) and improves the beamforming towards UEs through adjusting the antenna diversity gain measured from the CIR. In the antenna array, set of elements is kept in active mode (turn ON always) to make balance at the time of coverage impermeability exists [31]. Remaining, antenna element is keep adjusting the active (ON) and sleepy (OFF) modes continuously depends upon the MPS profile and data traffic. Suppose, if the antenna element is turn OFF, then, discovery signal is shared to any possible UEs within the macro cell region. Periodically, coordinated ON-OFF switching is performed to ensure minimum number of antenna elements are activated for instantaneous conjugate beamforming with optimistic power allocation without degrades the grantee services to the desired UEs. Figure 2 shows the massive FD-MIMO transceiver architecture with coordinated ON-OFF switching antenna array elements.

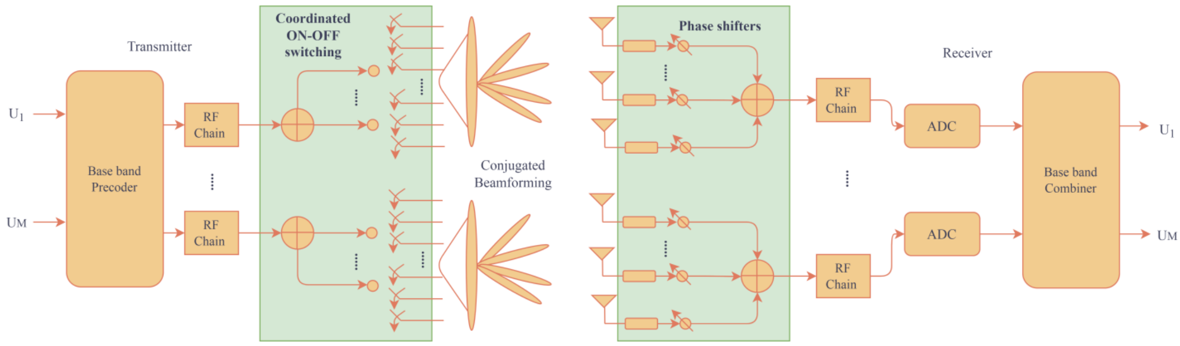


Figure 2. Massive FD-MIMO transceiver architecture with coordinated ON-OFF switching antenna array elements

Once, the coordinated ON-OFF switching is applied, then, the change of the mode is purely depending on $\beta_{r,c}$. Where, r and c represent the antenna matrix and there are pre-defined set of antenna element to be turn ON always denoted as $\beta'_{r,c}$. That implies, if $\beta_{r,c\neq 0} = 1$, then, it indicates active mode while, $\beta_{r,c\neq 0} = 0$, then, it indicates sleepy mode. The set of all antenna element is considered to be Z and the available UEs within the macro cell is denoted as U_M. The signal-to-interference noise ratio (SINR) for all available UEs associated to M antenna element is calculated as (5) [14].

$$SINR_{p,M} = \frac{\beta_M P_M G_{p,M}}{\sum_{Z\in M}\beta_Z P_Z G_{p,Z} + N_0 BW_p} \tag{5}$$

where, P_M and P_Z denoted as transmitting power of p^{-th} UEs and total power serving from all antenna element respectively. The channel gain is achieved between UEs and BS at the macro cell which is denoted as $G_{p,M}$. The noise power spectral density is defined by N_0, and bandwidth of the p^{-th} UEs is given by BW_p. To specific UEs is required maximum data rate for certain instance in that point frequency resource allocation is properly assigned to the desired UEs based on the conjugated beamforming along with power optimal. By using Shannon's equation as mentioned in [19] for data rate of UEs at the p^{-th} path is given by (6).

$$R_{p,M} = BW_p log_2\left(1 + SINR_{p,M}\right) \quad (6)$$

On the other hand, the minimum number of data rate is achieved by the p^{-th} UEs from the signal allocated beamforming is mentioned as (7).

$$R_{p,M}^{min} = R_{block} * R_{p,M} \quad (7)$$

where R_{block} be the reserved resource block to ensure the minimum achievable data rate of any possible UEs within macro cell.

The conjugated beamforming with power optimization is reduced the interference of the UEs and consequently increases the data rate. According to the proposed model, minimum number of antenna element is selected and activated to generate beamforming to its respective UEs. Thus, provides only reasonable amount of power is used to operate the selected antenna element. Therefore, the total power distribution of the entire antenna array element is defined as (8).

$$P_{tot}^{a} = P_{ON}^{a} + L_a P_{tx}^{a} \quad (8)$$

where P_{ON}^{a} be the power related to pre-defined antenna element turn ON always, P_{tx}^{a} is the power consumed by the antenna element at the time of beamforming to the respective UEs, and L_a is the transmission loss due to signal fading. The antenna array element those who are in turn OFF mode, consume some amount of power due to signal discovery to the any possible UEs. It is denoted as $P_{OFF}^{a} = \psi P_{ON}^{a}$. Where, ψ gives the inbuilt power leakage existing during ON-OFF changes. Now, the total power consumption of the antenna element can be calculated [20] using (9) given as (9).

$$P_{tot}^{a} = \psi P_{ON}^{a} + (1-\psi)\beta_{r,c} P_{ON}^{a} + L_a P_{tx}^{a} \quad (9)$$

In this work, the coordinated ON-OFF switching model is minimized power consumption of the linearly polarized antenna array element based on the MPS profile. However, the interference contribution power (ICP) is often caused by the active antenna element is calculated [14] with respect to desired UEs given as (10).

$$\chi_{P_{tx}^{a}} = \frac{\sum_{i \notin U_M} P_M G_{p,i}}{\xi \sum_{j \notin U_M} P_M G_{p,j}} \quad (10)$$

Because of the continuous turn ON-OFF of the antenna element is included the correction factor $\xi = 0.5\ ln(M)$ to compensate the handoffs situation. By increasing the ξ factor, may reduce the ICP at the time of launch of the beamforming to the UEs. The pseudo code of the coordinated ON-OFF switching model is described as follows:

Coordinated ON-OFF switching algorithm

```
Input: No. of UEs within macro cell 'M', Size of the antenna array 'Q', Load threshold L_th,
Output: Minimum number of active antenna element selection 'Z_min'
/* Selection based on the MPS profile and ICP */
Begin
For i=1 to M do
If M=0; then
Z_min → Z_OFF /* To ensure all set of antenna element equal to zero */
Else if L_actual ≥ L_th, then
Z_min → Z_ON = Q/2;
Else if P_tot^a < P_tx^a
Z_min → Z_ON = Q/4;
Else
/* Update the antenna element active mode */
Find ICP for interchange the active mode between antenna elements using Eq. (10)
For i=1 to Q do
If χ_{P_tx^a} > χ' /* Where, χ' be the ICP threshold limit */
Q_select → Z_off
Else
Q_select → Z_ON
Update χ'
End if
End for
End if
End for
```

3.4. Conjugate beamforming with optimistic power allocation

In this sub-section, discuss about the signal reception by conjugate beamforming with optimistic power allocation scheme. That means, based on individual antenna potential and channel condition, power optimization is performed to obtain target data rate with respect to corresponding UEs. There is separate SINR expression is derived (5) to show the downlink data rate of say M number of UEs. Here, conjugate beamforming with optimistic power allocation scheme is introduced which is modified version of the specific power adjustment (SPA) strategy.

a) The number of antenna element in the array is denoted as Q. The beamforming signal gets attenuated due to fading and thereby, channel coefficient is adjusted which is computed by (1);
b) Each antenna distributes the discovery signal within macro cell and its respective pilot sequence are $\varphi_i, i = 1,2, \dots M$;
c) All Q's estimates the channel coefficient instantaneously, which is given as $h_s'(\tau, \theta)$;
d) The conjugate beamforming with optimistic power allocation, for the *m-th* antenna element's transmitting signal.

$$X_M = \sqrt{P_M} \sum_{m=1}^{M} \sqrt{\eta_{p,M}}\, h_s^{'}(\tau, \theta) D_m \quad (11)$$

where, D_m is the data intended to UEs, and $\eta_{p,M}$be the power coefficient used by p-th path of the m-th UEs. Therefore, the received signal is computed in (12) for the m-th UEs is given by (12),

$$Y_k = \sum_{m=1}^{M} h_s(\tau, \theta) X_M + W_k \quad (12)$$

where, $W_k \sim \mathbb{N}(0,1)$ is the additive gaussian noise and 'k' represents the only the statistical estimation of the channel coefficient [7].

4. RESULTS AND DISCUSSION

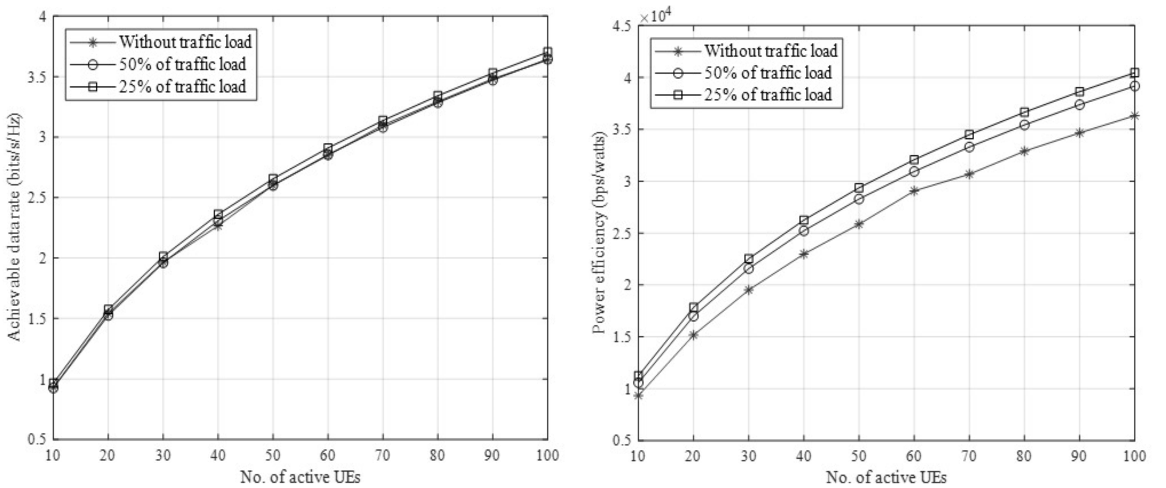
In this section, the evaluated the performance of the proposed model in different streams includes i) with use of all set of antenna element is active; ii) a half of the antenna element turn into active based on MPS profile, and iii) update the turn ON-OFF condition remaining inactive antenna element based on the ICP threshold. The simulation purpose, the coordinated ON-OFF switching is performed on basis of the ICP and MPS profile by considering the random selection of antenna element say 50%, 25% of antenna element to be active (turn ON) along with pre-defined set of existing active antenna element. Moreover, the random induction of data traffic with similar distribution percentage like 50% and 25% respectively. The actual target is to compute minimum selection of antenna element to be active for fulfilling the demand request send from UEs in terms of data rate and energy efficiency. Table 1 shows the simulation parameters which is considered as follows.

Table 1. Simulation parameters

Parameters	Values
Transmission power of the macro cell	At center 20 dBm and edge 22 dBm
Frequency band	3.5 GHz
Size of the antenna array	16x16, 32x32, 64x64 and 128x128
Number of the UEs	20-120
Baseline power	6.5 Watts
Power spectral density for noise	-180 dBm/Hz
Fading loss	$F_{loss} = 140 + 35.4 log_{10}(d)$, where d is the distance between BS and UEs in Kms
Mean AoD in the elevation	90°
Mean AoD in the azimuth	0°
Horizontal inter-element spacing, dH	0.5 λ
Vertical inter-element spacing, dV	0.8 λ
Antenna element gain, Gmax; E	8 dBi
Antenna gain, Gmax	15 dBi
Vertical HPBW, 3 dB	15°
Horizontal HPBW, 3 dB	70°
Number of antenna ports in the horizontal direction	4
Number of antenna ports in the vertical direction	8

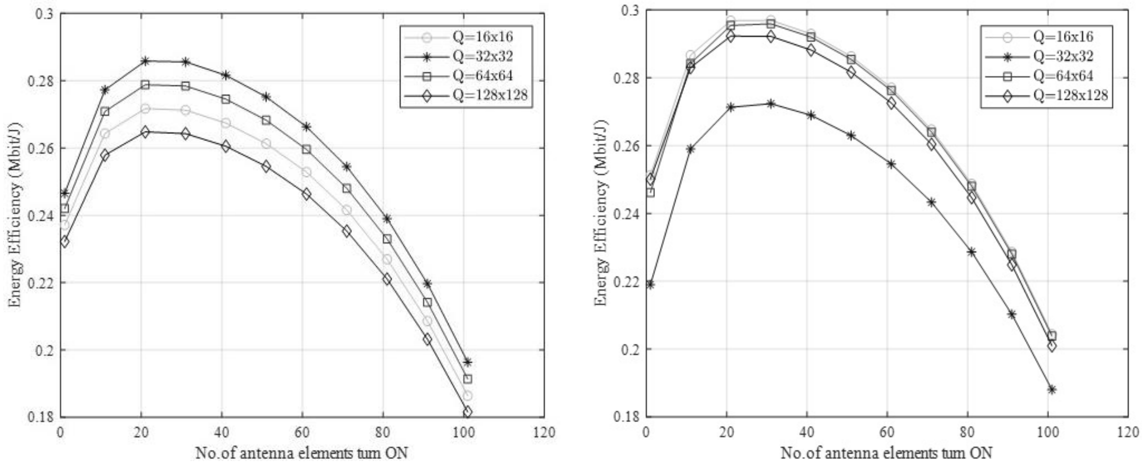
Figure 3 shows the simulation results of the coordinated ON-OFF switching method under different random traffic load percentage profile. Figure 3(a) gives the maximum achievable data rate in the consolidated form of the different antenna array size. It is clearly shown that UEs received the data rate is much higher when compared to 50% of random traffic load. Reason behind that, the coordinated ON-OFF switching is significantly influencing the antenna array position and selection numbers which means for lower size antenna array, say 16×16 cases, for continuous ON-OFF switching, only minimum number of antenna element is selected for signal beamforming irrespective of the distance. Thereby, there is not much variation when different percentage of the random traffic load is occurred. If the antenna array size increases, then selection of antenna element is varying with respect to UEs distance and therefore, probability of occurring signal fading is more that consumes large amount of the transmission power. It is clearly shown in the Figure 3(b). However, the antenna array is uniformly spaced between adjacent elements which can adjust the beamforming either smaller or larger depending on the distance, and thus the bandwidth of the transmitting signal is properly exchanged between the BS and the UEs.

Figure 4 shows the energy efficiency of the of the coordinated ON-OFF switching method under varying antenna array size with two different random traffic load (50% and 25%) respectively. According to continuous ON-OFF switching reduces the number of antenna element which is not required for that instant signal beamforming to the targeted UEs. However, for internal energy consumption difference between active and sleep mode antenna element would be considered for performance evaluation. As long as antenna selection increases, then, energy consumption is more for that energy efficiency is start decreases. Moreover, traffic load is another distributing factor further consumes energy without need of proper signal validation. Whenever, higher ratio of random traffic load occurs then it affects the antenna ON-OFF switching which leads to occupy a greater number of antenna elements for unnecessary signal beamforming. It is clearly shown in Figures 4(a) and 4(b) respectively. Meanwhile, specific UEs is required maximum data rate for certain instance in that point frequency resource allocation is properly assigned to the desired UEs based on the conjugated beamforming along with power optimal. Figure 4 shows the number of antenna element is selected to turn ON-OFF for making effective signal beam forming. The random traffic load is absent, then the smooth way of antenna selection is taken and almost the antenna count is maintained constant. It is evidently shown in Figure 5(a). that means, less than half of the antennas are selected for signal beamforming and if the random traffic load is interrupted then, some adjustment is carried in the antenna element selection. That implies, last quart half of the antenna is kept turn OFF position as long as traffic load is reduced. Figure 5(b) stated that the middle of the time, antenna element gets selected more than the usual antenna element count. it happened due to different % of the random traffic load occurrence. However, the beamforming may be larger or smaller, allowing the bandwidth of the transmitting signal to be assigned between the BS and the UEs. Using the UE's location, the row element of the matrix is responsible for azimuth beamforming. Additionally, the column element is responsible for adjusting the angle of elevation beamforming based on the user's position. Antenna arrays with linear polarization can be used to generate multiple beams for different UEs in a macro cell. Therefore, minimize the energy utility as well as fulfill the grantee services to the desired UEs as shown in Figure 6. Table 2 shows the comparative analysis of energy efficiency under different % of random traffic load.



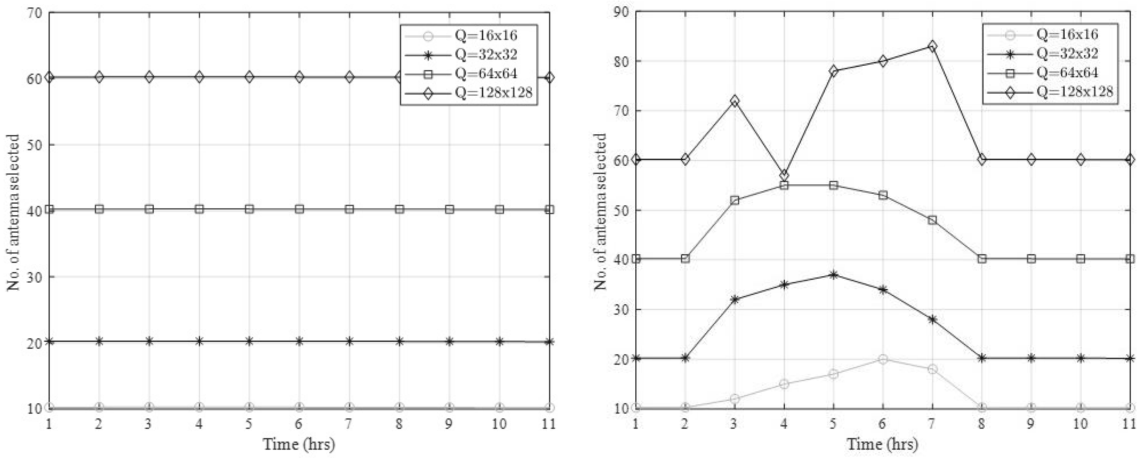
(a) (b)

Figure 3. Simulation results under different % of random occurrence of the traffic load: (a) achievable data rate (bits/s/Hz), and (b) power efficiency (bps/watts)



(a) (b)

Figure 4. Energy efficiency vs number of antenna elements turn ON: (a) under 50% of random traffic load, and (b) under 25% of random traffic load



(a) (b)

Figure 5. Number of antenna element selection vs time: (a) without the traffic load condition, and (b) combined 50% and 25% of traffic load condition

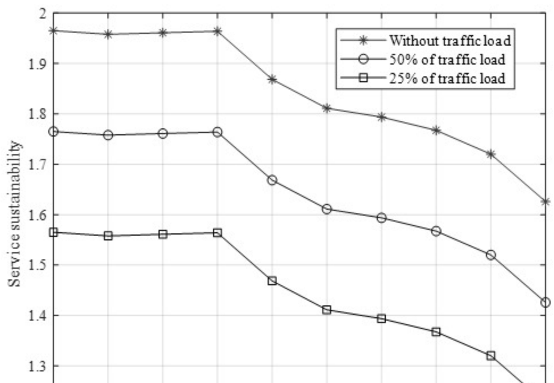


Figure 6. Grantee services to the desired UEs

Table 2. Comparative analysis of energy efficiency under different % of random traffic load

Condition	Macro cell (3.5GHz) at center 20 dBm and edge 22 dBm			
	Q=16x16, $Z_{min} = 12$	Q=32x32, $Z_{min} = 37$	Q=64x64, $Z_{min} = 74$	Q=128x128, $Z_{min} = 88$
Without traffic load	5.28	4.96	4.23	3.05
50% Random traffic load	2.38	2.56	2.43	2.27
25% Random traffic load	2.91	2.48	2.83	2.74

According to [28], the number of antenna elements is determined by the size of the antenna array. The turn-on of the selected antenna elements for successful beamforming is solely determined by the MPS profile and ICP threshold. That is, the smallest number of antenna elements is chosen, such as 12, 37, 74, and 88 for 16×16, 32×32, 64×64 and 128×128 correspondingly. In the case of lower order antenna arrays, such as 16×16, the possibility of surpassing the pre-defined threshold level is minimized. Even with erratic data traffic, signal beamforming with a small number of antenna elements is steady. When the size of the antenna array grows, there is a greater probability of reducing the sustainability of the minimal number of antenna components that are activated. However, the suggested approach keeps the minimum number of antenna elements operational even less than two distinct percentages of random traffic loads.

5. CONCLUSION

In this study, we introduced the Massive-FD-MIMO system to a concept of coordinated ON-OFF switching. Adjust the antenna array radiation pattern and pick the minimum number of antennas possible for successful beamforming targeting UEs. The beamforming operation was lowered in energy consumption and grantee services were supplied to the intended UEs because of the multipath spatial profiles and ICP. As part of the test, we used a conjugated beamforming with power optimization scheme to determine the individual antenna potential and fading channel conditions, power optimization is performed, and the minimum number of antennas turned ON and OFF to obtain achievable data rates with respect to corresponding UEs is ensured. Experimenting with different-sized antenna arrays, such as 16×16, 32×32, 64×64 and 128×128 can be evaluated the model's quality of service, reliability, energy consumption, and data rate.

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