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Advanced Radio Resource Scheduling Algorithm for Energy Efficient Cellular Base Station

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Abstract: This work is to introduce an advanced calculation to enhance the energy efficiency of the radio base station for MU-MIMO-OFDM framework. Advanced Radio Resource Scheduling (ARRS) is introduced. Power utilization is considered a standout amongst the most imperative parts of the research for the wireless network. In view of the increasing mindfulness for saving the earth, and to give green frameworks. The calculations fundamentally divided into two phases. First, it discovers the resource shares, and the number of dynamic antennas in light of channel state based on essential Resource Allocations as Bandwidth Adaptation (BA) and Discontinuous Transmission (DTX). Secondly, it applies the Amplitude Carving Greedy (ACG) and Inverse Water Filling (IWF) Algorithms for the ARRS. Which finds the ideal number of resource blocks allocated to every client in view of the wanted rates, and the number of dynamic receiving antennas that maximize the utilization of base station power for the time changing frequency selective channel. The results illustrate that the proposed ARRS Algorithm is giving an upgrade in the diminishment of the supply power utilization from 10% in low rates up to 17% in high rates, compared with essential asset designation for RAPS calculations.

Keywords: Green wireless network, energy efficient, radio resource management, OFDMA, MIMO.

I. Introduction

The evolution of the wireless communication technologies has become enormous lately. Moreover, the usage of these systems has increased rapidly. Furthermore, the demand to access the internet to get any information has become huge. As result, the wireless communication section has become on high demand.

The carbon foot print has been a factor to measure the global warming based on the increased emission of CO2. Moreover, the power generation has been considered as one of the primal sectors to increase the greenhouse gas (GHG) in our atmosphere. Furthermore, the wireless communication section has become one of the rising sections in power consumption.

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On the other hand, uprising awareness for our plant leads to the term “Green Technology”, which is concerned about proposing the technology with minimum impact on the environment. One of the new trends is self-sufficient standalone Base Station (BS) that is used to minimise the mobile network power consumption [1].

There are different basic power saving techniques; Radio resource management (RRM) techniques like power control (PC), which is the most known technique, because it has advantages in linking adaptation and interference minimization, besides reducing consumption of the power as mentioned in [2], [3]. Other researchers investigate the field of the Antenna Adaptation and sleep mode for the long Term Evolution (LTE) as given in [4], [5]. Other researchers work on the inverse water filling is examined in [3], [6] - [8]. Discovering the suboptimum answer for the transmission control per client, including the transmission control utilization, the bit limit, and the adjustment for MIMO framework, which is examined in [3]. While another examination is done to discover suboptimum arrangement by keeping up reasonableness oblige, which is discussed in [6]. Other work in summing most of these techniques is the algorithm of Resource allocation using Antenna adaptation, Power control and Sleep mode (RAPS) in [8].

In this paper, we present new calculation, which studies the essential resource allocation strategies; the assignment of the resource blocks with the consideration of active sleep mode under the presumption of channel information.

This study focuses on the following: Segment II shows the power demonstrations and the framework display that are utilised. Segment III defines the problem under investigation. Segment IV demonstrates the steps for the proposed Algorithm which consist of two phases. The initial phase of the proposed algorithm ARRS, which is utilised for solving the problem to discover the initial values for the resource share and number of dynamic RF chains. and the second step of ARRS that helps in finding the best effort quantities of resource blocks for every client and number of dynamic RF chains and the aggregated power utilizations that is displayed. As for segment V, it explains the different results of the simulation case studies. Segment VI defines our conclusions.

II. The Models of System and Power

A. Model of the System

In this model, as explained in [8], we consider downlink transmission outline for indicated multipoint remote correspondence framework. In this model, there is a solitary base station that gives administration to a few cell phones. We consider applying the MIMO procedure, as the BS has M_T Transmitter antennas and the recipients have M_R Receiving antennas. The orthogonal frequency division Multiple Access (OFDMA) is utilized to share the resource shares. K, N, and T are Users, Subcarriers and Time Slots individually. For every resource block, $H_{n,t,k}$ with M_T x M_R, assuming frequency selective time variant channel. The frame structure is shown in Fig.1 [8] and the framework is considered interference free.

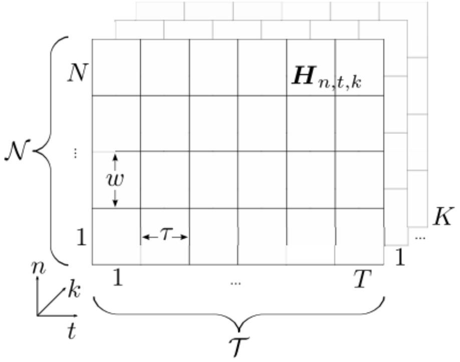

Fig. 1 OFDM frame structure [8]

B. The Model of the Power

The verified power models are used to calculate the total power consumption of the cellular BS in [9] and [10]. The supplying of power to the RF transmission is allowed by these models. The model of power in [11] is made from the implementation of the actual BS hardware, which has been verified by a detailed hardware model. A linear power model is used in this paper, which gives good basics for the analysis of the BS energy efficiency. Whereas, the power model of [9], [10] where the total supply power for the BS consists of the power consumed by base-band (BB) circuits, DC and AC conversation circuits, cooling system and RF chains. Each RF chain is considered as the combination of power amplifier (PA), small signal transceiver and transmitting antennas. The total supply power as given in [11]

$$P_{Total} = (P_{PA} + P_{RF} + P_{BB} + P_{DC} + P_{AC} + P_{cool}). \qquad (1)$$

Then the total BS Power consumption is giving by

$$P_{supply} = M_{sec}(P_{Total}). \qquad (2)$$

where, M_{sec} is the Sectors number for given cell, P_{Total} is the total consumption for the single sector. It is demonstrated that the greatest power consumption is in the Power Amplification (PA) area as appeared in [9]; and the framework is utilizing single antenna for every RF Chain. The antenna Adaptation (AA) is utilized to change the number of antennas in light of the requested rates. We could shut down the RF chains or place them in sleep mode independently based on the required QOS.

In this model, changing the RF chains status has no postponement to influence the transmission time, which is checked in [12].

In power model [9], the parameters are accommodated macro BS with one sector, and there is altered power that is utilized for the whole BS, which is equivalent to least dynamic power utilization $P_{o,Mt}$,in view of the quantity of dynamic RF chains ; in this manner the aggregated power is fluctuating as indicated by the dynamic load utilized by the client, which relies on upon straight transmission power reliance considering Δ_{pm} and the power utilization amid the sleep mode P_s. The power utilization for transmission at whatever time slot is P_t.
The aggregated power utilization for one sector is given by

$$P_{supply}(P_t) = \left\{ \begin{array}{ll} P_{o,Mt}+\Delta_{pm}.P_t & if\ P_t>0 \\ P_s & ,\ if\ P_t=0 \end{array} \right\}. \qquad (3)$$

III. Formulation of Problem

In this section, a brief discussion of the different power saving techniques and the minimizing issue for the aggregated OFDMA supply power is proposed.

Strategies of Power Saving

There are three strategies that impact the utilization of BS power, the transmitted power P_t, the dynamic number of RF chains M_t and the span time for which the BS enters the sleep mode as shown in Fig. 2 [9]. The three fundamental saving techniques are:

a. **Power Control (PC):** it means minimizing the transmission control for every resource block utilized.
b. **Antenna Adaptation (AA):** it intends to diminish the quantity of the antennas.
c. **Discontinuous Transmission (DTX):** it does not intend to transmit for all the time frame yet tries to increase the time spend in sleep mode.

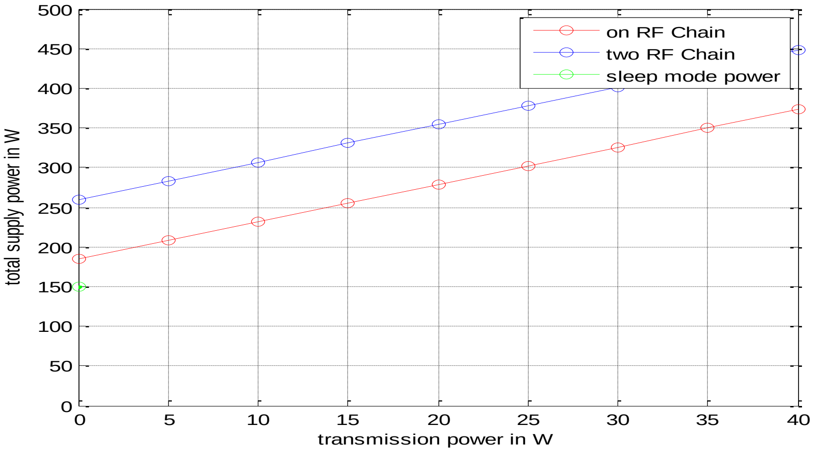

Fig. 2 Comparison between Different RF Chain Power Consumption. [9]

Global Problem

The problem of the power consumption is defined first by accepting that the channel state Matrices $H_{n,t,k}$ which is known for each channel and the objective rates per users (R_1,R_2,… ..,R_k). The arrangement of resource blocks that have been apportioned to every client is A_K. The power level for every resource Block is $P_{a,e}$, the spatial channel is e=1,..$\varepsilon_{a,k}$ and active number of antennas number is M_T. The most extreme power transmission is P_{max}. Thus, the aggregated limit with respect to any client k on transmission frame duration T_{frame} is giving by

$$C_k = \frac{wt}{T_{frame}} \sum_{a=1}^{A_k} \sum_{e=1}^{\varepsilon_{a,k}} log_2(1 + \frac{P_{a,e} * \varepsilon_{a,k}(e)}{N_o w}). \quad (4)$$

where *w* is the subcarrier bandwidth in Hz, t is the duration of time slot in seconds, and N_o is the density noise spectral in W/Hz. The RF transmission power for any time slot is

$$P_t = \sum_{a=1}^{A_T} \sum_{e=1}^{\varepsilon_a} P_{a,e}. \quad (5)$$

where ε_a is the channel eigenvalues on resource a, A_T is the set of subcarrier assigned for any user k, From (3), (4) and (5) the problem is to minimize the total supply power as:

$$P_{supply}(r) = \frac{1}{T}\left(\sum_{t=1}^{T_{Acive}} \left(P_{o,Mt} + \Delta_{pm} P_t\right) + \sum_{t=1}^{T_{sleep}} P_s \right). \quad (6)$$

Subject to $P_t \leq P_{max}$, T=T_{active} + T_{sleep} = frame duration.

In addition, the rates for each user:

$$R_k = \frac{wt}{T_{frame}} \sum_{a=1}^{A_k} \sum_{e=1}^{\varepsilon_{a,k}} log_2(1 + \frac{P_{a,e} * \varepsilon_{a,k}(e)}{N_o w}). \qquad (7)$$

where T_{active} is the active number of time slots, T_{sleep} is the number of time slot in sleep mode.

The assignment process of the Resource Blocks powerfully is known to be exceptionally mind boggling strategy for the subcarriers of every time slot and frequency selective channels, which is determined by means of computational costly calculations as specified in [2], [13], and [14]. Consequently, in this paper, the issue has been partitioned into two phases similar to [8]. In the first phase, the estimation of the Resource shares for every client μ_k, the quantity of sleep mode time slots, and the quantity of Active RF chains computed based on two techniques Bandwidth Adaptiation (BA) And Discontinuous Transmission (DTX). Secondly, the power utilization is resolved for the arrangement of doled out subcarriers and applying Amplitude Carving Greedy ACG And inverse water filling (IWF) power allocation until the ideal power utilization is accomplished.

IV. The Proposed ARRS Algorithm

A. Step 1: Finding the Estimates Parameters

This section is attempting to focus of the finding the initial values for solving our problem using the proposed framework presumptions. First, it is confirmed to assume that each resources confront the same block fading instead of frequency selective fading as the middle Resource Block as in [8].

The equivalent power pre-coding and uncorrelated receiving antennas are utilized to recognize the connection capacity. The objective rate R_k in the downlink block fading multiuser is given by

$$R_k = W\mu_k \sum_{e=1}^{\varepsilon_k} log_2 \left(1 + \frac{P_k \varepsilon_k(e)}{M_T N_o W}\right). \qquad (8)$$

where the ε_k is the channel eigenvalues per user k, P_k is the transmission power and μ_k is resource share time = t/T_{frame} .

In addition, in the proposed system, the receiving antennas M_{RX} equal two. From the transmission power computation and the power model in [8], the BS after serving the clients can go into sleep mode.

At this stage, we distribute the resource blocks among the users by two resource allocation techniques like bandwidth adaptation (BA) which transmits each resource block with the same power level P_{max}/N or by using the discontinuous transmission (DTX) which tries to transmit with the max power but in the same time minimize the number of time slots used to transmission and increase the sleep mode time.

B. STEP2: Optimum Allocation of Power for ARRS

The second phase of the ARRS is exhibited in this section of the study. The calculated estimations of step 1 are utilized to achieve the best effort values for the resource blocks for every client, while maintaining the same QoS.

At first it tries to quantize the resource shares from step1 and the T_{active} TS.

At that point, the genuine esteemed asset share μ_k is changed over into the OFDMA asset number per client $m_k \leq N$,

$$m_k = \lceil m_k N T_{active} \rceil \qquad \forall k = 1, \dots \dots .., K. \tag{9}$$

$$m_{rem} = NT - \sum_{k=1}^{K} m_k - NT_{sleep} \,. \tag{10}$$

The remaining unassigned resources $m_{t,rem}$ are conveyed between various clients in round robin design, while the availabilities considered for sleep mode is relegated to the end of the edge statically.

$$m_{t,rem} = N - \sum_{k=1}^{K} m_{k,t} \,. \tag{11}$$

After that we apply one of the greedy algorithms like Amplitude Carving Greedy (ACG) as subcarrier allocation calculation from Kivanc et al. [13], which is demonstrated to give great results with low complexity. The initial step is to apply all the data we created like the subcarrier blocks, the quantity of dynamic RF chains and the quantity of sleep mode T_S which are utilized to ascertain the transmit power in the area of time-frequency, and utilizing the inverse water filling (IWF), which works by first putting away the channels by their quality, and figuring the level of water of the best channel, that fulfils the bit load target. Furthermore, with every cycle, add the following best channel to the gathering of utilized channels, keeping in mind the end goal to decrease the water level. The calculation stops when the water level is less than the following channel metric to be utilized.

The target bit load for every client

$$\beta_{target,k} = R_k T_{frame} \,. \tag{12}$$

To satisfy the target bit load, the next condition has to be maintained.

$$\beta_{target,k} - \sum_{a=1}^{A_k} \sum_{e=1}^{\varepsilon_{a,k(e)}} wt\,log_2\left(1 + \frac{P_{a,e}\varepsilon_{a,k}(e)}{N_o w}\right) = 0\,. \tag{13}$$

which ensures that the entirety limit with respect to the given gathering of channels and resource. The water level υ which will be computed in every cycle for gathering of channels Ω_k as takes after

$$log_2(\vartheta) = \frac{1}{\Omega_k}\left(\frac{\mathrm{B}_{target,k}}{wt} - \sum_{e=1}^{\Omega_k} log_2\left(\frac{t\varepsilon_{a,k}(e)}{N_o \log(2)}\right)\right). \tag{14}$$

Then, the power level per spatial channel

$$P_{a,e} = \frac{\vartheta wt}{\log(2)} - \frac{N_o w}{\varepsilon_{a,k}(e)}\,. \tag{15}$$

The yield of this water filling calculation is the transmission power level $P_{a,e}$ for every resource unit. Rehash the entire procedure until the quantity of free resource blocks is less than the quantity of resource blocks in a single TS (as $N = 50$). At the final stage, the figuring of the utilization of the supply power is finished by summing the transmission power for every resource block utilized. This is sketched out in the proposed ARRS is in Fig. 3

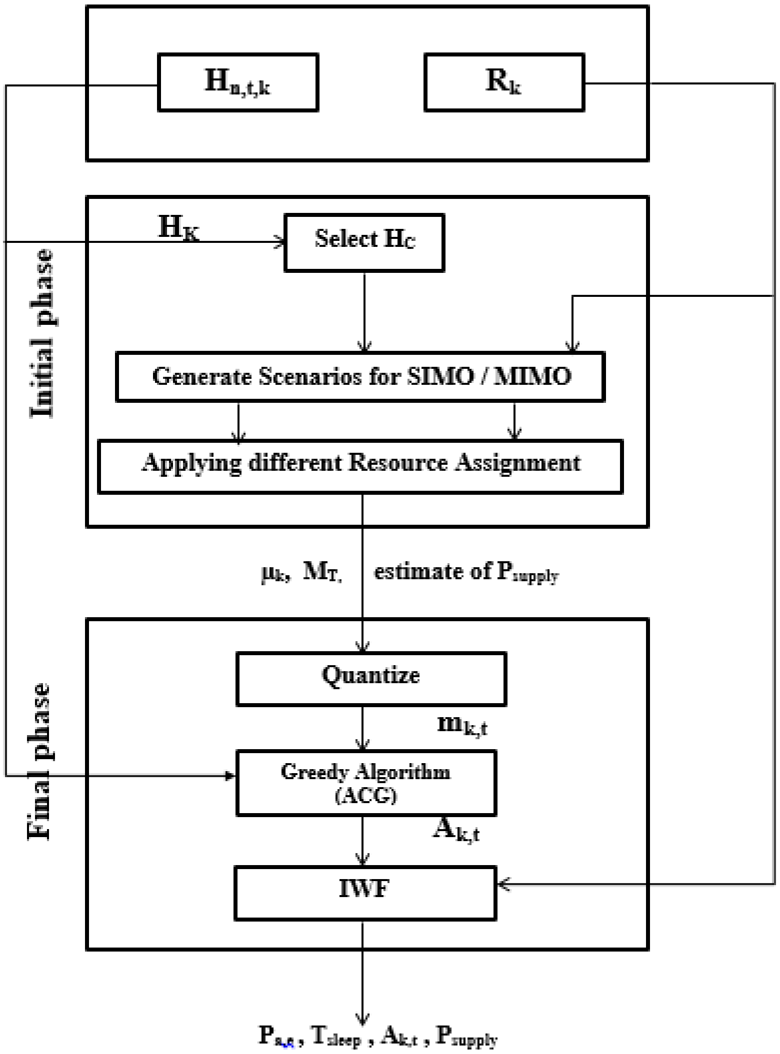

Fig. 3 The proposed Algorithm

Proposed Algorithm ARRS: Advanced Resource Allocation. The channel state indication $H_{n,t,k}$, the rate for each User R_k, the number of Active RF chains M, the number of Users K, and the number of time slots T. The resource shares μ_K per user, the number of the sleep mode time slots T_s.

1: collect the rates vector $R_K=R_1, R_2 \ldots R_k$.
2: collect the channel state information
    CSI=$H_{n^c,t^c,k}$ for the Rf Chains.
        3: preform resource allocation technique as (BA / DTX) and get estimates of {M, μ_K, Psupply, T_s}.
4: quantize the RBs over the T_{active}.
5: apply greedy Algorithm (ACG) to assign each user with required RBs.
6: preform IWF to calculate the P_{tx} for each RB.
7: calculate the supply power for the system.

V. Simulation Results

In order to test the ARRS Algorithm, Monte Carlo simulation is applied, as in [8] demonstrated with the accompanying parameters:

On hover with span 250m, the mobiles are consistently circulated around the BS, with least of 40m to the BS. As indicated by the NLOS display depicted in 3GPP.TR25.814, selective fading channels is processed as in [15], where shadowing standard deviation is 8dB. The model of the recurrence specific divert BS depicted in [16] with 3m/s versatile speed. Each transmitter and receiving antennas is thought to be commonly uncorrelated.

The system parameters are in table.1.

Table 1 System parameters

Variable	Name	Value
K	Number of users	10 – 20
N	Number of subcarriers	50
T	Number of time slots	10
M_T	Number of transmit antenna	[1,2]
M_R	Number of receiver antenna	2
$P_{o,MT}$	Circuit power consumption	185 W,260 W
Δ_{pm}	Load dependence factor	4.7
P_s	Power consumption in DTX	150 W
P_{max}	Maximum transmission power	46 dBm
T_{frame}/t	Duration of frame / time sot	10 ms/1 ms
W/w	System /subcarrier bandwidth	10 MHz/200KHz
N_o	Noise power spectral density	$4\text{x}10^{-21}$ W/Hz

Keeping in mind the end goal to look at the outcomes, the accompanying transmission techniques are performed:

- Maximum BS power utilization, where the BS has settled transmission power P_{max}.
- Bandwidth Adaptation (BA), where it tries to locate the base number of subcarriers that accomplish the objective rate and the sleep mode is not activated and all channels transmit with power equivalent to P_{max}/N.
- Discontinuous transmission (DTX), where BS transmits with P_{max} and go into sleep mode when the objective rate accomplished.

Figure 4 shows that the DTX method is more effective than the BA; as it tries to free some Time slots. The BS in sleep mode, however, it is as yet consuming much power. Henceforth, the work is done on the others strategies like RAPS and the proposed method ARRS.

The examination begins for the recommended algorithm ARRS versus the RAPS and the hypothetical maximum. Fig.5 reveals that those new calculations in the high rate area is giving 17% gain against the RAPS and 51% gain against the theoretical Maximum while the RAPS is giving 41% gain. Nonetheless, morals on low rate area gain is 10%compared to RAPS, while it gives 62% compared to the theoretical maximum and the RAPS is giving 58%

While in Fig.6, the energy efficiency (bit/joule) is investigated; where,

$$E = P_{supply}^{-1} \sum_{k=1}^{K} R_k \tag{18}$$

For BA and DTX based ARRS assigned for the users on the overall energy efficiency.

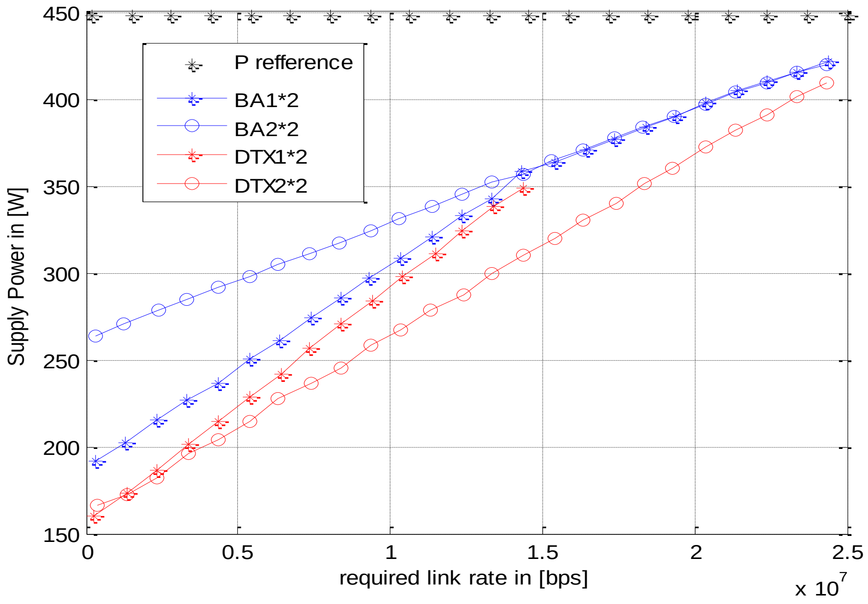

Fig. 4 Reference Power Consumption for Bench Mark Algorithm

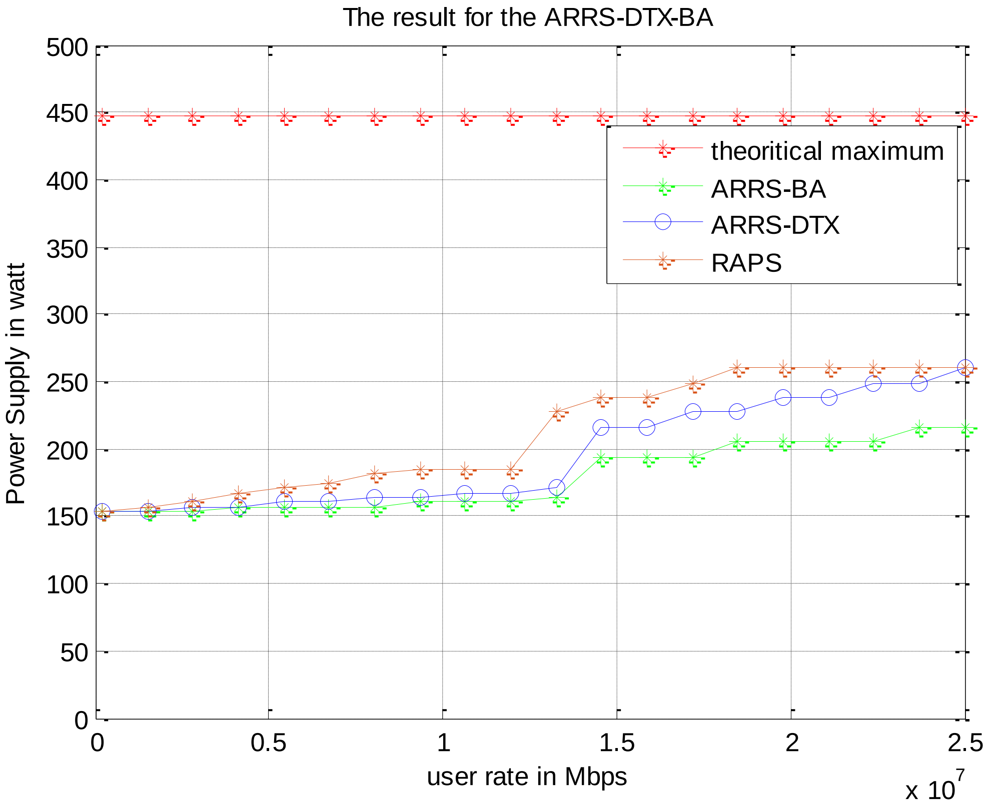

Fig. 5 Supply Power Consumption vs. the Requested Rates for Users

The Efficiency in ARRS is superior to RAPS by 20.4% at most maximum summation rates and it is superior to the theoretical maximum by 107.35%, while the RAPS is better by 72.23% compared to the theoretical maximum. And is also superior to the ARRS.

The proposed ARRS algorithm is providing better results with almost the same ration for different power models like the improved DTX and STOA 2010 as shown in Fig. 7 and Fig. 8.

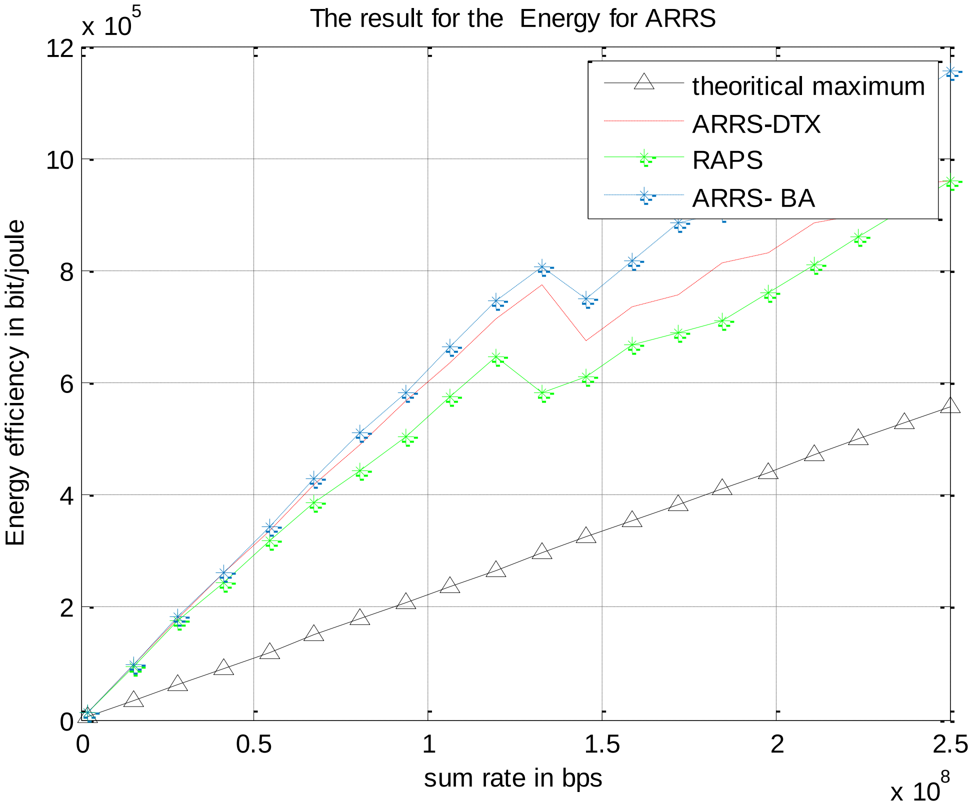

Fig. 6 Comparison between Energy Efficiency for both Resource Allocations

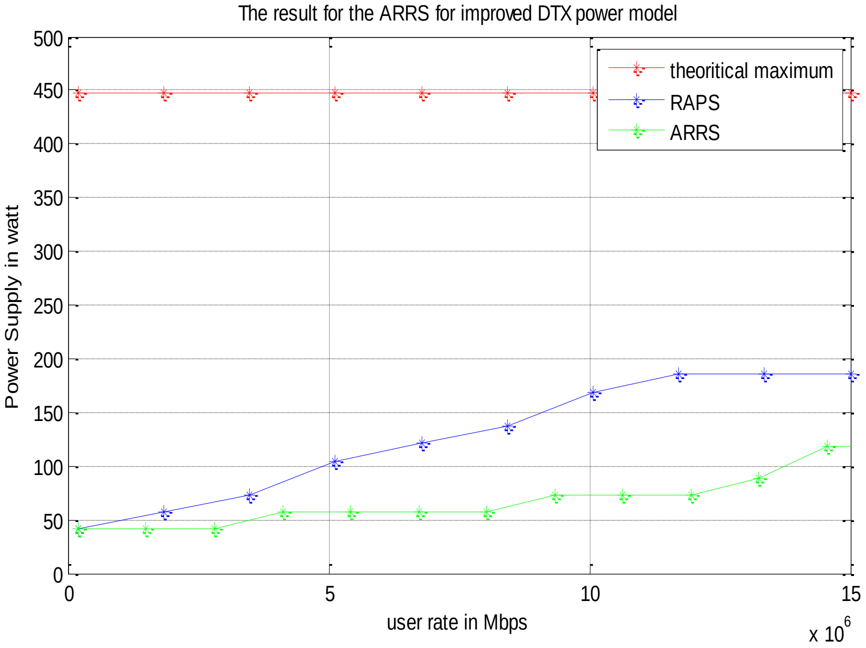

Fig. 7 The Result for the improved DTX Model.

Fig. 8 The Result for the STOA 2010 Power Model

VI. Conclusion

In this paper, BS resource Assignment methods like BA, DTX, and RAPS are studied and contrasted in regards to their execution and the proposed algorithm ARRS, we have thought about the framework display for multiuser MIMO OFDM. Reproduction results from demonstrating that the ARRS calculation is better in results than RAPS .also the ARRS is giving upgrade in lessening of supply power utilization from 10% in low rates to 17% in high rates; which is contrasted with RAPS calculation in [8].

And to 62% in low rates to 51% in high rates compared to the maximum power usages.

It also shows that while the DTX is giving better results than BA for power consumption, But our proposed algorithm is giving better result when depending on the BA as the first state in our algorithm than using the DTX.

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