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Rate and Power Control Based Energy Saving Transmissions in OFDMA Based Multicarrier Base Stations

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Abstract

Digital signal processing came long way from wire-based optical fiber communication to wireless-based high rate supported communication models. Radio waves supported long distance satellites, radars to microwave supported mobiles has changed in terms of technology and data rate in last two decades. Mobile communication has become part of daily life and mobile usage has witness immense growth results in high energy consumption which remains concerned area in resource management. Green communication technology is proposed in this paper for effectively controlling the date rate and power consumption to save the energy. The problem of energy minimization at BS transceivers subject to certain quality-of-service and fairness requirements for all users is addressed in this work based on communication activities in downlink transmissions of the BS with orthogonal frequency-division multiple access-based multi CCs are considered. Experimental results reveal that proposed method yields better results than traditional algorithms.

Keywords: Component carrier, Energy saving, Green communication technology, OFDMA

1. INTRODUCTION

In recent years, 4th generation (4G) cellular systems have been developed and deployed in order to better handle the data demands of ever-increasing numbers of network users, and cellular technologies are even now advancing towards 5th generation (5G) cellular systems and beyond. Importantly, one of the key features of 4G/5G and future cellular systems that allow them to achieve higher capacities than less advanced networks is the ability of base stations (BSs) to utilize multiple component carriers (CCs) together during data transmissions. At the same time, the power consumed by such wireless networks, especially by their BSs, has become a matter of increasing concern due to rising energy costs and the environmental impacts of the carbon dioxide (CO2) emissions that accompany energy production. As a result, the concept of green communications has received increasing attention as a potential means of addressing these concerns. The primary goal of green communications is reducing the overall amount of power consumed by the transmission of communications without causing any reduction in the service quality enjoyed by users.

Moreover, it is worth noting that network operators and network users have different goals and preferences when it comes to the issue of radio resource management. Specifically, network users want radio resource allocation to be both fair and sufficient to guarantee their requirements in terms of service quality, whereas network operators are more concerned, given that radio resources are by nature finite, with maximizing the utilization of those resources as much as possible. Accordingly, certain trade-offs are inevitably required given these competing aims of network users and operators, a subject which has previously been explored by various researchers. However, no past studies have comprehensively examined how the fair scheduling schemes for BSs in multi-CC systems might be refined to yield power savings.

With these points in mind, the goal of the present study was to minimize the amount of power consumed by the operation of BS transceivers with multiple CCs, while still ensuring fairness in resource allocation for various types of users, including the maintenance of sufficient user data rates. To that end, this paper proposes a novel optimization scheme that interprets data transmissions at BSs in a fundamentally different manner than many previously presented resource allocation models. The main contributions of the paper can be summarized as follows:

- A novel and efficient transmission scheme for orthogonal frequency division multiple access (OFDMA)-based multi-CC cellular systems that saves power while concurrently supporting both real-time (RT) (delay-sensitive and high data-rate) and non-real-time (NRT) (non-delay-sensitive) types of downlink traffic and maintaining efficient control of fairness indexes for the two types of users based on their respective data usage needs.

- By adaptively activating and deactivating CCs during periods of relatively light traffic loads, the proposed scheme can yield significant reductions in the power consumed during data transmission. Thus, the proposed scheme has considerable potential in terms of reducing the energy costs and CO2 emissions associated with cellular networks.

2. BACKGROUND

(A) Radio Resource Allocation

(B) Green Wireless Communication

(C) OFDMA

3. PROPOSED METHOD

(A) Admission Control Mechanism

The considered framework model is adroitly appeared in Fig. 1. The session-level transmission is expected in the model. Expect that the greatest number of sessions that every CC can suit is consistent indicated as S. At the point when a session demand arrives, the classifier in the framework will first group it into either RT or NRT session, and after that it will be sent to the booking line. Next, the confirmation control component is proposed to be utilized to figure out if to obstruct the session demand in the booking line and further which CC ought to be relegated to the session in the event that it is permitted to access the system

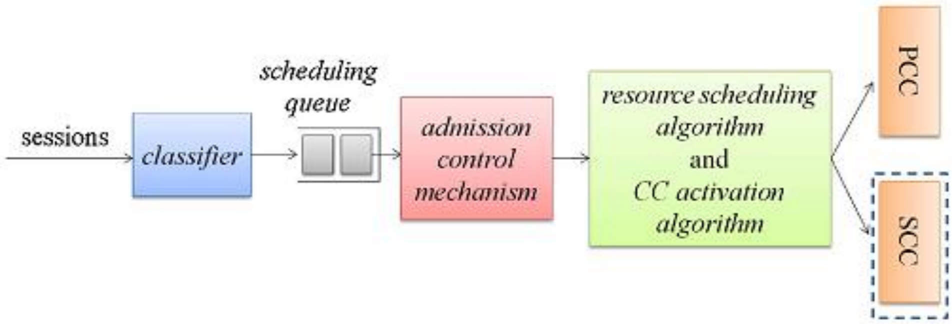

Figure 1: Admission Control Mechanism

(B) Affirmation Control Mechanism

To begin with characterize $(m, j)_{RB}$ as the RB on the m th time space and the jth subchannel. At that point characterize the perfect transmission rate of the $(m, j)_{RB}$ on

CC k for supporting client session n as $\boldsymbol{r_{m,j\_n}^{(k)}}$. Based on $\boldsymbol{r_{m,j\_n}^{(k)}}$ can be given as

$$\boldsymbol{r_{m,j\_n}^{(k)} = \beta \log_2\left(1 + \frac{KP_{m,j}^{(k)}\left|H_{j\_n}^{(k)}\right|}{\beta N_0}\right)} \quad (\mathbf{1})$$

Note in (1) that is the channel pick up between subchannel N_0 is the commotion power unearthly thickness, j and client session n on CC k, β = 12 · 15000 is the data transmission in Hz for a RB, since one subchannel incorporates 12 subcarriers what's more, each subcarrier is characterized to have 15 000 Hz, K = −1.5 log(5B E R), where BER is the wanted (steady) piece blunder rate, and $\boldsymbol{P_{m,j}^{(k)}}$ is the required transmission energy to accomplish $\boldsymbol{r_{m,j\_n}^{(k)}}$ under the plan structure in (1). In light of (1), the transmission force of $(m, j)_{\boldsymbol{RB}}$ on CC k can be given as

$$\boldsymbol{P_{m,j}^{(k)} = \frac{\beta N_0}{K\left|H_{j\_n}^{(k)}\right|}\left(2^{\frac{r_{m,j\_n}^{(k)}}{j}} - 1\right)} \quad (\mathbf{2})$$

In like manner, the aggregate vitality utilization in this considered in the subframe on CC k indicated as E_k is given to be

$$E_k = \frac{t_{Sub\_frame}}{2} \sum_{(m,j)_{\boldsymbol{RB}} \epsilon \Omega_k} \boldsymbol{P_{m,j}^{(k)}} \qquad (3)$$

Where t_{Sub_frame} edge is the length of each sub frame in seconds furthermore, Ω_k is the arrangement of all RBs in each subframe of CC k.

At the point when another session arrives, the system will in the first place do the vitality check by looking at E_k and ρ $E_{max}$where E_{max} implies the most extreme accessible vitality in each subframe also, ρ is the upper negligible element. In the event that permitted, the component will facilitate check the SCC status to recognize if the SCC can be utilized. Notice that the PreOnFlag is a pointer speaking to whether the new client session can get to the SCC. To be more point of interest, if PreOnFlag==0, the new session can't get to the

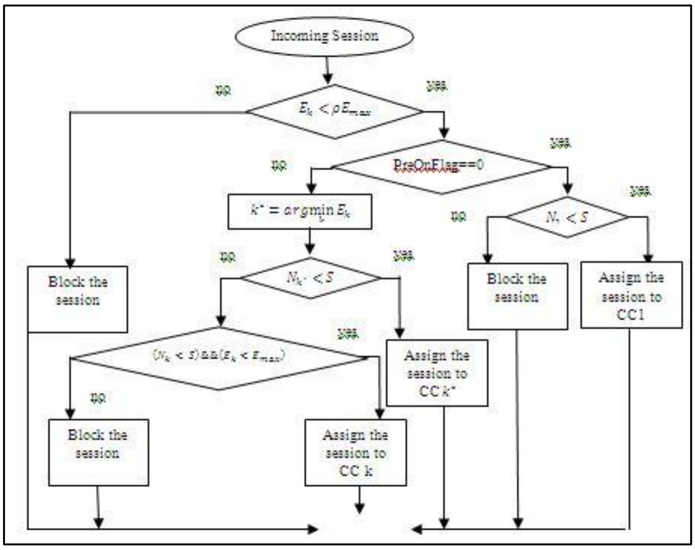

Figure 2: Flow chart of the admission control mechanism

SCC regardless of the possibility that the SCC is still dynamic and the new session can just utilize PCC if N1 < S, where N_k speaks to the number of client sessions in the framework on CC k. In the other case, in the event that PreOnFlag==1, CC k* that has the base Ek will be chosen. Taking after that, the instrument will check whether N_{k*} < S. On the off chance that yes, CC k* will be doled out to the new session; something else, the instrument will promote check whether N_k < S furthermore, E_k < E_{max} to figure out whether the new session can get to CC k. Notice that the operation and count of the system is executed toward the start of each subframe.

(C) Objective of the Novel Energy-Saving Transmission

Scheme In view of the considered framework demonstrate, the aggregate vitality utilization in each sub frame at the BS handsets is pointed to be minimized, while keeping up the blocking likelihood of all client sessions, the base required information rates for every kind of clients, and the reasonableness among all clients in an satisfactory level. To productively and adequately accomplish the above objective, a novel vitality sparing plan, which incorporates an asset booking calculation in Section III and a CC initiation calculation in Section IV, is proposed

(D) Resource Scheduling Algorithm

The introduced asset booking calculation incorporates two calculations that are independently proposed for the operation as takes after: 1) vitality versatile rate control calculation (EARCA) also, 2) radio asset designation calculation (RRAA).

The RRAA calculation is further isolated into two sub algorithms named B.1) data transfer capacity task calculation (BAA) and B.2) asset piece designation calculation (RBAA), separately. EARCA is intended to powerfully alter the NRT client's allotted limit in view of his/her way misfortune criticism and the current utilized vitality. After the NRT client's information rate is set, BAA decides what number of RBs ought to be doled out to each client session, while RBAA is utilized to encourage decide the set of RBs for those sessions.

(E) Radio Resource Allocation Algorithm (RRAA)

RRAA is outlined on the premise of the asset allotment approach utilized, for its computational multifaceted nature advantage. Pseudo codes for the point by point operation are composed in Figs. 5 and 6, separately. In every choice age of each subframe, the BAA sub algorithm in Fig. 5 will be executed first. Every single remote client will criticism their channel additions to the BS so that found the middle value of squared channel increases can be computed as information contentions. Likewise, the quantity of required RBs for all the client sessions will be set to 0 at first. After instatement, all the client sessions will be distributed 1 RB to begin with, to ensure least information rate prerequisites. Next, the rest of the RBs will be assigned as indicated by the distribution metric. It plans to apportion the RB to the client who can best advantage in term of the vitality utilization diminish in the wake of getting the RB, and the quantity of required RBs for the chose client will be included 1 after the allotment. After the execution of BAA, the RBAA subalgorithm in Fig. 6 will in this manner be executed.

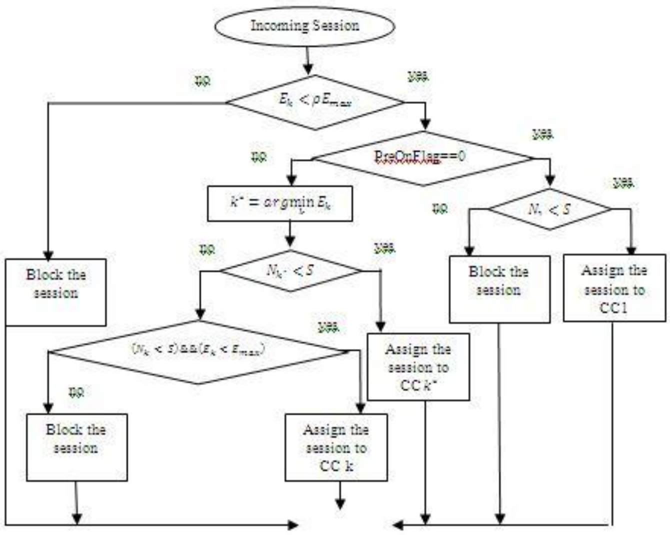

Figure 3: Pseudo code of EARCA

In RBAA, channel picks up and the quantity of each client session' required RBs are utilized as info contentions. For every RB, the subalgorithm means to discover the client who has the biggest channel pick up among all the clients. In the wake of finding the client, check whether the quantity of the current allotted RBs of the client equivalents to the quantity of its required RBs. In the event that yes, set the channel increase of the client approach to 0, and discover another client whose channel increase is the biggest among every one of the clients till the while circle is over. After the while circle, designate the RB to the client session picked amid this run. Once the two sub algorithms are done in grouping, each client session's accessible RBs are resolved. Next, the craved information rate of every client session will be circulated similarly over its designated RBs, and the vitality for every RB is thusly decided.

Figure 4: Pseudo code of *BAA*

/$S_n^{(k)}$: the set of current allocated RBs for user session n on CC K/

For each $(m, j)_{RB}$

$$n^* = \arg\max_n \left|H_{j\_n}^{(k)}\right|^2;$$

While $\left(\left|S_n^{(k)}\right| = m_{n^*}^{(k)}\right)$

$$\left|H_{j\_n}^{(k)}\right|^2 = 0;$$

$$n^* = \arg\max_n \left|H_{j\_n}^{(k)}\right|^2;$$

End

$$S_{n^*}^{(k)} = S_{n^*}^{(k)} \cup \{(m, j)_{RB^*}\}$$

End

Figure 5: Pseudo code of *RBAA*

/$\overline{|H_{j\_n}^{(k)}|}$:1 the average squared channel gain across all j sub channels for user session n on CC k, which is expressed $\overline{|H_{j\_n}^{(k)}|} = \frac{1}{j}\sum_{j=1}^{j}\overline{|H_{j\_n}^{(k)}|}$/

$\forall$ users $\in CCk$

Allocate each user session 1 RB;

While $\left(\sum_{n=1}^{N_k} m_n^{(k)} < 2j\right)$

For n=1: N_k

Calculate the allocation metric expressed as

$$G_n^{(k)} = \frac{\beta N_0}{\kappa \left|H_{j\_n}^{(k)}\right|}\left[(m_n^{(k)} + 1) \cdot 2^{\frac{r_n^{(k)}}{\beta((m_n^{(k)}+1)}} - m_n^{(k)} \cdot 2^{\frac{r_n^{(k)}}{\beta(m_n^{(k)})}}\right];$$

End

$$n^* = \arg\min_n G_n^{(k)};$$

$m_{n^*}^{(k)} = m_{n^*}^{(k)} + 1;$

end

4. RESULTS

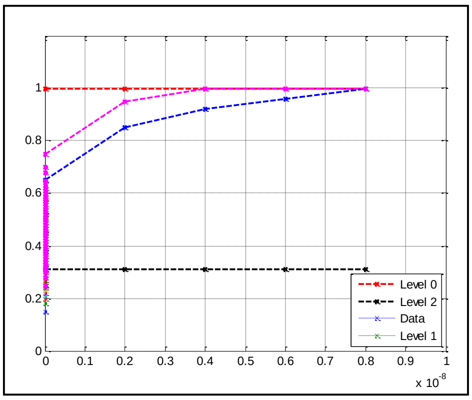

Figure .6. Illustration of the reduction ratio as a function of the channel gain being used to determine the allocating capacity for the NRT users

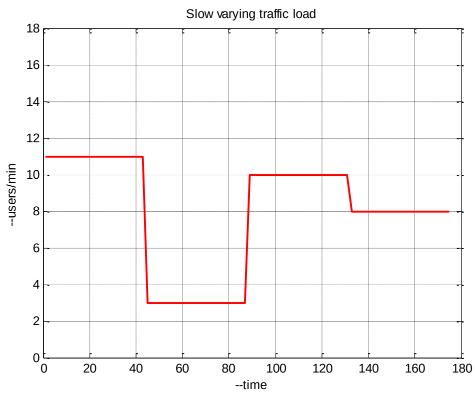

Figure. 7. Slow time-varying traffic loads versus time

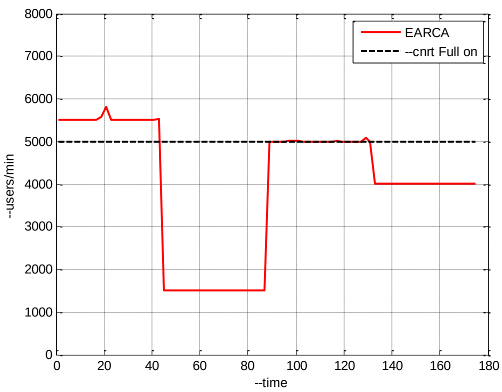

Figure. 8. Comparison of the energy consumption between the proposed scheme with EARCA, Level 2, and the comparison scheme.

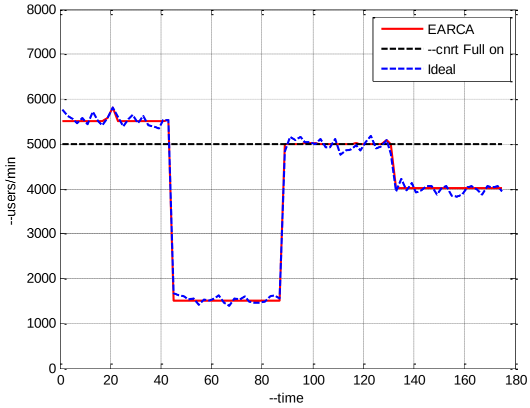

Figure. 9. Comparison of the energy consumption between the proposed scheme with EARCA, Level 0, and the comparison scheme.

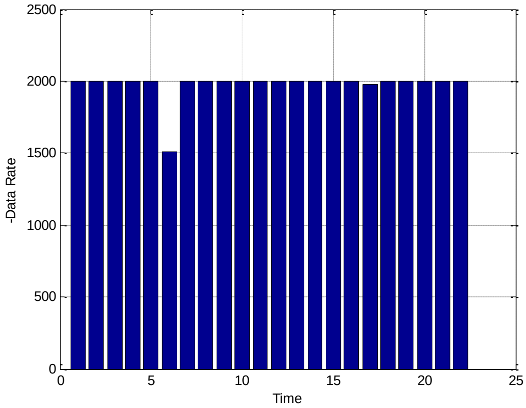

Figure. 10. NRT users' average data rate every 10 minutes of the proposed scheme with EARCA.

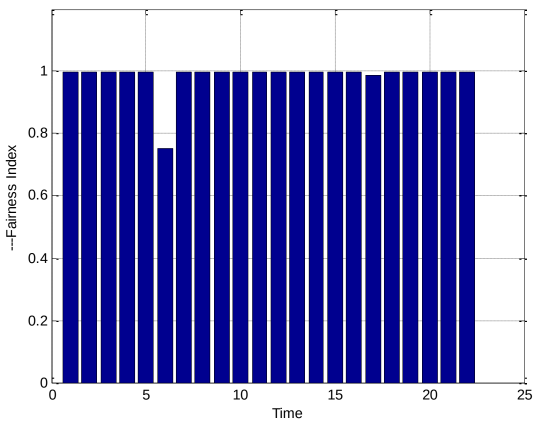

Figure. 11. Fairness index of the proposed scheme.

5. CONCLUSION

In this paper, a novel energy-saving downlink transmission scheme in OFDMA-based multi-CC network systems was successfully proposed. The proposed scheme could allocate the radio resource with an adaptively rate-and-power control to users and support an acceptable level of the QoS and the fairness at the same time. Compared with the currently existing works, the proposed one had the great advantage of flexibility to activate/deactivate the SCC according to the dynamically fluctuating traffic load to effectively avoid unnecessary energy consumption.

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