

A Novel Mechanism utilized for Rate and Energy Control in OFDMA based Base Stations

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ABSTRACT

In this paper, we proposed a technique for adjustment of data transmission to enable energy efficient transmission i.e. by utilizing necessary energy for transmission. In our model we are considering downlink transmission of base station with OFDMA based component carrier considering both real time and non-real time user. We employ a computationally efficient schemes according to the fluctuating traffic loads to address the problem of energy minimization at base station transceivers, subject to constrains of minimum data rate for all users. Simulation results demonstrated that the QoS and Fairness Index among the user are much better than the existing schemes with less energy consumptions.

Keywords: OFDMA, LTE-Advanced, Energy saving mechanism, Quality of Service, Green Communication.

I. INTRODUCTION

In order to enhance the capacity of cellular network to deal with fast growing data demand, LTE-advance technology [1] is being used. It is well known that for an LTE base station multi component carrier can be used for the fulfillment of promising features of 4G technology for achieving high data capacity. As a result energy consumption mainly in base station has become an important concern in last few years, due to rising energy cost and serious environment impact on green houses gases emission like CO₂. Till now, the issue of designing the resource scheduling algorithm [2] and energy allocation to improve the system performance has been fully studied by numerous researchers [11]-[17] based in energy saving management group in 3GPP[3] for wired and wireless communication. With the help of radio resource allocation rate-and-energy control to users can be done adaptively, which supports an acceptable level of the Quality of Service (QoS) and the fairness at the same time, and can effectively avoid unnecessary energy consumption with consideration of green communication [10].

Motivated by the above reasons, an efficient energy saving transmissions scheme in the OFDMA [4] based multiple Component Carrier (CC) system is proposed. We focus on downlink transmission that can support both real time (RT) and non real time (NRT) traffics simultaneously. Simulation are conducted to show that the performance of the energy consumption of our proposed scheme is much better than that of other existing schemes in which all CCs are always active. The objective of this research aims to minimize the total energy consumption in each sub-frame for the Base Station (BS) transceivers of OFDMA-based multiple CCs, while maintain certain QoS and fairness among users. Here, QoS is considered to be the blocking probability and data rate.

II. PROPOSED METHODOLOGY

In this paper we consider the downlink transmission from a base station for wireless users in the cellular network. We are going to consider multiple CC in a same frequency band that can be jointly utilized in BS for transmission. Assume that we have two CC having same bandwidth β in Hz, classified as primary CC (PCC) and secondary CC (SCC). The PCC is considered as main component carrier, while SCC will act as supplementary component carrier when the traffic is relatively heavy. The OFDMA technology is herein employed as the underlying downlink transmission access scheme because of its high spectral efficiency, bandwidth scalability and robustness against the multi path fading. We are considering SUI [5] channel model for simulation of data transmission for better QoS and fairness among user.

The frequency bands below 11 GHz use the channel model which is proposed by Stanford University Interim (SUI) model. This model is derived for the Multipoint Microwave Distribution System (MMDS) frequency band from 2.5 GHz to 2.7 GHz. The model covers three most common terrain categories. This channel model is recommended by IEEE 802.16 Broadband Wireless Access Working Group. All the parameters follow 3GPP criteria and are satisfying IEEE802.16 wireless access protocol [6].

A. Simulation parameters

N = 100	Number of Independent Random Realizations
OR = 4;	Observation Rate in Hz
M = 256;	Number of Taps of the Doppler Filter
Dop_res = 0.1;	Doppler resolution of SUI parameter in Hz (used in re-sampling process)
res_accu = 20;	Accuracy of re-sampling process

The SUI channel parameters (SUI-3)

P = [0 -5 -10];	Power in each tap in dB
K = [1 0 0];	Ricean K-factor in linear scale
tau = [0.0 0.5 1.0];	Tap delay in μs
Dop = [0.4 0.4 0.4];	Doppler maximal frequency parameter in Hz
ant_corr = 0.4;	Antenna correlation (Envelope correlation coefficient)
Fnorm = -1.5113;	Gain normalization factor in dB

B. Basic assumptions

In LTE-A transmission, scheduling process is executed sub-frame by sub-frame. In each sub-frame there are J sub channels and two time slots. The resource block (RB), is consists of seven OFDM symbols in one time slot and 12 subcarriers in one sub channel, considered as the smallest allocation unit. The basic system model is conceptually shown in fig. 1, in which session-level transmission is assumed. When a session requests arrives, the classifier present in the system will first classify the session into either RT or NRT session, and then it will be forwarded to scheduling queue. Next the admission control mechanism is used to resolve whether to block the session request in scheduling queue and if the session is allowed to access the network then which CC should be assigned. Those allowed sessions are transmitted through a resource scheduling algorithm, whose details are elaborated in section III. Reduction in data rate is represented by reduction ratio and enforced data to an NRT user is compared with the largest allowed data rate.

C. Admission control mechanism

This is the basic mechanism used to assign the proper component carrier on the basis of data traffics. By using this mechanism the requirements of the data rate is going to be checked. Below data rate formula is there which is derived from the basic formula of channel capacity. First let us define $(m, j)_{RB}$ as the RB on the m_{th} time slot and j_{th} sub-channel. The ideal transmission rate of $(m, j)_{RB}$ on CC K for supporting session n as $r_{m,j,n}^{(k)}$ is defined. Using basic formula of channel capacity, $r_{m,j,n}^{(k)}$ can be derived as

$$r_{m,j,n}^{(k)} = \beta \log_2 \left(1 + \frac{K P_{m,j}^{(k)} |H_{j,n}^{(k)}|}{\beta N_0} \right) \quad (1)$$

Here N_0 is the noise power spectral density, $|H_{j,n}^{(k)}|$ is the channel gain between sub channel j and user session n on CC k, $\beta = 12.15000$ is the bandwidth in Hz for RB. $K = -1.5 / \log(5BER)$, where BER is the desired bit error rate.

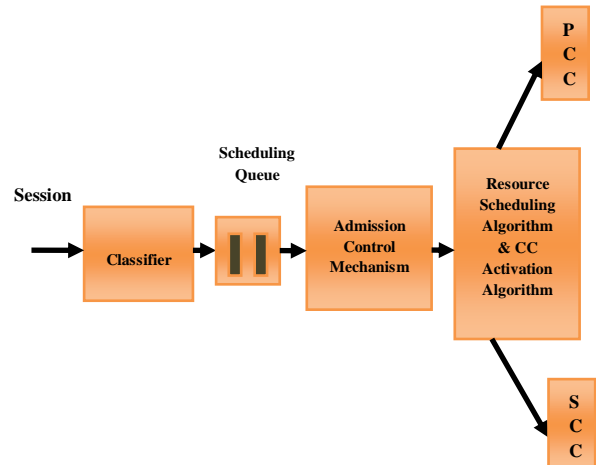


Fig 1: Admission Control Mechanism

Based on (1) the transmission power of $(m, j)_{RB}$ on cc k can thus be expressed as,

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

Accordingly, the total energy consumption herein considered in the sub-frame on CC k denoted as E_k is given to be

$$E_k = \frac{t_{su} b_{frame}}{2} \sum_{(m,j)_{RB} \in \Omega_k} P_{m,j}^{(k)} \quad (3)$$

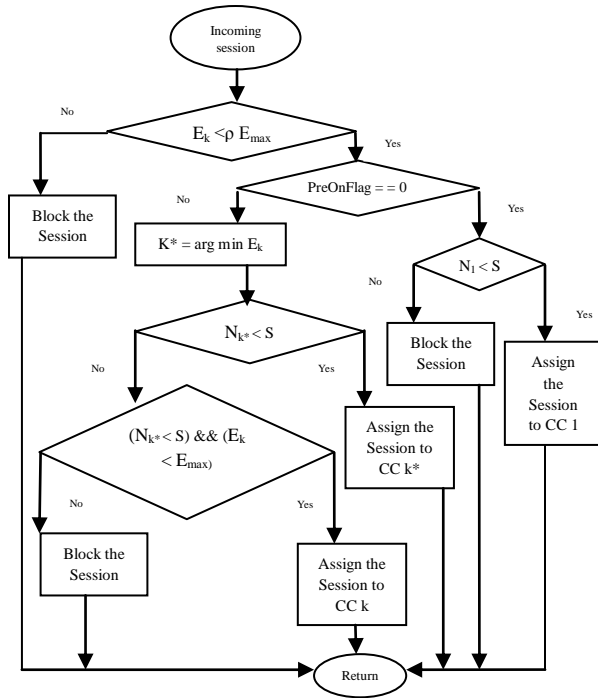


Fig 2: Flow chart of the Admission Control Mechanism

Fig 2 shows the detailed flow chat for admission control mechanism. When a new session arrives, the mechanism has to first do the energy check by comparing E_k and E_{max} , where E_{max} denotes the maximum available energy in each sub-frame and ρ is the upper marginal factor. Further the mechanism will check the status to identify the SCC to be used, if it is necessary. PreOnflag is basically an indicator to represent whether the new user is going to access the SCC. If PreOnflag = 0, the new session cannot access the SCC even if the SCC is still active and the new session can only use PCC if $N_1 < S$, where N_k represent the number of user session in the system on CC k^* . If PreOnflag = 1, CC k will select the minimum E_k and it will check $N_k < S$ and then new session is going to assign.

III. Energy Adaptive Rate Control Algorithm (EARCA)

The algorithm used to minimize the energy consumption is EARCA. This algorithm is useful in the adjustment of NRT users allocated capacity based on his/her path loss feedback and energy. EARCA is consist of three levels of reduction ratio that can be indicated as level i , $i=0, 1, 2$ respectively. Reduction ratios represent the amount of reduction in data rate enforced for an NRT user when compared to large

allowed data rate. The natural log function of level 1 is designed on the basis of classic PF criterion [7], to maintain the fairness among the user in any certain levels. Firstly a large number of NRT users are randomly placed in the cell, and they are allowed RB based on the PF criterion to provide equal amount of energy on each RB considering fairness index [8]. After the long term simulation NRT users averaged data rate is considered. Then natural log function based on fitting method of minimum mean squared error is used. The natural log function is normalized so that the reduction ratio for NRT users should have maximum channel gain equal to 1. Here ρ and γ are considered as upper and lower marginal factors respectively.

Table 1: Pseudo code of EARCA

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If (( $E_k > \gamma E_{max}$ ) || ( $E_k < \rho E_{max}$ ))
    If (( $E_k > \gamma E_{max}$ ) && (level < 2))
        Level = level + 1;
    Else if (( $E_k < \rho E_{max}$ ) && (level > 0))
        Level = level - 1;
    End
End
NRT users
Set their capacities according to the level;
End
    
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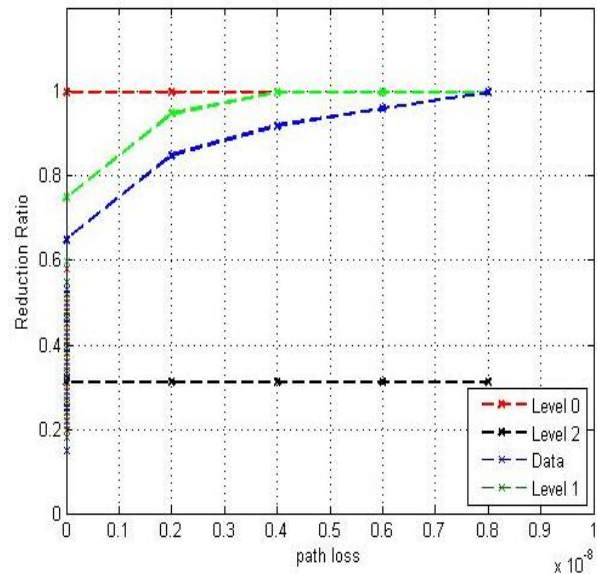


Fig 3: Illustration of reduction ratio and channel path loss to determine capacity for NRT users

IV. SIMULATION RESULT

In this section the effectiveness and efficiency of proposed energy saving schemes are examined with the MATLAB coded simulation. Energy consumption of proposed scheme with SUI channel model with EARCA is shown in fig respectively. Most of the simulation parameters are adopted by [9] such as $t_{sub-frame}=1ms$, $C_{RT}=64kbps$, $C_{NRT}=5000kbps$, $N_0=130dBm$, $\beta=12.5$. Additionally channel parameters setting are adopted by SUI channel model which follows 3GPP defined by IEEE 801.16 wireless technology. The fairness index of data rates for all users under the proposed scheme evaluated by fairness index formula in [8] is able to maintain at least larger than 0.75 as shown in Fig [6].

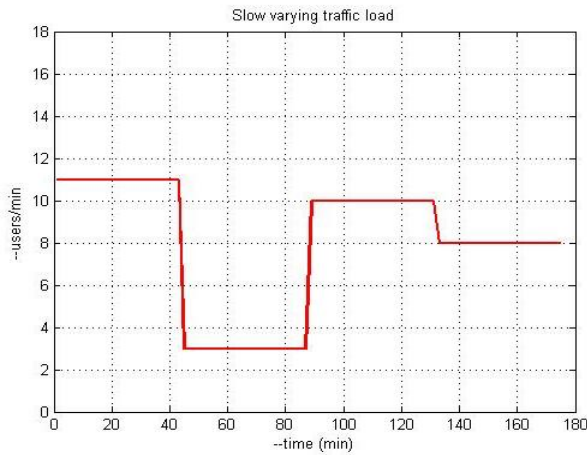


Fig 4: Slow time – varying traffic loads versus time

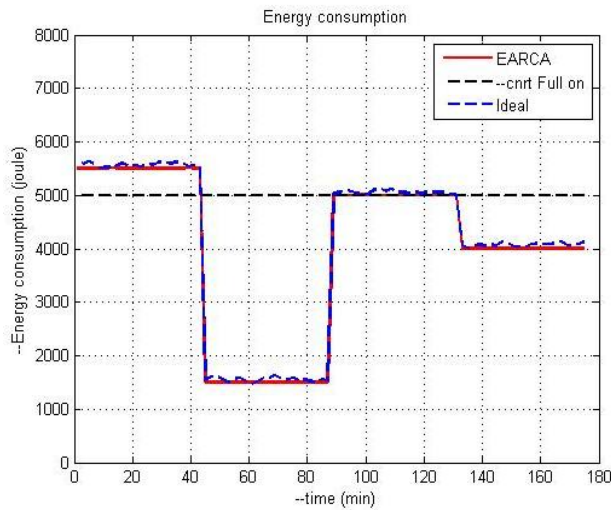


Fig 5: Comparison of energy consumption between the proposed schemes with EARCA

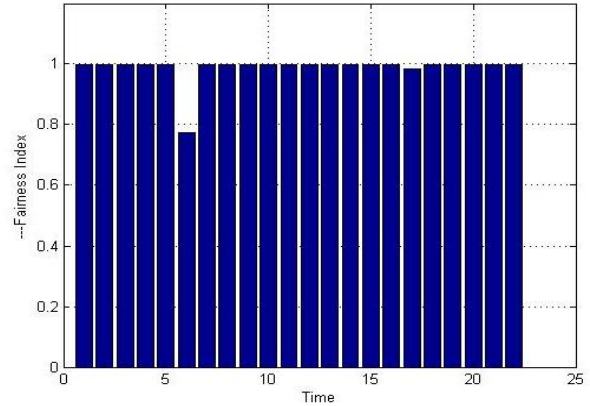


Fig 6: Fairness Index of the proposed scheme using SUI channel model

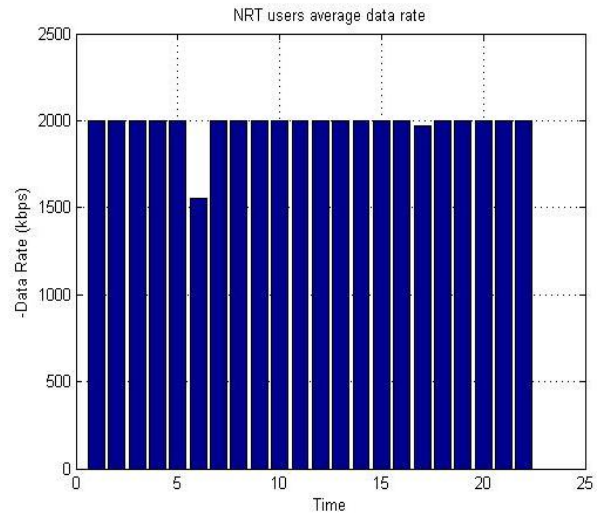


Fig 7: NRT user's average data rate of proposed scheme with EARCA using SUI channel Model.

TABLE 2: COMPARISON BETWEEN THE PROPOSED SCHEME AND THE SCHEME IN [9]

Aspect	Total Energy consumption (KJ) in 3 hr	Average Fairness Index	Average Data Rate of NRT users (kbps)
Method			
Proposed Scheme	242.1607	0.989	1978.168
Scheme in [9]	427.3344	0.988	1976.514

Table 2 lists a comparison of performance result in various aspects compared between the proposed scheme and scheme in [9] which verify the improvement in design of proposed scheme. Simulation for energy consumption was done for approx 3Hr and it is found that the energy

consumption by the BS employed the proposed scheme can significantly reduced, saving almost 56%, moreover average allowed data rate and fairness index among users are also better than the previous one.

V. CONCLUSION

In this paper a novel energy saving downlink transmission scheme in OFDMA based multi CC network system is successfully proposed. The proposed scheme can allocated resource data level with adaptively rate and energy control to users and support an acceptable level of the QoS and fairness at the same time. Compared with the existing works, proposed scheme is flexible to activate/deactivate the SCC according to the traffic load to avoid unnecessary energy consumption. It is believed that proposed energy saving scheme is an excellent approach to be employed in the future multi CC cellular system at the BS side for transmission to overcome the energy consumption and CO₂ emission. Based on the different environmental terrain more parameters can be considered according to the requirements for better results.

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