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Enhanced Frequency Resource Allocation Schemes For Interference Management In Lte Hybrid Networks

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ABSTRACT—*In this paper, we present and evaluate the performance of various frequency allocation schemes. We use resource allocation algorithm in addition to traditional frequency reuse schemes that aim to enhance the Quality of Service (QoS) provision, increase overall channel capacity, reduce the BER(Bit error rate) and increase the energy efficiency of uplink Long Term Evolution (LTE) systems. The proposed algorithm considers the main constraints in uplink LTE resource allocation, i.e., the allocation of contiguous sets of resource blocks of the localized Frequency Division Multiple Access (FDMA) physical layer to each user, and the imperfect knowledge of the users uplink buffer status and packet waiting time. The proposed optimal resource allocation algorithm uses information on the estimated uplink packet delay, the average delay and data rate of past allocations, as well as the required uplink power per resource block.Based on simulation results, the proposed algorithm achieves significant performance improvement in terms of packet timeoutrate, goodput, and fairness. Moreover, the effect of poor QoSprovision on energy efficiency is demonstrated through the evaluation of the performance in terms of energy consumption per successfully received bit. We analyze the system performance with various frequency allocation schemes via different metrics such as throughput, quality of service (QoS) and fairness. Simulation results show that the pro-posed resource allocation scheme with an optimized parameters provides an acceptable tradeoff compared to other allocation schemes.*

Keywords— Femtocells, Frequency Reuse, Resource Allocation, FFR, SFR, PFR, SFFR, Heterogeneous LTE Networks, frequency planning, Fractional Frequency Reuse, interferencemitigation, performance evaluation, Delay, energy efficiency, long term evolution(LTE), quality of service (QoS), resource allocation, uplink, SC-FDMA

1, INTRODUCTION

Long Term Evolution (LTE) is currently being evolved by 3GPP into LTE-Advanced to meet the requirements set by ITU-IMT-advanced of affordable mobile broadband systems. LTE characteristics like scalability of bandwidth,orthogonality of subcarriers and immunity against inter-symbol interference makes it the best choice for wideband data services and multimedia transmission. Advantages of LTE over previous 3GPP releases (i.e. WCDMA, UMTS, and HSPA) include its higher spectral efficiency, lower delay and higher peak data rates [1]. LTE exploits OFDMA and SC-FDMA as access schemes for its downlink and uplink respec-tively. A main feature introduced in LTE-Advanced is its sup-port of heterogeneous cellular networks having macrocells, picocells, femtocells and relays.

Femtocells have been proposed as a solution for poor cov-erage and unreliable data services that typically occur indoors. Femtocells are low power wireless access points that can be deployed by users indoors to extend the coverage of the cellu-lar network [2]. Femtocells can provide high data services as well as offload traffic from the cellular network air interface to a residential cable broadband connection or DSL. Changing the network topology by deploying smaller cells such as femtocells can alleviate possible problems of scarce resources in LTE. The overlay of a femtocell network over the pre-existing macrocell network represents a major challenge. Inefficient deployment of the femtocell network may lead to a degrada-tion of the overall performance of the cellular system. Efficient frequency allocation for both macrocell and femtocell networks is a major step towards effi-cient network deployment. Co-channel allocation of frequency resources leads to high spectral efficiency at the expense of quality of service (QoS), while orthogonal channel allocation leads to a high quality of service at the expense of poor spec-tral efficiency. Hybrid co-channel and orthogonal channel allocations are more efficient frequency allocation schemes.

Many frequency allocation schemes have been studied for macro-cell networks. Increasing the frequency reuse factor (e.g. Reuse-3) can decrease interference from neighboring cells and enhance cell-edge performance compared to Reuse-1, at the expense of spectral efficiency. Soft Frequency Reuse (SFR) has been proposed in as a mix of Reuse -1 and Reuse-3 schemes. The concept of Fractional Frequency Reuse (FFR) has been used for the same purpose. Other varia-tions of FFR as Partial Frequency Reuse (PFR), and Soft Frac-tional Frequency Reuse (SFFR) have been proposed for macrocell networks.

In this paper, we proposed frequency allocation schemes for hybrid macrocell-femtocell networks by exploiting popular macrocell frequency allocation schemes. Our proposed alloca-tions schemes enhance the coexistence of both types of net-works. These proposed allocation schemes are assumed to be fixed as they require no coordination, and no signaling be-tween macrocells and femtocells. We compare the different proposed schemes in different femtocell deployment densities using some metrics like throughput, QoS, and fairness. We choose SFR as a suitable frequency allocation scheme and enhance the performance with optimal resource allocation scheme for uplink that provides an acceptable tradeoff and overall enhanced system performance.

2, SYSTEM MODEL

The system model consists of a LTE macro cell and Femto cell with number of UE devices, randomly deployed in the macro cellcoverage area. Each user has an active real-time video connection on the uplink and the eNodeB is responsible to allocate the available resources in a fair, QoS and energy efficient manner, employing the proposed resource allocation algorithm.

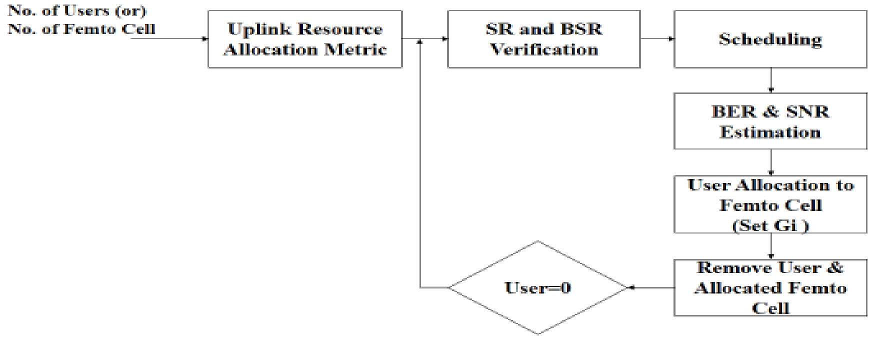

Figure.1 Block diagram of Optimum Resource Alloaction Algorithm

2.1 Uplink Resource Allocation in hybrid systems

The LTE protocol specification for the transmission of uplink scheduling requests(SRs) and the notification of the eNodeB regarding the bufferstatus of each UE will depend on uplink packet delay, average delay, data rate of past allocations of specific user and uplink power per resource block..Resources on the LTE uplink are allocated to the users in terms of uplink scheduling grants. A scheduling grant applies to a specific carrier of a UE, and is not limited to a specific application class within the UE. A UE that requires uplink resourcesin order to transmit one or more of its pending data packets sends a SR to the uplink scheduler. A SR can occur on a periodic manner, and its frequency is a UE-specific parameter provided by the higher layers. However, in order for the uplink scheduler to be able to determine the required amount of resources to be granted to each user, information on the amount of data available for transmission in the uplink UE buffers is also necessary. Therefore, the information on the UE buffer situation is provided to the eNodeB in the form of Buffer Status Reports (BSRs). A BSR consists of a buffer size field, which contains information on the amount of data awaiting transmission across all logical channels in a logical channel group. The amount of data is indicated in number of bytes.

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3, PROPOSED ALGORITHM

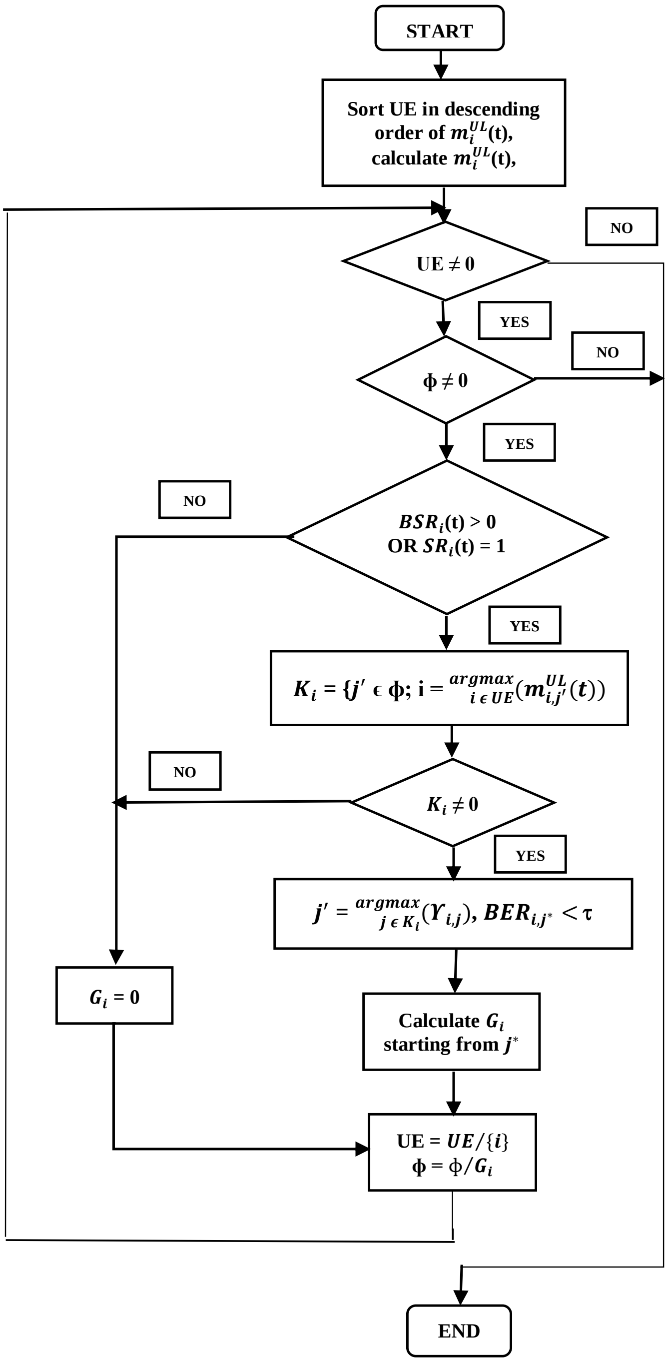

Figure 2. Flowdiagram of Proposed Optimum Uplink SC-FDMA Resource Allocation.

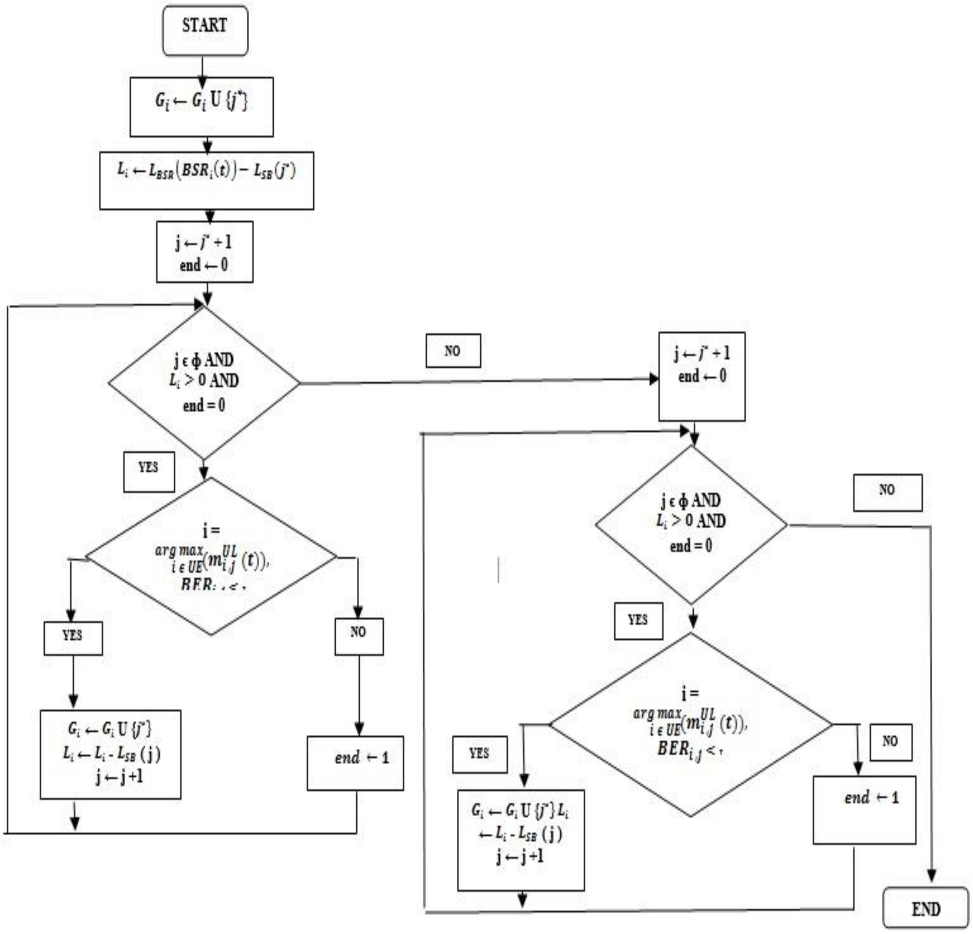

Figure 3. Flowdiagram for calculation of set G_i

The set G_i can be obtained by the above flow. The blocks can be then scheduled according to the flowchart 1.

3, RESULTS

In order to evaluate the performance of the proposed uplink resource allocation algorithm, a simulation model was built in MATLAB. The performance of the system employing the proposed resource allocation algorithm is compared to a legacy system that equally distributes the available uplink resources to the users, without estimating their delay constraints and buffer status, or taking into consideration their QoS and energy efficiency requirements. The simulation environment consists of a single LTE cell and a variable number of UE devices within the cell's coverage area. The maximum distance from the eNodeB is 330 m. The traditional frequency reuse schemes is compared with the best performing reuse with optimum resource alloaction algorithm with the specified physical layer parameters with channe bandwith 10MHz, total number of resource blocka as 50, with path losss model, transmitter and receiver antenna gain as 0 dBi and 18 dBi respectively. Interference margin as 1 dB. Log normal shadowing, rayleign fading is considered. Maximum UE transmitter is designed as 23 dBm, subcarrier spacing is 15 kHztarget received power as -57dBm. Uplink path loss compensation factor (alpha) is assumed to be 0.7. maximum tolerable dealy i.e., dealy thershold is 20 ms. Reference signal transmissions is 2 signal per frame.modulation and coding scheme is QPSK 1/2 , 16-QAM ½ and 64-QAM ¾. The graphs are plotted against the system metrics like average user capacity, throughput, outage probability, fairness (fairness ratio), Bit Error Rate (BER), Delay and energy efficiency.

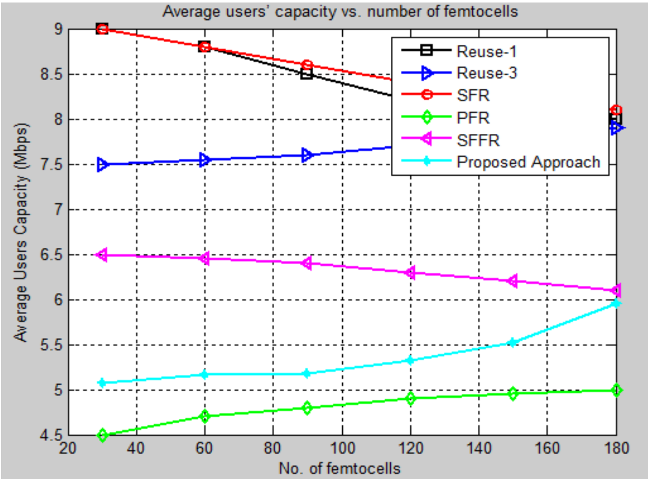

Figure 4. Average User Capacity Vs Number of Femtocells

In the this graph, Average users capacity has been calculated for every users by varying the number of femtocell. The capacity is given by $\mathbf{capacity} = (\frac{2}{N}.* \left(\mathbf{log2}\ (1 + \mathbf{powerAllo}.'.* H)\right) * 10\text{^}5$ Where, PowerAllo is the Allocation of power when user transmitted via channel. H refers to the Channel coefficient or channel gain. N –denodes Number of Subcarrier present in the coverage area. The proposed algorithm is faring better in the graph comparing other two reuse schemes.

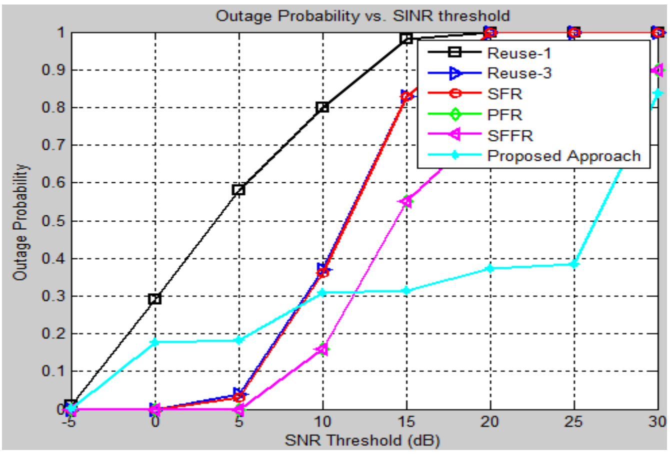

Figure 5. Outage Probability Vs SINR Threshold

Outage Probability in fig 5 is calculated based on the overall average UE capacity. The overall capacity is given by

$$C_{overall} = \frac{N_{Ch1UE}\, C_{avg}^{Ch1} + N_{Ch2UE}\, C_{avg}^{Ch2}}{N_{Ch1UE} + N_{Ch2UE}}$$

Where, N_{Ch1UE} – Number of user in Channel1 User

N_{Ch2UE} - Number of user in Channel2 User.

C_{avg}^{Ch1} - Average Capacity of Channel1 User.

C_{avg}^{Ch2} - Average Capacity of Channel2 User.

The outage is greater than SFR and SFFR initially for small number of femto cell. Then when the femto cell increases the outage probability which gives the probability of outage that occurs as a result of non allocation of efficeint scheduing blocks to the inteneded user is decreasing in comparision with other schemes is depicted in the graph in fig 5.

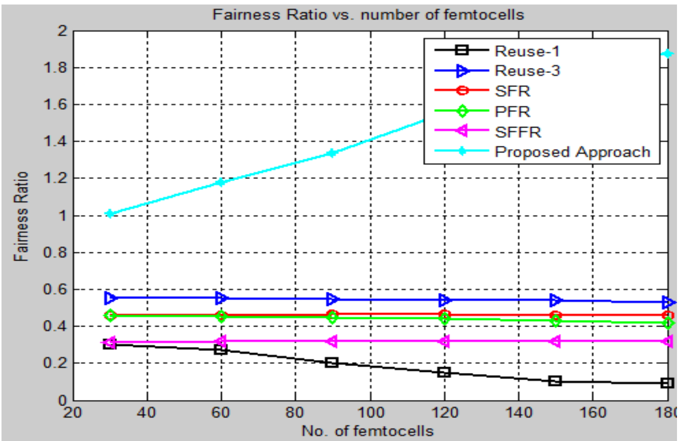

Figure 6. Fairness ratio Vs Number of Femtocells

The fairness ratio is defined here as the ratio of the 5percentile capacity of all UEs (MUEs + FUEs) to the overall average UEs capacity $C_{overall}$ The fairness ratio is given by

$$\textbf{Fair Ratio} = \frac{\textbf{5 \% − tile capacity}}{\mathbf{C_{Overall}}}$$

The tile capacity is subtracted from 5 percentile points and is divided from overall capacity. The proposed optimum algorithm fairs higher than the other traditional reuse schemes and it is depicted in the fig 3. Fairness measure can also thought of as consistent system metric performance.

In terms of fairness and throughput Vs fairness ratio comparision, the proposed optimum algorithm optimises the fairness with throughput, unlike the average user capacity graph.The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure.

$$\text{BER} = \frac{\text{Number of errors}}{\text{Total number of bit errors}}$$

The BER may be improved by choosing a strong signal strength (unless this causes cross-talk and more bit errors), by choosing a slow and robust modulation scheme or line coding scheme, and by applying channel coding schemes such as redundant forward error correction codes. Energy Efficient is estimated based on the remaining power, it depends upon the utilization of power.

$$\text{powerAllot} = (\text{ptotA} + \text{sum}(1./\text{HT}))/(\text{ MP} - 1./\text{HT})$$

Where, PtotA is Total power allocated for all users in every subcarrier. HT is Estimation of Subcarrier coefficient which are having minimum power.MP is Counting the number of subcarrier which are having minimum power. The fig 6 testifies that optimum algorithm proposed is energy efficient comparing all other traditional reuse schemes. The efficiency is increasing with increasing number of femto cells. The proposed algorithm is adaptive and dyanmic as it searches for the nearest allocated scheduled block, taking into consideration the average delay factors, buffer status of the user in the realistic LTE systems.

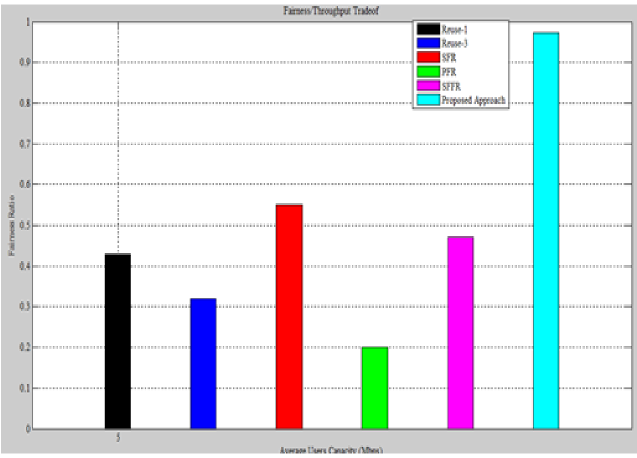

Figure 7. Fairness ratio Vs Fairness Throughput Tradeoff

The fairness can be interpreted in terms of increasing number of femtocells. The performance metrics of the model can be checked against increasing number of femptocells. The performance is consistent and not reducing for such increase.

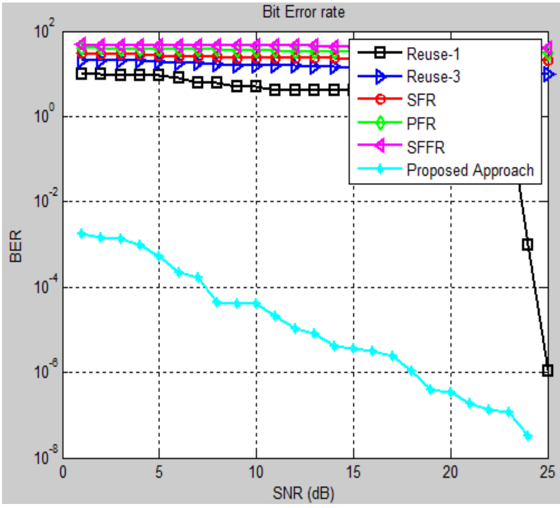

Figure 8. Bit Error Rate(BER) Vs SNR(db)

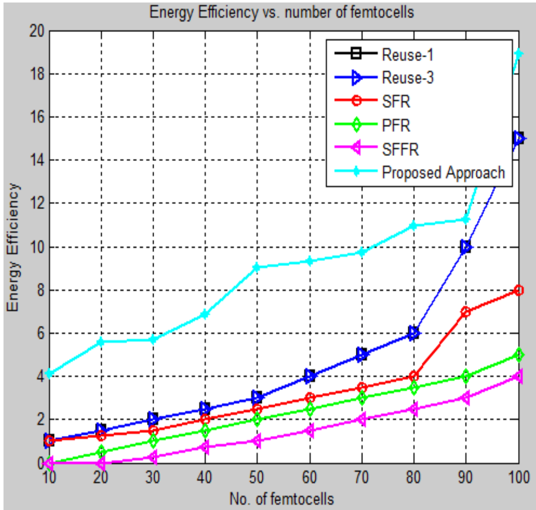

Figure 9. Energy efficiency Vs Number of Femtocells

Based on the remaining power, the energy efficiency can be calculated. As the algorithm is dynamic and adaptive, it searches for the nearest scheduled block.

VIII. CONCULSION AND FUTUREWORK

An Optimal uplink resource allocation algorithm for LTE-Hybrid systems is proposed, which focuses on optimising the best performing soft frequency reuse scheme with resource alloction algorithm. The proposed algorithm takes into consideration the inherent delay, LTE real time dealy, previously access by the user, users buffer status and each user's delay threshold thereby ensuring better Fairness, throughput,QoS provision in real-time applications and energy efficiency. Therefore, the proposed algorithm complies with the constraints of a practical uplink localized SC-FDMA LTE system, i.e., lack of knowledge of the packet delays in the uplink direction, imperfect knowledge of the users' buffer status, and allocation of contiguous sets of resource blocks to each user. Focusing on addressing the delay sensitivity of real-time applications and the need for improved energy efficiency, the proposed algorithm prioritizes users based on their estimated packet delay, the average delay and data rate of past allocations, as well as the required transmission power per resource block. Extensive simulation results highlighted the considerable performance improvement achieved by the proposed algorithm compared to legacy systems in terms throughput, and fairness. Therefore, it was shown that poor QoS, as a result of increased packet losses, also results in poor energy efficiency, as the loss of packet segments leads to the inability of the system to perform packet reassembly at the receiver side, resulting in waste of already received packet segments whose transmission consumed energy. The plans for future work include the extension of the proposed solution to a multicell scenario, also considering interference avoidance features.

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