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LTE system performance enhanced through interference reduction techniques

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Abstract Orthogonal Frequency Division Multiplexing Access has been increasingly deployed in emerging and evolving cellular system to reduce interference .However, in these systems inter cell interference still occur a real challenge that limits the system performance. Soft Fractional Reuse technique is proposed to overcome the co-channel interference through dividing total available bandwidth into primary and secondary segment. In this paper combining the SFR technique and optimally allocating the sub-band to end users which increases the system performance

Keywords Co-Channel, LTE, FFR

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1. Introduction

The expected convergence of fixed and mobile Internet services, the emergence of new applications and the growth of wireless subscribers will lead to an ever increasing demand for bandwidth in wireless access. With the Orthogonal frequency division multiple access (OFDMA) transmission technique, great benefits in handling inter-symbol interference, inter-carrier interference and high flexibility in the resource allocation can be reaped. Nevertheless, a big challenge issue with OFDMA still remained is co-channel interference (CCI) or so-called inter-cell interference (ICI). It is known that effective reuse of resources in a cellular system can highly enhance the system capacity. With a smaller frequency reuse factor (FRF), more available bandwidth can be obtained by each cell. So, in this sense the classical FRF of 1 is desirable. However, with the usage of FRF-1, the most user terminals (UTs) are seriously afflicted with heavy ICI, especially near the cell edge. And that causes severe connect outages and consequently low system capacity.

The conventional method to figure out this problem is through increasing the cluster-order, which can mitigate the ICI efficiently, nonetheless at the cost of a decrease on available bandwidth for each cell. This leads to restricted data transmissions and lower system spectrum efficiency. To take aim at improving cell-edge performance while retaining system spectrum efficiency of reuse-1, several solutions [1]-[5] have been proposed recently. Among them, the most representative approaches are the Soft Frequency Reuse (SFR) scheme [2], [4]-[5] and the Incremental Frequency Reuse (IFR) scheme [3]. These two methods concentrate on the high system spectrum efficiency with FRF-1 and efficient reduction of ICI (especially near the cell edge) simultaneously. However, the IFR scheme does not perform better than the classical reuse-1 scheme in full-load or overload situation.

The performance with the usage of the SFR scheme might be advanced, compared to the classical reuse-1 system, but the resources are still underutilized. Based on a thorough analyzing of the SFR approach, in this paper we will put forward a new design referred as like optimally selecting bandwidth for edge use and their by increasing the performance of the system for a better fulfillment of the goals, namely, to enhance the mean system capacity while restraining the ICI at cell edge. Moreover, since solutions with low system complexity and flexible spectrum usage are desirable, we will take systems with distributed radio resource management into account. The remainder of this paper is organized as follows.

In hybrid ICI mitigation scheme using both partial frequency and handover. They assume a fixed SINR metric to separate the user into center and edge, while the bandwidth partitioning of a cell has not been described for different SINR thresholds. The impact of scheduling strategies and number of users in a cell on the design of the optimal SINR threshold but it has not shown the improvement on cell edge performance. It is also fixed threshold for partitioning users between cell center and edge users. They show the impact of SINR threshold and bandwidth partitioning on the cell edge and center performance for both real time and best effort traffic. Normally bandwidth required for the users depend on the location. If the amount of resource required by users known, one can find the number of users supported in a cell. The allocation pattern ensures that sub-band of a cell-edge zone is not reused in any of the neighbouring cells. The cell varies greatly in the occurrence of interference, causing the difficulties in the standard FFR. Finally scalability become issues and allocation of sub-band is fixed, we can't give assurance for throughput of users, because users can dynamically changed.

2.Soft fractional frequency reuse:

A more flexible version of FFR is a soft FFR [7]-[12]. The soft FFR assigns subbands a reduced amount of transmit power, rather than no transmit power, to reduce intercell interference. The transmit power needs to be reduced enough to provide required throughput to cell edge users of neighboring cells. Also, the subbands of reduced transmit power are used for the inner cell users. Compared with universal frequency reuse (UFR) using FRF of one for all the subbands where the same average transmit power is assigned to all subbands, the soft FFR sets different transmit powers on different subbands, and neighboring cells are coordinated to avoid collision of high transmit power allocation on the same subband. The capacity of the soft FFR was evaluated in [7] assuming the offset in the transmit powers of different subbands. The performance was compared with the hard FFR in [8], and it was shown that the soft FFR performs better than the hard FFR in throughput due to its flexibility in transmit power assignment. Performance considering uplink power control was shown in [9]. Self-organization of the transmit power in the uncoordinated systems was shown in [11], [12] where some transient time is required to converge on the equilibrium state of power allocation. In this paper, downlink power allocation schemes are proposed for the soft FFR rather than simply setting an offset in the transmit power between subbands. The transmit powers are allocated so that the loss of spectral efficiency from the soft FFR is minimized, and the required cell edge user throughput is guaranteed. Different power allocation schemes are proposed depending on the tightness of coordination between neighboring cells, such as the loosely coordinated systems and the tightly coordinated systems. For the evaluation, the spectral efficiency represented by the average user throughput is obtained for different schemes. The FFR decreases frequency reuse, and thus it introduces less efficient frequency utilization than UFR that utilize spectral resource maximally. The loss of spectral efficiency in the FFR is evaluated depending on the subband power allocation schemes and system parameters, such as the number of subbands.

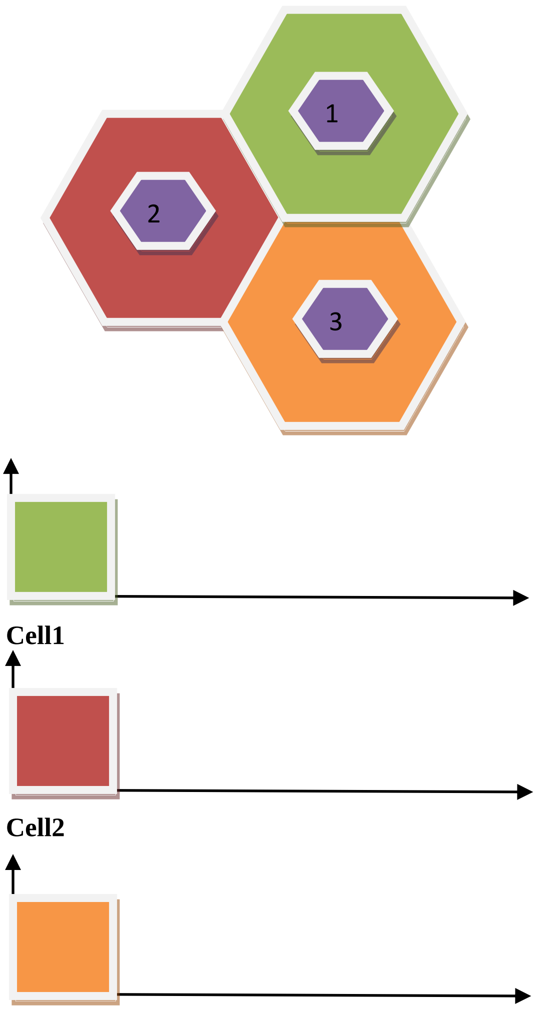

Figure : 1 Proposed Frequency band allocation

3.Soft FFR And Optimized FFR Model

The basic elements for the system model and notations are presented. Consider the set of cells in the particular coverage and it is denoted as $C=(c_{1,}c_{2.........}c_n)$. The coverage area represented by regular hexagon of a large number of pixels $J=(j_1,j_{2......})$. The total gain between the cell and the pixels denoted by the $G_{ij..}$ The cell is divided into center zone and edge zone , in which center zone is prone to interference and edge zone is sensitivity to interference from the surrounding cells. The total transmit power of cell antenna is denoted by p^{Tol}. The entire bandwidth is divided for center user and edge user, center user is denoted as $B_{c,}$ edge user is denoted as $B_{e..}$ Let K denote the number of edge sub-band $K=(k_1,k_{2.......})$ $B_{sub}=B_e/K$..In the generalized FFR number of sub-band allocated to each cell that is orthogonal to neighbouring cells.

Consider for sub-allocation and power assignment in each cell, now we have three base station. In first base station the number of sub-band is 4, second base station the number of sub-band is 5and finally third base station the number of sub-band in 4. Now we are going to calculate the SINR vale for each cell

$$SINR=p_i g_{ij}/\sum p_h g_{hj}+\sigma_j \quad (1)$$

Where, g_{ij} gain between cell antenna and pixel. Let us consider uniform power assumption over the edge sub-bands in each cell. The power used for cell edge zone is denoted by p_i and optimization value selected from the set of power levels ($p_1,p_2 \ldots\ldots$). The power assign represented by the following vector $p_L=(p_1,p_2,\ldots\ldots\ldots\ldots p_c)$. The maximum value of power depend on the number of sub-bands used in cell, then sub-band can range between one and k in this scheme. Assigning power value to cell is the product between the value of p_i and number of sub-band that does not exceed the value of p_L. By using bandwidth partitioning ratio α we going to divide the spectrum for the cell center and cell edge zone

$$\alpha=P_{Abc} \quad (2)$$

P_{Abc}, is the averaged probability of selecting band. The approach to partitioning the bandwidth in the cell is by finding the probability of a user to be in center band. Therefore the ratio of bandwidth allocated to center users is equal to the probability of an user to be at that band. This method uses the ratio between the average bandwidth required for a cell center user and average bandwidth required by each user throughout the cell. Bandwidth partitioning ratio α is obtained here as

$$\alpha=b_{uAc} \quad (3)$$

Where b_{uAc} is the area bandwidth required for a center band, BW the average bandwidth required by each user throughout the cell. The interference that occur comes from separate sets of downlink in the inner and outer region. A transmission in an inner region that is fixing specific frequency band causes interference only to inner users of others cells that are fixed the same band and it is important to distinguish two categories of BSs. The first consists of all interfering BSs transmitting to inner region users on the same sub-band as user x and second consists of all interfering BSs to cell edge users.

The capacity of user x on subcarrier n can be calculated by the following

$$C_{x,n} = \Delta f \cdot \log_2(1+SINR_{x,n}) \cdot P_i \quad (4)$$

Where, Δf refers to the available bandwidth for each subcarrier divided by the number of users that share specific subcarrier ,P_i refers to power allocated to user x.

Moreover, the throughput of the user x can be expressed as

$$T_x = \sum \beta_{x,n} \cdot C_{x,n} \quad (5)$$

Where, $\beta_{x,n}$ represents the sub carrier assigned to user x.

2.1 SEARCH STRATEGY

The aim of applying soft FFR to large network, we consider local search algorithm and finding high quality solution time efficiently. A local search algorithm find solution improvement by repeating the modification to the current solution and evaluating the outcome. The search strategy is defined by the operation used in making trial modifications. Solution generated by the modification operation are considered neighbours to the current one, and the definition of the modification operation is also known as the neighbourhood structure.

The algorithm stops when no improvement can be obtained by solution modification, that is the current solution is locally optimal in respect of its neighbourhood. We apply a type of greedy algorithm that assigning single sub-band to each cell to obtain solution. The algorithm goes through all cells one by one, for each cell the total throughput among the cell edge pixel is completed for each of the sub-band is (1……..K) with same power as reuse-1. Once assigning a sub-band, the allocation for the cell in the initial solution is fixed when considering the remaining cells. The algorithm tends to select the sub-band in which having least interference problem. The search is repeated until the current allocation is locally optimal in every cell. Let the current solution be $C=(C_1 \ldots\ldots C_k)$ and $P=(P_1 \ldots\ldots P_i \ldots\ldots P_c)$. The task is to find the new optimal sub-band allocation and power assignment for each cell. Suppose that power assignment is independent from sub-band allocation. Then the allocation of sub-band dynamically changed does not have any interference.

If we added the sub-band to all the cell then the throughput will grows and reusing sub-band will be decreased. Consider now the connection between sub-band and power assignment.

The algorithm can be analyzed as follows.

Step 1:Find the best number of sub-band using current solution

Step 2: Calculate the SINR change for the current cell

Step 3: Repeat the steps1-2 for all cells

Step 4: Find the highest throughput improvement among all the cells

Step 5: If the throughput is improved among the cell edge then no change in partition of sub-band

The optimized average cell edge throughput for various values of K are assumed and compared the results to reuse-1[8]. From the fig2 shows that if number of band is higher then increase in datarate. It is clear from that commonly used reuse-3 is not the best for an irregular cell layout. The optimized FFR performance tends to increase with K. This behavior is expected, because larger K gives granularity in resource allocation . There is no strict monotonicity. The reason is that the solution returned by the algorithm. By definition, all sub-bands are allocated to cell edge as well as cell center in reuse-1. Therefore performance is not dependent on K.

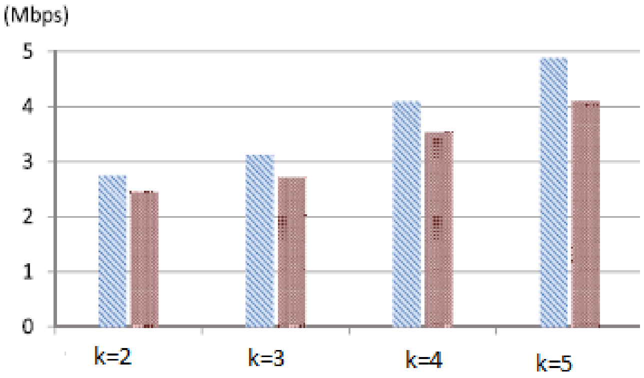

Figure: 2 Performance Comparison of value K

Thus considering larger area as cell edge brings down the average throughput. This is because a high threshold means that larger areas are considered cell edge, although parts of these areas as bandwidth sensitive rather than interference sensitive. The throughput loss of these bandwidth sensitive users contributes significantly to the decrease of the cell edge throughput. That standard FFR will not perform better than optimal FFR with K=3, the standard FFR cannot directly applied with fixed frequency reuse pattern, reuse-3 the number of neighbouring cells varies greatly over the area. In general, increasing in k implies that more candidate allocation solutions must be evaluated in the search algorithm, and enlarging the edge area size leads to higher number of sub-band, setting k between 3 and 6 achieves a good balance between the performance in throughput and computational effort. In general the choice of k depends on the network characteristics and finding a proper value is not trivial. In network planning our algorithm can be applied to a sub set of cell edge, to provide fast performance evaluation and thereby suggestions on proper sub-band division scheme.

It is showed that the improvement due to FFR is strongly related to the proportion of the area that is considered to be cell edge. Low SINR threshold leads to be small cell –edge areas with very high interference sensitivity and therefore more improvement in optimal FFR. Another factor having a strong influence on performance is the relation between B_e and B_c., setting bandwidth values is network specific and to a large extent, the optimal choice depends on the user distribution as well as the performance target. For optimal FFR enlarging or shrinking the edge bandwidth B_e does not change the optimal sub-band allocation. Hence we can easily observe the trade-off between the cell edge throughput versus the cell center throughput loss.

4.Simulation results

The following results show the performance of the OFDMA system using generalized FFR. By doing this datarate , throughput of the system has been enhanced . The results are based on the implementation of random reuse-1,reuse-3 among the cell .The input parameters chosen for the implementation of reuse-1 for cell center user and reuse-3 for cell edge user in order to simulate results of throughput and datarate by various SINR values.

Table: 1 Simulation parameters

Cellular layout	Hexagon
System bandwidth	15MHZ
No.of subcarriers	300
No.of eNb	8
Sub carriers spacing	15
SINR threshold	0-100
Antenna type	Omni
Propagation mode	OFDMA

The simulations results and comparison of the propose system were executed analyzed using NS2 version 2.31. The available bandwidth is shared among neighbouring cells based on the reuse factor. Cell center users use the frequency band f1 while the cell edge user are allocated with 1/3rd of the rest available bandwidth. The goal of this work is to investigate the impact of SINR threshold which is used to distinguish users as cell edge and cell center users

Figure:3 Throughput compared vs Delay

Fig 3 shows the relationship between throughput vs delay. From the figure it is evident that the delay is increased with respect to throughput

Figure: 4 Datarate performance over SINR

Fig 4 provides the correlation between datarate and SINR. The figure clearly shows that the datarate is increased with higher SINR values due to less interference

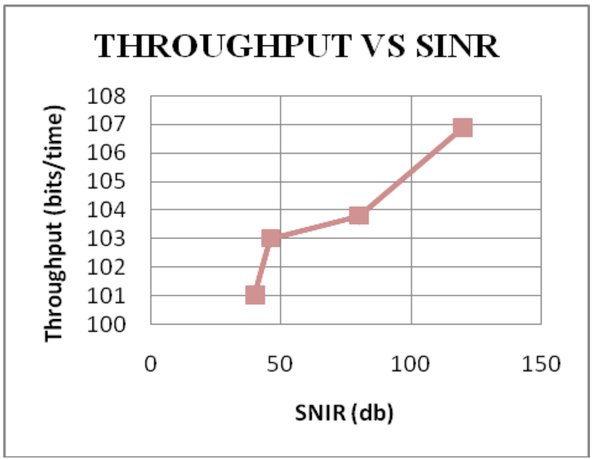

Figure: 5 Throughput compared over SINR

Fig 5 provides the link between Throughput and SINR. The figure shows that if SINR value is higher then parallel throughput value also get increased

3.Conclusion

To overcome the limitations of standard FFR and to address the performance of FFR in large scale networks with irregular cell structure, generalized FFR scheme was presented and also finding the optimal sub-band allocation among users was described. By doing this enhancement of system performance of LTE especially for cell edge users throughput was achieved. For highly interference sensitive cell edge zones, interference is minimized by sub-band isolation, where as for the other cell edge zones more bandwidth is allocated and this leads to better performance.

REFERENCES

[1] Defeng David Huang and Khald(2005), “An interference cancellations scheme for frequency offsets corrections on OFDMA sytem ,” in proc .IEEE Transcation Communication,pp.1-5

[2] Yikang Xiang,Jijun Luo(2006), “Inter cell interference mitigation through flexible resource reuse in OFDMA based communication networks,” in proc. of the 15th European wireless conference , Paris, France, pp.162-166

[3] 3GPP R1-060368(2006),”Performance of inter cell interference mitigation with semi static frequency planning for EUTRA downlink, “Texas Instrument, pp.1-5

[4] Zheng Xie,Bernhard Walke(2007),” Enhanced fractional frequency reuse to increase capacity of OFDMA systems,” in computer network, Germany,volume 314-325

[5] Matthias Kaschub, Christian M.Blankenhorn, Christian M.Muller and thomas(2007),” Interference mitigation by distributed beam forming optimizations,” Universitat Stuttgart, Institute of communication Networks and computer engineering,pp.1-7

[6] A.L.Stolyar and H.Viswanatham(2008),” Self-organizing Dynamic fractional frequency reuse in OFDMA systems,” in proc .INNFOCOM 2008.The 27th conf.Computer Communiations.IEEE,Bostan Volume.691-699

[7] Bujar Krasniqi, Martin Wrulich and Christoph(2009),” Network load dependent partial frequency reuse for LTE,” in proc. IEEE, Institute for Communications and radio frequency engineering Christian doppler laboratory,pp.1-5

[8] Quang Duy La, Yong Huat Chew, and Boon-Hee Soong(2009),” An interference minimization game theoretic subcarrier allocation for OFDMA based distributed system,” in proc .IEEE Trans . Wireless Commun,Vol,pp.1-5

[9] Zhang Huil,Xu Xiao-dong,L1 jing(2010),” Performance pf power control in inter cell interference for frequency reuse,” The journal of china universities of post and telecommunications,China,pp.37-43

[10] Han Young Yim,Byong Ok Lee and Kang(2011),” Distributed power allocation for sum rate maximization in a two cell environment,” in proc. IEEE wireless communication and networking conference, Hong Kong,pp.1-3