System Capacity Improvement by on Request Channel Allocation in LTE Cellular Network

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Abstract - Long Term Evolution (LTE) has introduced Femtocells technology in cellular mobile communication system in order to enhance indoor coverage. However, the impact of Femtocells on the performance of the conventional Macrocell system leads interference problem between Femtocells and pre-existing Macrocells as they share the same licensed frequency spectrum. In this paper an efficient method to mitigate interference and improve system capacity in the existing Femto-Macro two tier networks is proposed. In the proposed scheme, a novel frequency planning for two tiers cellular networks using frequency reuse technique is used where Macro base stations allocate frequency sub-bands for Femtocells users' on-request basis through Femtocells base stations to cancel interference by improving system throughput.

Index terms - Frequency Reuse (FR); resource allocation;Femtocells; interference management; Long Term Evolution (LTE); OFDMA; Macrocell

I. INTRODUCTION

In recent years, telecommunication operators experience tremendous demands from the mobile applications of broadband networks. Effectively dealing with the issues of the lacking coverage has become the challenging task. The Femtocells are presented as one of the candidates by the Third Generation Partnership Project (3GPP) Long-Term Evolution (LTE) [2, 3]. Femtocell is the latest step towards improving the quality of service for cellular users and enhancing the system capacity of a wireless network. A traditional cellular network overlaid with Femtocells can provide better system capacity, quality of service and enhanced coverage. The Femtocells serving as the small-scale base stations are embraced to enhance the system throughput by extending the coverage of the domestic areas such as offices, hotspots, residences and apartments. The dead zones can be covered and the spectral utilizations can be enhanced for cellular systems [4]. As opposed to conveying more Macrocells, the deployment of Femtocells is an economical option due to its low power consumption and low cost

II. BACKGROUND

Interference between Femtocell and Macrocell has been noticed by many alliances and has been solved to some extent but there are still some issues such as co-channel interference between Macrocell and Femtocell still needs to be addressed. Thus, in this section an effort is made to understand and analyze the work carried out by different authors on to mitigate the interference and different approaches used by them to suppress the co-channel interference between Macrocell and Femtocell. To mitigate the interference, several adaptive approaches have been proposed. Some of these approaches are: fractional frequency reuse (FFR) method [9-10], soft frequency reuse (SFR) method [11], semi static frequency reuse method [12] and adaptive frequency reuse method [13]. Fractional frequency reuse (FFR) [14] and soft frequency reuse (SFR) [15] methods have been proposed to achieve frequency reuse factor I and reduce ICI in LTE networks.

In FFR, the system spectrum is divided into two non-overlapping bands, referred to as inner and outer bands. The inner band is reused in every inner cell region to serve users near the cell center while the outer band is shared by outer cells to serve users located in cell edge, with a reuse factor greater than 1. SFR scheme has been proposed as an alternative to FFR scheme [14], [15]. SFR differs from FFR in that the whole spectrum can be reused in every cell. In SFR the spectrum in each cell is divided into two groups, major and minor subcarriers. The major subcarriers can be used by users located in both inner and outer cell regions and they are orthogonal to each other in adjacent cells. The minor sub-carriers have lower transmit power than the major subcarrier's and are used only by inner cell users. The ratio between minor and major subcarrier transmit powers is referred to as power ratio [15]. Simulation results in [14] showed that SFR achieves higher spectrum efficiency than FFR.. However, the spectrum and power allocation for major and minor subcarriers in the SFR schemes are fixed. In [8] a hybrid frequency assignment for Femtocells in co-channel operation system has been proposed. Co-channel operation is only allowed in the edge zone, while Femtocells in the center zone use a dedicated frequency band which is not used by Macrocell users.

III. PROPOSED METHOD

3.1 System model:

A number of randomly distributed outdoor and indoor environments with macrocells, femtocells and the mobile stations are defined. A cell layout comprises of seven hexagonal macrocells environment, each of them is partitioned into central zone and edge zone. Edge zone are divided into three sectors.Each sector has 600 meters radius with 10 MHz bandwidth. The macrocells are installed in residential area where as femtocell base stations are located in a random location within macrocells range. Femtocell ranges are around 10 meters. Only one femtocell user for each femtocell BS is considered in an indoor environment. All femtocells users are located within femtocell range and macrocell users are normally located randomly throughout the cell. Each femtocell operates in a closed subscriber group (CSG). CSG is chosen because when a macrocells user enters within femtocell range and if the user receives stronger signal at the time from the femtocell base station then interference occurs.

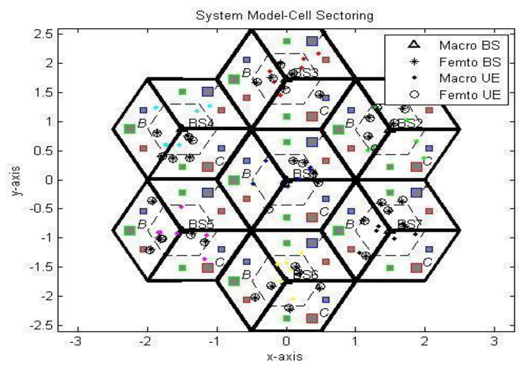

Fig3.1 System model

$$P_{in} = \beta P_{edge}$$

3.2 Channel Model:

In order to estimate the performance of scenario the following parameters are used.

3.2.1) SINR

The signal to interference noise ratio (SINR) is a measure used to provide theoretical upper limits of channel capacity in wireless communication systems. For femtocell user FUE, the received SINR is given as follows:

Indoor UE to M-BS: This path loss model takes into account the wall penetration loss (Lw) as the signal travels from indoor to outdoor and vice versa between an indoor located UE (macro-UE\femto-UE) and macro BS.This is calculated as

$$LS = 15.3 + 37.60\ log10\ (d) + Lw$$

3.2.3) Throughput Calculation

The throughput is calculated as follows using Shannon capacity formula

$$C_{user} = \sum_{n=1}^{N} B_0 \log_2(1 + SINR)$$

The throughput of base station is the sum of its serving UEs and B_0 is the bandwidth of a single PRB.

3.2.4)Transmitted power

Transmitted power on each PRB is given as P_r

$$SINR_{F,K} = \frac{P_{F,K} \cdot P_{l,F,m,k} X_{F,k}}{N_0 + \sum_{F'} P_{F',k} P_{l,F',m,k} X_{F',k} + \sum_M P_{M,m,k} P_{l,M,m,k} X_{M,m,k}}$$

where, $P_{F,K}$, $P_{F',k}$ and $P_{M,m,k}$ denote the transmit powers from serving Femtocell Base Station (SFBS), neighborFemtocell Base Stations (NFBS) and Macrocell Base Stations (MBS) respectively on PRB k. $P_{l,F,m,k}$ represents the path loss between FUE F and its serving BS l $P_{l,F',m,k}$ represents path loss between FUE F and its neighbor Femtocell BS which is known as interfering signal on F. $P_{l,M,m,k}$ Represents path loss between FUE and neighbor Macrocell BS.

$X_{F,k}$=1 when FUE F requests PRB k from Macro BS through Femto BS to occupy PRB k and then SINR will be calculated for FUE F on PRB k. When $X_{F,k}$=l, then $X_{F,k}$=0 and $X_{M,m,k}$ =0 because one PRB cannot be shared by more than one user at a time. If $X_{M,m,k}$=O, it means there is no PRB occupied by the user F and then SINR for the user F will be zero.

3.2.2) Path loss

Models for path loss are utilized to characterize various channel environments. Path loss models are most suited for the dense urban femtocell deployment. Path loss LS is estimated by the distance between the transmitter and receiver for each subcarrier. Three models for the channel path loss are considered here.

a)UE to Femto-BS: The path loss LS for interfering and non-interfering links between a femto UE or a macro UE and a femto-BS is expressed as

Where: $LS = 127 + 30log10\ (d/1000)$ path loss LS is in dB, d (meters) is the distance between receiver and transmitter.

b) links between outdoor Macro-UE and neighboring Macro BS is calculated as

$LS = 15.3 + 37.60log10\ (d)$

= P_{total} / N. In SFR, edge or outer PRBs and center or inner PRBs transmit at different power levels. If the power on edge PRBs is denoted as P_{edge} and the power on inner PRBs is denoted as P_{in}, then each can be calculated as,

$$P_{edge} = \frac{nP_{total}}{N(1+\beta(n-1))}$$

where n is the reuse factor, and β is defined as the power ratio. The power fraction β has a range $0 < \beta < 1$. If β = 1, the scheme becomes a Reuse-I scheme where all the PRBs, inner and outer, transmit using the same power level.

3.3 Channel Allocation Scheme used:

For macrocell, different PRBs are allocated to the each

Macrocell sub-area according to the SFR. Considering that the total number of PRBs as N. 2/3 Number of PRB are allocated for the center zone and N/3 number of PRBs for edge zone. Also considering N/3 number of PRBs as the sum of PRB.N_0,N_1,N_2 allocated for sub area A,B and C respectively.Only edge zone is considered and it is focused on only one sector i.e sector A for PRB allocation.The other two sections are treated in a similar manner.The total number PRBs of N_1 can be used at Macro layer.

The algorithm is divided into three main steps as described below

1)When a Macrocell user or Femtocell user attempts to make a call.It then measures the signal strength receiving from nearer BSs.Say, T1 signal is received from its serving BS and T2,T3,T4 signals are received from other BSs.

2)If T1>>T2 or T3 or T4 in terms of signal strength then user is allocated PRBs from its serving BS.

3)If T1>T2 of T3 or T4 OR T1<T2 or T3 or T4 in terms of signal strength then user is allocated PRBs from either virtual sub-sector A or virtual sub sector B on request basis.

IV. SIMULATION RESULTS

Simulation parameters

Parameters	Values	
	Macro	Femto
Number of cells	7	40
Radius	600m	20m
BS transmitted power	22W/18 W	20mW
Topology	3sector 7hexagonal cell	Density of 5 per Macro cell
Number of UE	5 per Macro	1 per Femto
Bandwidth	10 MHz	
Number of total PRBs	24 PRBs (PDSCH), 1PRB (PDCCH)	
Subcarrier Bandwidth	375Khz	
Subcarrier spacing	15Khz	
Carrier frequency	2GHz	
Channel Model	3GPTypical urban	

Table 4.1 Simulation parameters

The proposed sub-band allocation scheme with equal power distribution for edge and center macro users for the average cell capacity of macrocell system has been compared with the FFR-3 scheme and the average cell capacity of macrocell edge user with equal power distribution and with varied power distribution are compared the average PRB efficiency of the system with equal power distributions is compared with the schemes:(1) RAFF-LL [18] and (2) DRA HL [19]

4.1 Average Cell Capacity of the system

Figure 4.1 shows the average cell capacity of macrocell system. The system capacity is increased when the number of femtocell users is reduced in the macrocell edge zone area. Specifically for the case of 50 to 100 femto users, the capacity of the femto user is satisfactory as up to this number of femtocells is enough to share a specific number of frequency channels without any interference. However capacity is reduced as number of femto cells increase. Thus the average cell capacity of the proposed scheme is higher as compared to FFR-3.

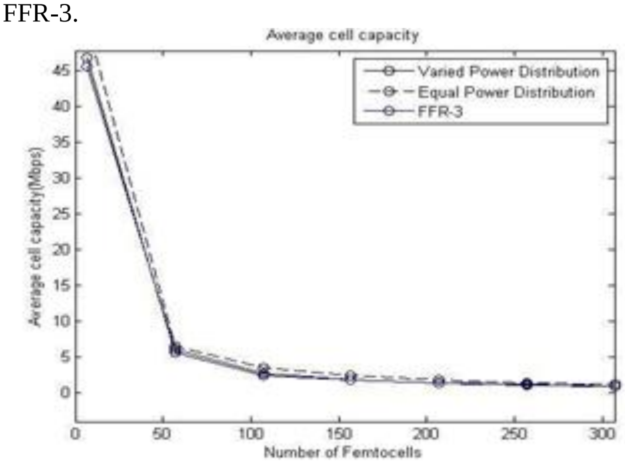

Figure 4.1 Average Cell Capacity Of Macrocell System

4.2 Average Cell Capacity of Macro cell edge users

Figure 4.2 shows the average cell capacity of macrocell edge users. The simulation result shows a significant improvement in the capacity of macrocell edge users with varied power distribution with power ratio $\beta = 0.8$ fixed value for the simulation. The average throughput decreases for smaller β values this is due to the increase in interference or due to decrease in SINR for cell-edge users. SINR for cell-edge decreases because of the increase in transmit power on inner PRBs as β decreases.

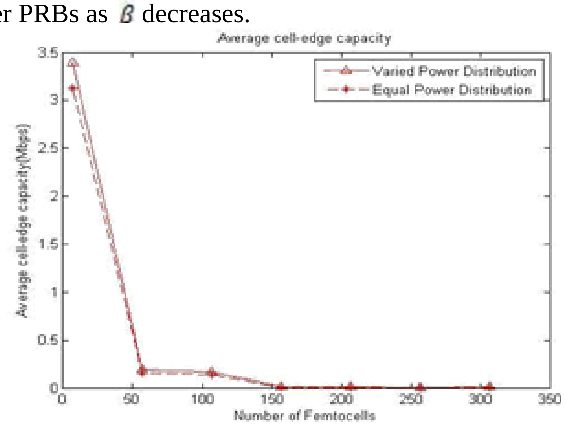

Figure 4.2 Average Cell Capacity of macrocell edge users.

The result shows a improvement in the capacity of macrocell edge users when there is increase in power of the PRBs allocated to the cell edge users. When the transmit power on edge PRBs for a cell increases, SINR for outer-cell users decreases by reducing the interference from adjacent cells. The resulting decrease in SINR leads to the increase in the number of edge PRBs and the increase in resource could mitigate the resource shortage by the increase in inner cell area, which increases the number of outer cell users, that it increases the average user throughput.

4.3 Average PRB efficiency of the system

Figure 4.3 shows the average PRB efficiency of the system with respect to the number of femtocells. The simulation result shows a significant improvement by proposed method in the average PRB efficiency. The proposed scheme has lower average PRB efficiency compared with DRA-HL and RAFF-LL when the number of Femtocells is between 30 and 50; however, the average PRB efficiency still improves 11 % by the proposed method. The PRB efficiency is higher when the number of Femtocell is between 200 and 250 compared with DRA-HL and RAFF- LL.

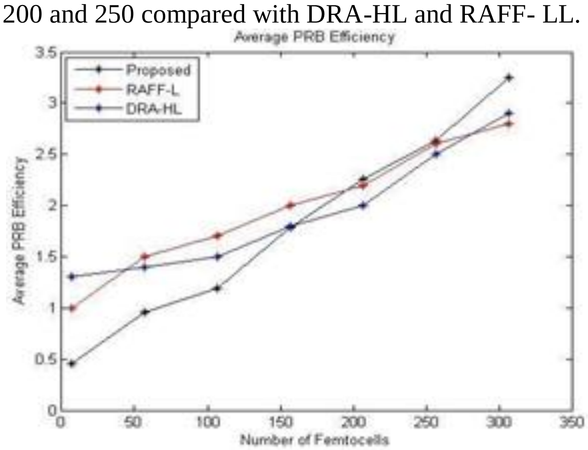

Figure 4.3 Average PRB efficiency

Figure 4.3 illustrates the average PRB efficiency under different number of femtocells. When the femtocells present in system are less than 100, the resource frame are not completely occupied and the resources are still insufficient to provide services. However, when the number of femtocells is more than 150, the system gets congested and the resources allocations in DRA and RAFF are limited by the size of the resource frame. Thus better performance is observed as the number of femtocell increase in the system.

V. CONCLUSION

LTE Femtocell combination provides very effective solution for wireless communication networks. However, there is interference problem due to lack of proper frequency band allocation method. In this work, an interference mitigation technique based on channel allocation that allows the macrocell edge users to access PRBs to satisfy higher data rate is employed. In this work soft frequency reuse (SFR), used for inter-cell interference avoidance techniques in the OFDMA cellular downlink with varying input parameters for femtocells has been analyzed. The simulation results have shown that the proposed method can reduce the interferences through increasing the throughput. Furthermore, this increase is obtained without any decrease in the quality of service.

VI. FUTURE SCOPE

Future work will focus on developing a two tier system where the total interferences between Macrocells and Femtocells would be completely mitigated. Further the call handover problems between femto and macro BS are not considered in the study. As a future work this project can be extended to handover problems in this scenario.

VII. REFERENCES

[1]. V. Chandrasekhar and J. G. Andrews, "Femtocell Networks: A Survey", IEEE Communications Magazine, vol. 46, no. 9, pp. S9-67, Sept. 2008.

[2]. G. Mansfield, "Femtocells in the us market -business drivers and consumer propositions," in Femtocells Europe 2008.

[3]. D.Lopez-Perez "Evolved Universal Terrestrial Radio Access (E-UTRA); 3GPP TR 36.921 V 10.0.0, May 2009

[4]. Jie Zhang, Guillaume de la Roche, "Femtocells Technologies and Deployment," John Wiley & Sons Ltd, Publication, 2010.

[5]. H. Claussen, "Performance of Macro- and co-channel Femtocells in a hierarchical cell structure," IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2007, September 2007.

[6]. K. Cho, W. Lee, D. Yoon, K. Hyun, and Yun-Sung Choi, "Resource allocation for orthogonal and co-channel Femtocells in a hierarchical cell structure," 13th IEEE (lSCE2009), May 2009.

[7]. L. T. W. Ho and H. Claussen, "Effects of user-deployed, co channel Femtocells on the call drop probability in a residential scenario, "IEEE 18th Int.Symposium on Mobile Radio Communications(PIMRC) Sep 2007.

[8]. I.Guvenc,m.r.Jeong F.Watanabe and H.Inamura,"A hybrid frequency assignment for the Femtocells and coverage area analysis for co-channel operation,"IEEE Communications Letters,pp.880-882,Dec 2008.

[9]. Aboubaker Lasebae,Jonathan Loo,Shahadete Rezvy and Shahedur "SYSTEM CAPACITY IMPROVEMENT BY ON REQUEST CHANNEL ALLOCATION LTE CELLULAR NETWORK".IEEE 48TH ANNUAL CONFERENCE(CISS)MARCH 2014.

[10]. 3GPP,RI-OSOS07,Huawei,"Soft frequency reuse scheme for LTE," 2008.

[11]. R.Yan and G Zhang , " An Effective Semi-static Interference Coordination Scheme for Wireless Cellular Systems ", IEEE Commune. Mag., vol. 46, no. 9, pp. S9-67, Sept. 2008.

[12]. M. Qian and W.Andrews, "Inter-cell Interference Coordination Through Adaptive Soft Frequency Reuse in LTE Network ", IEEE Wireless Communications and Networking Con: MAC and Cross Layer , Sept. 2012

[13].S. E. Elayoubi, O. Ben Haddada, and B. Fourestie, "Performance evaluation of frequency planning schemes in OFDMA-based networks, "IEEE Trans. on Wireless Commun., voI.7,pp. 1623-1633, 2008.
[14].3GPP , Huawei, "Soft frequency reuse scheme for LTE," 2008.
[15].T. Novlan, JetaI, "Comparison of FFR Approaches in the OFDMA Cellular Downlink," in Proceedings of IEEE GLOBECOM Sep. 2010.
[16].L. Chen and D. Yuan, "Soft Frequency Reuse in Large Networks with Irregular Cell Pattern: How Much Gains To Expect?," in Proceedings of IEEE PIMRC '09 , pp. 1467-1471, 2011
[17].I. Guvenc, M.R. Jeong, F. Watanabe, H. Inamura "A Hybrid Frequency Assignment for Femtocells and Coverage Area Analysis for Co-Channel Operation," IEEE Comm. Letters, vol. 12, no. 12, pp. 880-882, Dec. 2012
[18].Lopez-Perez, "OFDMA Femtocells: A self-organizing approach for frequency assignment, "IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 2009.