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Cell Edge User Performance Analysis in Heterogeneous Network under FFR and SFR

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Abstract— In this paper I have compared the FFR1, Soft FFr and FFR3 to evaluate the performance of Heterogeneous network. The evaluation parameters are schemes throughput and outage probability. From this work I find that Soft FFR is best among all schemes.

Keywords: Femto cells, Heterogeneous network, LTE, FFR, HeNB, MeNB, MUE, and FUE.

I. INTRODUCTION

It has been observed that heterogeneous wireless network [HetNets] is satisfied the current user requirement of high data rate, high network capacity and user throughput. Heterogeneous deployments have so many advantages over traditional deployment as in [1]. So far as it has been observed that the interference is measure issue in HetNets and this is wide area of research in wireless communication. In [1] author described the HetNets and there measure issues. A details survey is done by the author in [1]. As I have studied during my literature survey Interference is measure topic for research .Inter-cell interference is well described and eICIC method is adopted to reduce the interference in HetNet's in [2]. Some author use ABS (Almost Blank Subframe) technique to reduce the interference in HetNet's scenario. There are some
technical challenges in HetNets scenario as we seen in [1]. Offloading and range expansion of Pico base station is given in [6]. Biasing of Pico cell is done to increase the footprint of Pico cell is well described in [6].There are some interference mitigation technique in HetNets, Time domain based and frequency domain based .Performance evolution of frequency domain technique SFR, FFR, HFR in [4] based on their throughput comparison at various traffic load. Time domain based scheduling of downlink signal is famous throughout literature survey.

II. SYSTEM MODEL

I evaluate the performance of the different static FFR schemes in a HetNets scenario by simulations (in MATLAB) in terms of outage probability, network throughput (or network sum rate), and spectral efficiency. I formulate downlink Signal to Interference and Noise Ratio (SINR) and system throughput. The overall network is composed of two- tier 19 macrocells. A
macro user is interfered by 18 macrocells and all of the adjacent femtocells. In my simulation the HeNB are located in serving macro cell area give interference to the macro user m on Subcarrier k and given as [1]: -
SINR = The signal to noise interference ratio for downlink transmission to MUE x_m from MeNB m

Outage Probability
We define the outage probability as the probability that a UE device's instantaneous SINR a
given subchannel k falls below the SINR threshold γ

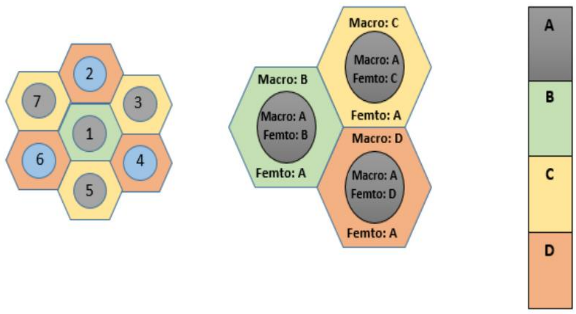
$$\text{P (outage)} = \text{P}\,(SINR_{x_m}^{k} < \gamma)\ldots\ldots$$

III. INTERFERENCE REDUCTION IN HETNETS USING FRACTIONAL FREQUENCY REUSE METHODS

The basic mechanism of FFR corresponds to partitioning the macrocell service area into spatial regions in cell edge region and cell centre region, and each sub region is assigned with different frequency subbands. Therefore, cell edge-zone MUE devices do not interfere with cell centre –zone MUE devices, and with an efficient channel allocation method cell edge zone MUE may not interfere with neighboring cell edge-zone MUE. As a result cell edge-zone MUE devices receives an acceptable quality of signal quality and reduces the outage probability furthermore throughput is increases. This type FFR schemes based on large time scale is known as static FFR. We provide comparison among all schemes based on performance metrics such as outage probability and network sum rate. Here we discuss three methods of FFR used in OFDMA based HetNets FFR1, Soft FFR, and FFR3.

IV. CHANNEL ALLOCATION TECHNIQUE IN DIFFERENT FFR SCHEMES

FFR1 (Fractional Frequency Reuse one): - The basic mechanism here to apply a frequency reuse factor of one to centre-zone MUE and FRF of N at edge-zone MUE. The available frequency band is partitioned in such a way that in cluster of N cells, the centre-zone MUE devices in each macrocell are allocated with common subbands of frequencies while the rest of the subbands are partitioned equally and allocated to the cell edge-zone MUE depending upon the FRF of edge zone. Therefore total of N+1 subbands are required as shown in figure 1



(I) (II) (III)

Figure 1shows the cellular structure with FFR1. Figure 1 illustrate FRF of one at cell centre and FRF of N = 3 at cell edge-zone. Figure 1 represents the vertical bar of subbands used by MeNB and HeNB at cellular structure. In this scheme, MUE devices in macrocell are not interfered by any other MeNB.

This significantly reduces the intercell co-tier interference. Also the cell edge-zone and cell centre-zone MUE uses the different subbands therefore intracell co-tier interference is reduces. To reduce intracell cross-tier interference, a HeNB located in the centre zone needs to choose a subband that is assigned to the MUE in the edge zone. Since in each cluster in a cell we can choose only two subbands therefore edge zone HeNB has to select the subband that ear the transition area of the centre and edge zone in a macrocell. Also the at cell edge zone HeNB uses the same subbands the cross tier interference is significant is used by the centre zone MUE as in figure 10(ii). In such technique the cross tier interference is significant between HeNB. One of the important design parameter is here the radius of centre zone of the macro cell. The result is obtained using Monte Carlo simulation in [21] that, for uniformly distributed
MUE, if the radius of centre zone (r centre) is 0.65 times the total radius R then total throughput
can be maximized. From [21] total number of channel that can be allocated to centre zone MUE
is given by

$$k_{centre} = [k_{total}\{r_{centre}|R\}^2]$$

The total number of available channels allocated to the cell edge zone MUE is given by

$$k_{edge} = [(k_{total} - k_{centrel})/N]$$

where N is reuse factor at cell edge zone.

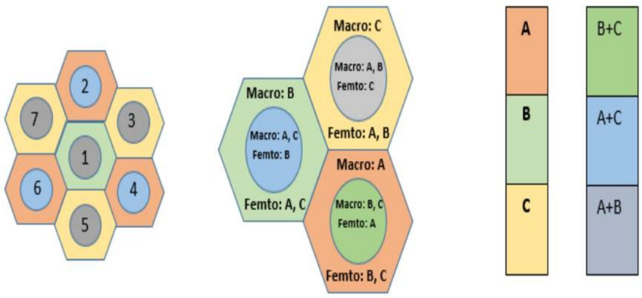
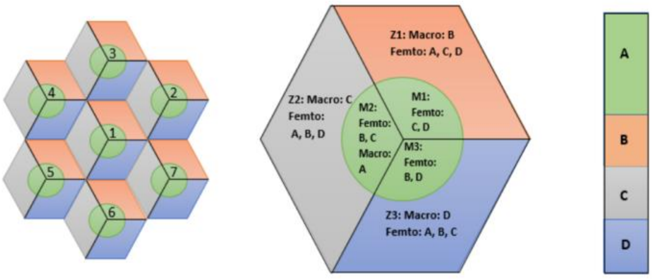


Figure 2
Soft FFR Scheme

Soft FFR Scheme: - This uses similar cell partitioning technique as in FFR1. However,the centre zone MUE device can use the subband allocated to cell edge zone MUE of any of the neighboring cell within a cluster. For a cluster of dimension N, the total available bandwidth is divided into N number of subbands and one subband is assign to the edge zone. Figure 2 shows deployment of a soft FFR. In figure we can see that the cell 1, 2, 7 assigned with the subchannel A, B, and C respectively at edge zone. While centre zone of cell 1 can be assigned with the subchannel B and C. Similarly centre zone of cell 2 are allowed to use subband A and C (Subbands of edge zone MUE of macrocell 1 and 7). Therefore soft FFR is more spectrum efficient then FFR1.In this scheme interference is increased. Both the cell edge and centre zone MUE experience interference from the tier 1 macro cell. A power control factor is introduced for the cell edge zone MUE to reduce intercell interference. Therefore if MUE device m located at centre zone then transmitted power is P_{mk} on subchannel k, and if MUE devices located at cell edge zone of macrocell then transmitted power is εP_{mk} where ε power control factor its value is $\varepsilon > 1$. One of the major advantage of this technique is better spectrum efficiency with good sum throughput. Cell edge users have more option to select the subband.

Figure 3



FFR-3 Scheme

FFR3 Scheme: - The macrocell area is divided into two regions centre and edge zone, including three sectors each as in figure 3. The entire frequency band is divided in two parts one part A is assigns to cell centre and other part is partitioned in three part B, C, and D. and assigned to three edge zones. A HeNB chooses a subbands that is not used in the microcell sub area. If HeNB located in center zone then it excludes the subband that is used by MUE in cell edge zone in current sector. For example when a HeNB is in sector Z2 as in figure.3(II) it uses the subbands A, B or C and excludes the subband D is used by MUE in Z2 sector. Similarly when HeNB is in cell center zone sector M2 its uses the subbands B and C excludes

S.N.	Parameter	Value
1	Network size	Two-tier (19 macro cells)
2	Radius of a macro cell	280 m
3	Radius of a Femto cell	30 m
4	SNR at an MUE device	10 dB
5	Number of Femto cells in a macro cell	30 to 180 per macro
6	HeNB transmit power	20 dBm
7	MeNB transmit power	46 dBm
8	Number of MUE devices in a Macrocell	50
9	Size of center zone	0.65 times of macro cell radius
10	Maximum number of FUE devices per Femtocell	1
11	Channel bandwidth	10 MHz
12	Number of sub channels	50
13	White noise power spectral	-174dbm/Hz
14	Power control factor	4
15	Channel model: path loss(outdoor)	28 + 35 log(d) dB
16	Channel model: path loss(Indoor)	38.5 + 20 log(d) +7 dB for 0<d <10m 38.5 + 20 log(d) + 10dB for 10<d<20 38.5 + 20 log(d) + 15dB for 20<d<30

Each macro station transmit the power of about 46 dBm and each femto cell transmits the 20 dBm. Here simulation is done in two cases when no femto nodes are deployed and when number of femto nodes are deployed. For both the cases we assumes that users are uniformly randomly distributed within a macro cell. I generate some basic results like power, Interference power, SINR, CDF of SINR, channel capacity, spectral efficiency and Outage probability in first case. For second case we distribute the femto nodes uniformly randomly within a macro cell. Herewe use indoor and outdoor path loss model to find the path loss for channel. Macro cells uses the outdoor path loss model and femto node uses indoor path loss model. Power and interference power is calculated for each user. We assumes the noise is white Gaussian noise.Then find downlink SINR value for each user. Using this value, the throughput and outage probability are calculated via users located in the central serving macrocell of 19 cells. Further simulation parameters are listed in table .

IV RESULTS AND ANALYSIS

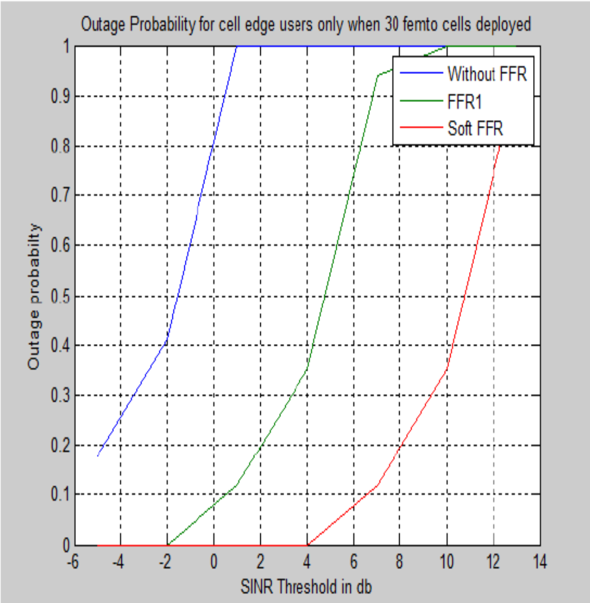


Figure 4 Outage Probability for cell edge users only when 30 femto cells are deployed
(For cell edge users only).

Figure 4 shows the performance of cell edge users in terms of outage probability for all
three schemes when 30 femto cells are deployed. From figure it has been clear that without FFR probability of outage of edge users is more as compared to FFR1 and Soft FFR. Soft FFR has better coverage performance as compared to without FFR and FFR1.

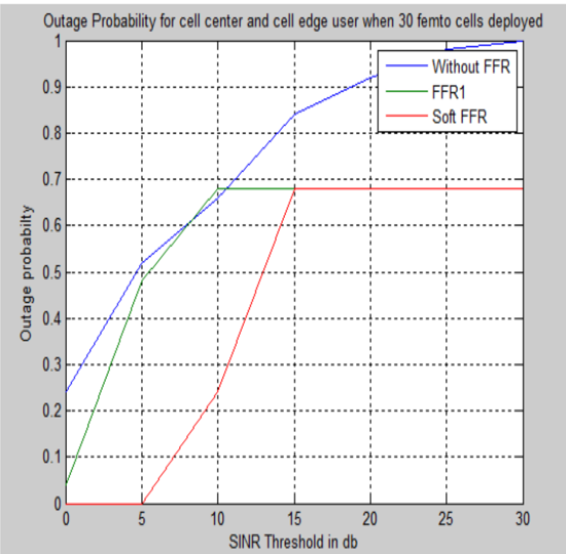


Figure 5: Outage Probability for cell edge + cell center users when 30 femto cells are deployed

Figure 5 shows the performance of cell center and edge users for outage probability, and as we can see again sof FFR has better then remaining schemes.

VI. CONCLUSIONS

In this work the Comparing the schemes on the basis of throughput and outage probability we found that Soft FFR is best among all schemes.

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