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Comparative Analysis of Cell Centre and Cell Edge Performance in Heterogeneous Networks using FFR and SFR

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Abstract :. In this work I have discussed two method FFR1 and Soft FFR. This two method is compared with respect to without FFR scheme in terms of two parameters, throughput and outage probability. And the results shows that the performance of proposed method is above in terms of Total/Edge throughput and outage probability**.**

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

I. INTRODUCTION

Heterogeneous wireless network deploying lower power nodes like Pico nodes and Femto nodes to meet the requirement of current users like high user data rate and large throughput. Deployment of femto cells in a macro cell for extension of indoor coverage for users causes high interference, considering downlink performance of users. As the number of femto cell is increases interference is increases. However interference problem between macrocell and femtocell should take care in advance. In this paper we discuss some interference management technique to mitigate the interference between macro and In [2] 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 my literature survey. LTE frame structure is necessary to understand the scheduling concept of resources between maco and Pico base station which is well described in [11, 12].

Performance analysis of different frequency domain technique (SFR, FFR, and FFR-3) is done in paper [12]. Comparison among all these schemes based on performance metrics such as outage probability, average network sum rate, and spectral efficiency in a two-tier HetNets. A detail survey on Femto cells is given in [13]. CCI and ICI based upon OFDMA structure using frequency scheduling is described in [14]. Graphical method for Femto cell clustering and evaluation of spectral efficiency is very effective approach to manage interference in HetNets [15]. Beam subset selection strategy maximizes the throughput of the macrocell [16].

Efficient spectrum utilization is the method used to interference management through cognitive radio communication between Femto cells [19]. Fractional frequency reuse method in OFDMA network is described in [20, 21]. Ratio of inner radius to outer radius and outage probability graph has been generated in [21].Optimized value of inner to outer radius is found in [21].Throughput estimation verses number of Femto cell is given in [22].The optimal interior cell region radius is determined and is approximately equal to 2/3 of the overall cell radius [23].

II. SYSTEM MODEL

The system model consists of macro-cells and on subchannel k then SINRx k m ,m, is given by

$$\gamma = \frac{P_m^k h_{x_m,m}^k G_{x_{m,m}}^k}{N_o \Delta B + \sum_{m \in M''} P_{m'}^k \, h_{x_m m'}^k \, G_{x_{m,m'}}^k + \sum_{f \in F} P_f^k \, G_{x_{m,f'}}^k}$$

Where pm is the transmit power from MeNB m and pm' neighbouring MeNB m' on subcarrier k, respectively. h^k_x is the exponentially distributed channel fading power gain associated with subchanel k, and G x k m,m is the channel gain associated sub channel k between MUE xm and serving MeNB m. Channel gain from neighbouring macro cell is given by which is given by

$G_{x\,k\,m,m}$

$$\gamma = \frac{P_f^k h_{x_f,f}^k G_{x_{f,f}}^k}{N_o \Delta B + \sum_{m \in M} P_m^k \, h_{x_f m}^k \, G_{x_{f,m}}^k + \sum_{f \in F} P_{f'}^k \, G_{x_{fm,f'}}^k}$$

. Where $G_{x\,k\,m,m} = 10^{-PL\ OUTDOOR/10}$.
In case of femto user, it is interfered by all the 19 macrocells and adjacent femtocells. The received SINR of a femto user on subcarrier k can be similarly given by Channel gain is dominantly affected by path loss, which is different for outdoor and indoor.

Path loss for outdoor environment is given as: - P Loutdoor = 28 + 35 log10 d. Here wall loss is zero.

Path loss for indoor environment is 38.5 + 20log10 (d) + Lwall loss and given as below

P indoor = 38.5 + 20 log 10 d + 7 dB for 0 < d < 10m. .... (3)

= 38.5 + 20 log10 d + 10 dB for 10 < d < 20m.
= 38.5 + 20 log10 d + 15 dB for 20 < d < 30m.

Wall loss is varying here depending upon distance from HeNB. Here d is the Euclidean distance between MeNB and MUE in meters. However, G x k m,f is affected by both indoor and outdoor path loss. In this case, d would be the Euclidean distance between HeNB f and the edge of the indoor wall in the direction of MUE, xm . After the wall, the path loss will be based on an outdoor path loss model.

Maximum achievable capacity
For an MUE xm on sub-channel k is then given by, Maximum achievable capacity

For an MUE xm on sub-channel k is then given by,

$$C_{m.k} = \Delta B\left(1 + \ \alpha \ SINR_{x_m}^{k}\right) \ Bits/second \ \ldots\ldots\ldots\ldots$$

Where SINR x k m is the signal to interference noise ratio for different user position when

Using the subchannel k. Where α = −1.5/log(5 ∗ BER) Here BER = 10−6 .

Spectral Efficiency
We define the spectral efficiency (bits per second per hertz) in terms of average bits per second successfully received by a UE device per unit spectrum. The spectral efficiency of transmission to MUE xm is given by

$$S=\left(1 + \ \alpha \ SINR_{x_m}^{k}\right) \ bits/second/Hz$$

Where α = −1.5/log(5 ∗ BER)
Here BER = 10^{-6} .

Overall Throughput (Sum throughput):
Practical capacity of serving macro cell is given by

$$T = \ \sum_m \sum_k \beta_{m,k} \ C_{m.k}$$

In this particular system parameters and mathematical models are described. In simulation I compare three techniques without FFR, FFR1 and soft FFR. I consider 19 cell structure scenario in rural macro area. All the base stations are operated by the OFDMA technology. each subcarrier is allocated only one macro user in a macrocell in every time slot.

This implies that∑m=1 N β xm,k = 1, where N is the number of users in a macrocell. Similar expression for femto users related to the practical capacity and overall throughput is possible except ∑N m=1 β xf,k = 3 , here N is the number of femto users in a macrocell.

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. We 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. Here we 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

Figure 1
Throughput against number of femto nodes in three different schemes
(For cell edge users only).

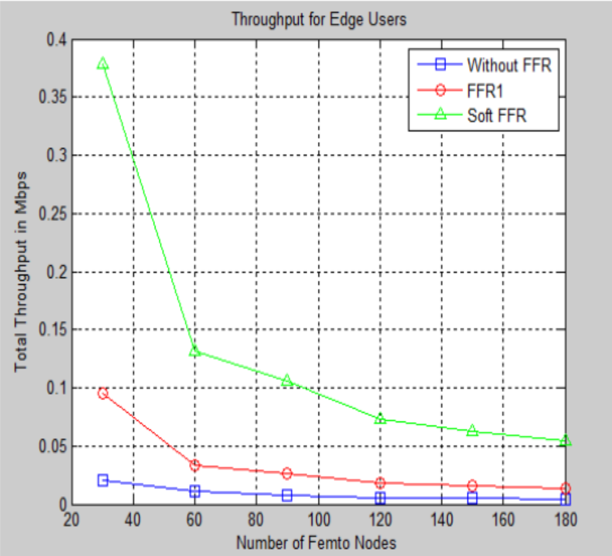
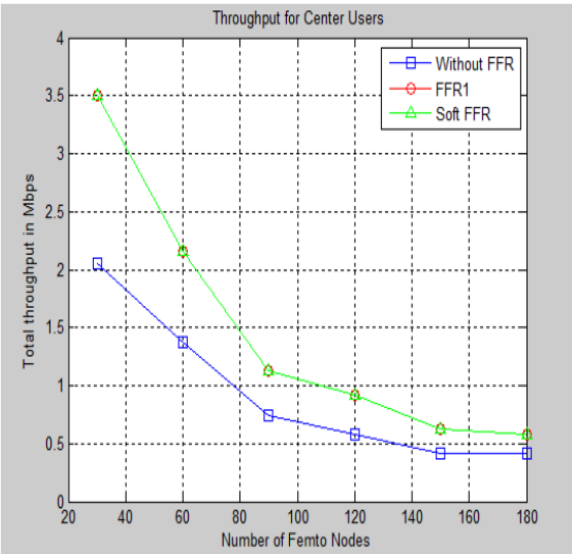


Figure 1 shows the performance of cell edge users in terms of throughput and varying number of femto nodes. As users are moved towards the edge of the cell they get affected more from interferers and power received is also decreases with distance. The performance of edge users is degraded due to interference. This performance can be improved by transmitting more power to edge users. Figure shows edge users have better performance while using FFR1 and SFR.

The performance of without FFR and FFR1 is almost constant as compared to soft FFR, thus soft FFR gives better performance at cell edge zone.

Figure 2
Throughput against number of femto nodes in three different schemes.
(For cell centre users only).



The Figure 2 shows the overall throughput of centre user is almost same and coinciding for SFR and FFR1 due the fact that we are transmitting same power to centre user in both the schemes.

But both the scheme have better result as compared to without FFR. Soft FFR have better spectral efficiency as compared to FFR1. In my simulation I compared all the schemes in terms of overall throughput

VI. CONCLUSIONS

In this work after 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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