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Throughput Analysis in Heterogeneous Network under FFR and SFR

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Abstract— In this work I have done the throughput analysis of the heterogeneous network under FFR and SFR. Comparing the schemes on the basis of throughput and outage probability we found that Soft FFR is best among all schemes.

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

I. INTRODUCTION

To meet the requirements set by ITU-IMT-advanced of affordable mobile broadband systems Long Term Evolution (LTE) is currently being evolved by 3GPP into LTE-Advanced. 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. There are so many advantages of LTE over previous 3GPP releases (i.e. WCDMA, UMTS, and HSPA) its higher peak data rate, higher spectral efficiency and lower delay. LTE deals with two access schemes OFDMA and SCFDMA for its downlink and uplink respectively. A very important feature introduced in LTE-Advanced is it support of heterogeneous cellular networks (HetNet's) having macrocells, picocell, femtocells and relays. Femtocells have been proposed as a solution for poor coverage 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 cellular network.

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 [1]. The deploying of a HeNB over the pre-existing macrocell network represents a major challenge. Inefficient deployment of the femtocell network may lead to a degradation of the overall performance of the cellular system. One example of this performance degradation is coverage holes for indoor macro UEs (MUEs) due to interfering transmissions by nearby femtocells. Efficient frequency allocation for both macrocell and femtocell networks is a major step towards efficient 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 spectral efficiency.

Hybrid co-channel and orthogonal channel allocations are more efficient frequency allocation schemes. There are so many frequency allocation schemes are available for macro cell network. Allocation of frequency with high frequency reuse can reduce the interference significantly. In this project we compare to technique FFR 1 and Soft FFR with respect to full frequency reuse method. We compare the results for different femto cell density.

II. HETEROGENEOUS NETWORKS

Requirement of current mobile users is increasing day by day like they are using video calling, conferencing, Internet surfing, downloading audio and video, opening high frequency websites and so on. These all applications required high data rate. For achieving current user requirement one should reduce the distance between users and cell site. So there are two approach to reduce the distance.

1) Densify Homogeneous Network (Traditional Deployment Approach)

By increasing more number of cells in present network the distance between user and base station can be reduce i.e. we are densifying the present network by introducing more number of cells within a cell coverage area. This deployment is known as homogeneous cellular network. Current deployment is based upon macro only planning process. A homogeneous cellular system is a network of base stations in a planned layout, in which all the base stations having similar back-haul connectivity, transmit

power level, antenna pattern and receiver noise floor. All the base stations having almost same number of user to serve with same quality of service. Same hand-off process is used here (Horizontal Hand-off) in traditional deployment approach. All the macro stations are placed with proper planning so that base stations are configured to maximize the coverage and interference can controlled between base stations. As soon as traffic demand increases and RF environment is changes, the network relies on cell splitting or additional carriers to overcome capacity and link budget limitations and maintain uniform user experience. However, this deployment process is complex and iterative. A more flexible deployment model is needed for operators to improve broadband user experience in a cost-effective way.

2) Heterogeneous Wireless Network

Macro only network deploying same type of cells require large power at each base station and not a flexible deployment model. It require prior planning before set up a network. Another method is deploying lower power nodes Pico, Femto and relay base station to improve the network coverage and data rates in macro cell coverage. The network containing Macro cell (MeNB), Pico cell (PeNB), Femto cell (HeNB) and rely nodes are known as heterogeneous wireless network. The placement of Pico/relay base stations may or may not be ad hoc, based on just a rough idea of coverage issues and traffic density in the network. Due to their lower transmit power and smaller physical size, Pico/Femto/relay base stations can offer flexible site acquisitions. Relay base stations offer additional flexibility in back-haul where wire line back-haul is unavailable or not economical.

Usually lower power nodes are deployed depending upon network requirement. Pico nodes are deployed at coverage hole, HeNB is deployed inside the large buildings like shopping malls, schools, universities, colleges and corporate offices. One or many femto nodes can be deployed in a macro cell.

Base Station Class	Range	Output power per TX Antenna
Macro BS	Few tens of Km	46dBm
Pico BS	200 m	Up to 30dBm
Femto BS	10 m – 30m	Up to 20dBm

The basic difference between macro and lower power node is transmitted power. Transmitted power of different base station is shown in table. Table shows that transmitted power for different base station and there coverage range. Rely base station is deployed to connect the user where coverage is not reached. Number of femto base stations can be vary according to the requirement of data rates. In homogeneous cellular system user is served with strongest received signal from base station. In heterogeneous wireless system by proper resource scheduling, frequency planning and with effective interference management technique better performance can be achieved with improve throughput and user experience as compared to traditional approach of deploying cellular network and infrastructure. For our sake of simplicity in calculation and simulation in our project we consider only femto nodes are deployed in a macro cell coverage Pico cells and relay base stations are not deployed.

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

III MACRO-FEMTO SCENARIO

In macro femto scenario we have created the 19 cell structure (2 tier cellular network). Users are deployed randomly in macro cell. Femto cells are also deployed randomly within macro cell.

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 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 macrocell. 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 andinterference 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 1 shows the result when we deployed the 50 users and varying number of femto cell (from 30 to 180 in an interval of 30) in a macro cell coverage of radius 280m.

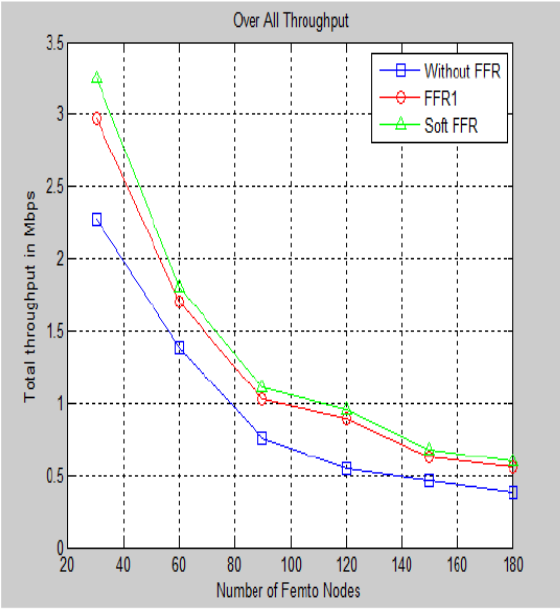

Figure 1

In this figure 1 have compared three schemes Without FFR, FFR1 (Frequency at cell edge and centre user is different and cell edge user is using one frequency) and Soft FFR (Power factor is introduced for cell edge users).In simulation I assumed that all the users are macro users and only first macro cell is serving macro cell. When we deployed the femto cells within a serving macro cell overall performance is degraded in terms of overall throughput.

Initially when no FFR technique is used all the first macro cell users are interfered from remaining 18 macro cells and from all of the femto cells within that macro cell. So the interference is very high when FFR technique is not applied. And as we can see in Figure 1 as soon as the number of femto nodes are increasing the sum throughput is decreases.

To apply FFR1 first we have to decide the either users are cell edge users or cell center users. Decision is based upon SINR threshold or macro cell radius, in our simulation we use the threshold radius to separate the users. Once we find the location of users FFR1 can be applied.

The user at cell center are not interfered by the cell edge femto cells. They interfere only from cell center femto cells and from remaining cell center macro cells (18 macro cells). While cell edge users are not interfere by cell center femto cells and all of the macro cells, since they are using different frequency sub-band from center and other macro cells. Therefore the interference at cell edge users is less as compared to cell center users.

From Figure 1 it has been clear that Soft FFR is best method among three in terms of total throughput. Soft FFR scheme is more spectrum efficient then FFR scheme as we have seen in literature at the cost of more interferences. To reduce the effect of interference in this scheme power factor is introduce between cell edge zone and cell center zone, i.e at cell edge zone more power is transmitted as compared to cell center zone depending upon the percentage of users in each of the zone.

In figure 2 sum throughput of each of the method is plotted (in Mbps) with varying number of femto cells in macro cell. From 30 femto cells to 90 femto cells performance is degraded,after 90 femto cells performance is almost constant in all of the schemes. Here total throughput is plotted for cell edge zone + cell center zone.

V. CONCLUSIONS

It is seen that Interference is major issue in Heterogeneous wireless network that need to be resolved. Lower power nodes are deployed to enhance the network coverage inside the buildings and at coverage hole. In this paper focus is on femto cells to improve indoor coverage. As soon as the number of femto cells are increased the interference is increased. We compare two techniques Soft FFR and FFR1 with respect to
without FFR. And we got better result for soft FFR in terms of outage probability and sum throughput. Conclusion can be drawn for edge users and center user's

separately as in figure 2 and 3 that Soft FFR is best among three methods we are comparing.

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