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LTE-A Heterogeneous Networks Using Femtocells

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***Abstract:** For the improvement of coverage and services of quality, Femtocells play important role in heterogenous Networks in LTE-A networks. Femtocells are used to provide good indoor voice, increase network capacity and high data coverage in LTE-A. the problem of Cross-Tier interference is a large problem in Femtocells Networks. Cross-Tier interference is an interference between Femtocells base station and Microcell's base station in a network structure. Throughput is increased while Cross-Tier interference can be decreased using Femtocell in any Networks. In this paper, we also show experiment results obtain by a simulation framework which shows how Femtocells can increase the throughput and reduce the interference.*

***Index Terms:** Heterogeneous Network, Experiment, Femtocells, LTE, Interference, Throughput, Pathloss, SINR.*

I. INTRODUCTION

LTE (Long Term evolution) is the technology is used in every cellular Networks working on 4G. LTE provides data rate in more speed and support the cellular telephones services. LTE networks have four major components. The main and 1st component is the Core Network. It works as brain in the LTE network. To provide access to multimedia and internet services gateways and servers are used in Core Network [6]. 2nd component of LTE Network is Radio Access Network, which are also known as mobile network towers. The tower has transceiver tools are known as antennas and node bees. Device are connected with them by using coverage which is wireless. 3rd component of LTE is known as Backhaul network, it is buildup of fiber and microwaves connection. For connecting two different component of LTE which are radio access network and core network Backhaul networks is used. So, that user can make telephone calls and also can use the different services given by the Networks. 4th component of LTE is user equipment which contain routers used for mobile, mobile phones and equipment which are pre-owned by the individual. LTE has many features and capabilities but there are four main feature exclusive spectrum, high speed, priority, and preemption self-organizing networks [16]. LTE-A has some new features as compared to the LTE system. There is some goal of LTE-A which are to increased data throughput. That means we required more throughout values so that it increased data throughput or more speed internet access. Next goal was to improved flexibility of Spectrum allocation and reducing latency. Then there was requirement to increased reliability of data transmission, especially at cell edges. Increase in communication efficiency is also the main goal of the LTE-A [7].

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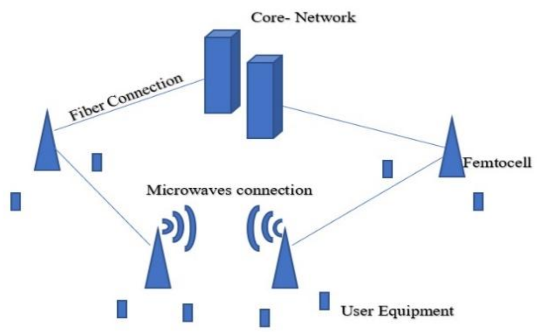

Diagram of LTE Network

LTE-A have some feature which are CA (Carrier Aggregation), Enhanced MIMO, LTE CoMP, Relay Node and Heterogenous networks.

The major challenge faced by the network operators today is to provide uniform coverage especially in metro cities which are filled with high rise buildings. One way to expands exist macro network is adding more eNodeBs. However, installing Macro sites can be very expansive. To overcome this challenge Heterogeneous network and Relay Nodes are used in LTE-A.

There are several techniques to improve the coverage. The simplest method is by the introduction of small cell, which contain many subs base station known as eNodeBs. These eNodeBs are also known as base station with low-power. The main purpose of eNodeBs are to provide coverage to area which are not able to covered by the Macro Networks. These enodeB can be used in both indoors and outdoors. These enodeB also increase the service quality and networks performance [5]. Bitrates per unit area can be increased by using small cells with Macro cells. The heterogeneous network may consist of macro, micro, pico, and femtocells, based on enodeB power.

Femtocell are used anywhere home, school which is connected by any internet connection of already existing broadband. Femtocell solves three different problems, first one is to increase around coverage which can be particularly poor in indoor. The second aspect concerns the capacity of the network where many mobile phone networks are becoming congested through a high level of data traffic [10].

II. EXPERIMENT SETUP

Due to the unorganized femtocells in heterogeneous networks can cause interference and affect the throughput. Parameters are also playing important role in the networks. If parameters are taken inappropriate then also a network can suffer from interference. How to calculate the path loss, SINR and Throughput in LTE-A networks are given below:

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A. Path Loss Model:

According to 3GPP, SINR can be estimated by calculating the
Path Loss between Base Station and mobile phones. Let take the first case as outdoor in an urban area we determine the path loss between a Macro BS and UE we need below [7] [2] Eq.:

PL (db) = 15.3 + 37.6 log10R [7][2]

On the other hand, if we take the case of indoor then path loss can be measured by given below:

PL (db) = 15.3 + 37.6 log10R + Low [7][2]

Path loss which comes between a Femto Base Station and UE can be determined by given below [7] [2] eq.:

PL (db) = 38.46 + 20 log10R + 0.7 d2D, indoor + 18.3n((n+2)/(n+1)-0.46) + q*Liw [7][2]

0.7d2d, indoor: penetrated loss by the inside walls.

On the other hand, PL of outdoor femto user connected with indoor femto BS can be calculated as below:

PL (db) = max (15.3 + 37.6 log10 R,38.46 + 20 log10 R) + 0.7d2D, indoor + 18.3n((n+2)/(n-1)-0.46) + q*Liw + Low [7]

B. SINR Estimation:

After getting Path loss which comes between Macro Base Station and UE & Path Loss which comes between Femto Base Station and User Equipment we can calculate the SINR. SINR is calculated for every user and every subcarrier. According to 3GPP, SINR of SISO transmission mode can be calculated by below [7] [2] Eq.:

SINRi,n=Pi,n(|hi,k(i),n|2) /($\sum_{l=1,l\neq i}^{N}$ Pl,n|hHi,k(l),n|2) + σ2n [7][2]

C. Throughput Calculation:

According to 3GPP, Throughput of macro user i on subcarrier can be calculated by a eq. below [21] [36]:

Ci,n : ▲f log2(1 + αSINRin) [7][2]

α :1.5/In(5BER)

The throughput of giving by microcell (M) can be calculated by given ex:

Tm: $\sum_i$ $\sum_n$ Bi,n Ci,n

After getting the mathematical analysis, it is implemented in the simulation for the test. To get Path loss, SINR, and throughput by using Macrocell, Femtocell, and UE. The simulation test has been implemented on the MATLAB environments. MATLAB consists of the useful tools for the experiment. When we run the simulator in MATLAB tool a window will appear which is given below fig. 1:

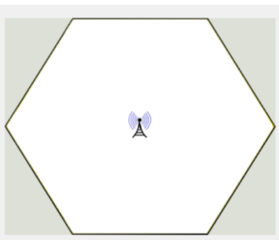

Fig. 1: Diagram of Simulator

After inserting the values in these parameters apply to the map on the simulator and through this result comes. In advanced option in the simulator, there is system level simulation parameters which can be changed at the time of use.

III. EXPERIMENTAL RESULTS

After the setup of the simulation, values are assigned to the parameters so that we are able to get some results from the simulation. Different outputs come from the different values of the parameters of the simulation. After inserting the values in the parameters, plot Femtocell, Macrocells and Femto users into the simulator. When all cells and users are plotted then run the simulator which gives Pathloss, SINR, and Throughput of every user. Users can be Macro user or it can be Femto users. In the next step, just click on the cell or the user and the simulator show its Pathloss, SINR, and throughput. Path loss, SINR, and throughput of the experiment is calculated. So that, it is able to know how building, distance, wall and Femto users affect the SINR, Throughput and Path Loss.

Parameters	Values of Fixed
Num. of Femtocells	5
Num. of Macro users	5
Num. of Femto users	15
Bw/Modulation	1.4Mhz/QPSK
Num of Building (x)	3
Num of Building(y)	3
Road width	15.0
Additional user	Macro User

Table 1: values of Parameters in experiments

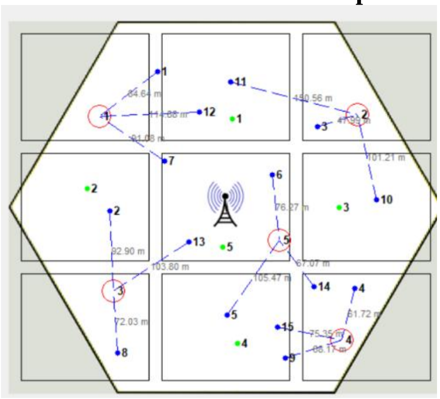

Fig. 2 Simulation Setup

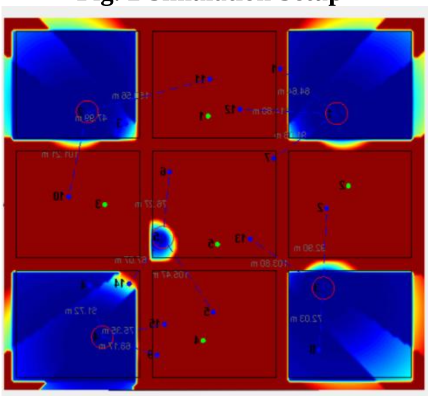

Fig. 3 Simulation Result

After plotting the macro users, femto users and Femtocells in the simulator (Fig 2). Run the simulator and it takes some time to process and gives the result (Fig. 3). When click is done on the Femto users or Macro users the simulator will give values of Pathloss, SINR, and Throughput. These values are plotted in below graph:

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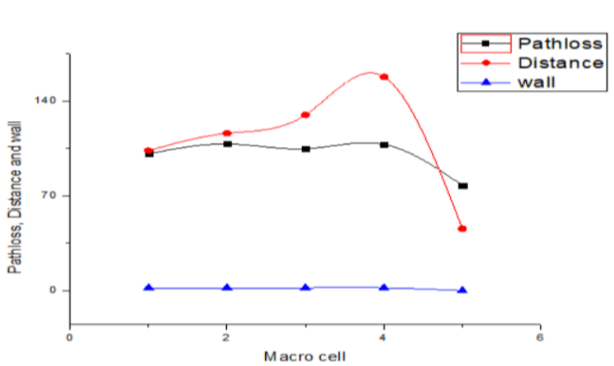

Fig. 4

In fig. 4, the horizontal axis represents the Macro users and Vertical axis represent Distance and Pathloss of Macro users. The red color line shows the path loss of Macro users, the Blue color line show walls and the black color line shows the distance of Macro users. As it is clearly visible from the line graph that distance of macro users from the Macrocells in a network affects the Pathloss which is shown in this fig.4. To conclude, it can be said that if the distance between macro users is increased from the Macrocell then Pathloss also will be increased.

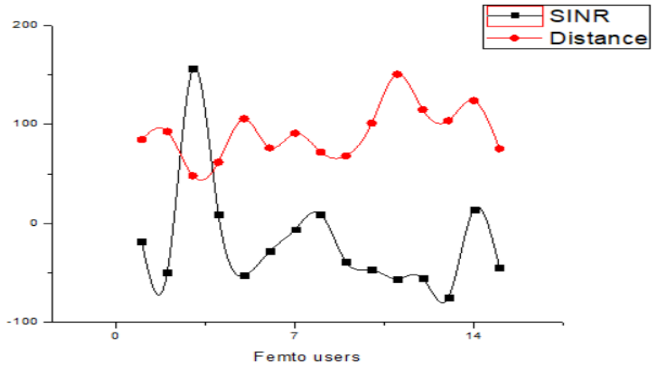

Fig. 5

In fig. 5, the vertical axis denotes SINR & Pathloss and the horizontal axis denotes the Femto users. The black color line shows the Distance and red color line shows the SINR. It is clearly visible from the line graph that if path loss of Femto users increases then SINR of femto users decrease and if Pathloss of Femto user decreases then SINR of Femto user increase.

In fig. 6, the vertical axis denotes Distance & Pathloss and the horizontal axis denotes the Femto users. The black color line shows the Pathloss and the red color line shows the Distance.

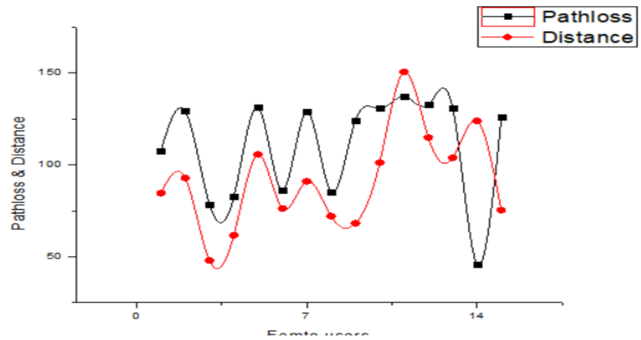

Fig. 6

It is clearly visible from the line graph that if Distance of Femto users increases from the Femtocell then Pathloss of femto users also increase and if Distance of Femto user from the Femtocell decrease then Pathloss of Femto user also decrease.

From the above, we come to know that the position of femtocells from the Femtocells users affect the Pathloss and SINR. And it decreases the throughput of the networks. Distance is a major parameter which affects the Path loss and SINR. If Pathloss and SINR are affected then throughput will also get affected. Distance Femtocells from Microcell's and Femto users is very important for increasing throughput and decreases interference.

IV. CONCLUSION

In this paper, we show that how Microcell's and Femtocells topologies in heterogeneous networks helps to decrease the cross-tier interference while on the other hand it increases the throughput. And how the position of Femtocell can be used to increase the throughput. This paper also shows that how distance and wall effect Pathloss and SINR in the heterogeneous networks in LTE-A. Distance is the main parameter which affects the throughput of any network. For future work, interference can be reduced by using the radio resource allocation in an efficient way. It will be also helpful in the increase of throughput of any Heterogenous networks in LTE-A.

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