



Power Control Schemes for Interference Management in LTE-Advanced Heterogeneous Networks

Amandeep, Sanjeev Kumar, Vikas Chauhan, Hari Saroop

Abstract: The issue of inter-cell interference with the co-tier and cross-tier arises in LTE-A Heterogeneous networks when the low power base station is deployed in a huge number in the ultra-densities area. This problem is managed by RRM (Radio Resource Management) technique. RRM uses different algorithms, application, and parameters to avoid and mitigate co-channel and cross-channel interference. The main objective of the Radio Resource Management is to maximize the use of limited resources. It manages all the resources like power, frequency and time. The power control Radio Resource Management scheme is used to control the interference between Femto to Femtocells and Femto to Macrocells. These resources are regulated separately or in combination, the approach is called hybrid Radio Resource Management. In this paper various power schemes based on Fixed, Constant Femto Base Station and Targeted SINR are used. These power control schemes are applied to the network topology with increment in the size of femto cell range and number of femto and macro users in increment order. The performance is analyzed on SINR, path loss and throughput. The comparison results of in between Fixed, Constant Femto Base Station and Targeted SINR power schemes are shown in graphs. The result reflects that constant FBS scheme has outperformed in user increment scenario and range increment scenario.

Index Terms: Femtocells, Resource allocation, LTE, Fixed, Constant Femto Base Station and Targeted SINR.

I. INTRODUCTION

In Release 8 LTE (Long Term Evolution) was introduced by 3GPP (Third Generation Partnership Project). LTE is a derived part from UMTS (Universal Mobile Telecommunication Service). UMTS was one of the segments of 3GPP system. The motive of LTE was transparent that users should receive enhanced data rates, low latency and proper optimization of RAT (Radio Access Technology) by packets. LTE supports high-speed cellular modems, voice over IP, video conferences and streaming multimedia which are some of the benefits of high data rates [10]. After LTE the user need of high data speed and good quality of service makes necessary to develop LTE-Advanced. It is an enhancement of LTE.

To achieve and fulfill the demand of users for high data throughput rates, LTE-A uses some key technologies which are Orthogonal Frequency Division Multiplex (OFDM), Multiple Input Multiple Output (MIMO), Carrier Aggregation (CA), Coordinate multipoint (CoMP), LTE Relaying and Heterogeneous Network [11].

The heterogeneous network is a network which holds two or more different types of cells in a major cell. Major cells are high power macrocells and low power nodes are the cells which are meant to maintain the quality of channel in the area where the reach of macro cell is very low. Low power cell includes Pico or Femto cell. Femto cells is the type of small cell or the broadcast communications base stations that can be introduced in private or business conditions either as single remain solitary things or in bunches to give enhanced cell scope inside a building. These are easy to deploy as it can be installed by the user only.

It was the general perception that phone scope; particularly for information transmission where great flag qualities are required isn't as great inside structures. By utilizing a little inward base station - femto cell, the cell execution can be enhanced alongside the conceivable arrangement of extra administrations.

There are different types of Femto cell which can be classified as closed, open and hybrid access. Which are protected by any kind of password are called closed access Femto cells, therefore any unauthorized person cannot be able to access the network.

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Networks which are accessible to anyone and are not password protected are known to be open access Femtocells. The installation of combinations of both open and closed femto cells issued to fall under Hybrid access Femtocells.

II. REVIEW OF LITERATURE

Inter-cell Interference is the vital problem in Resource Allocation. By the use of the interference avoidance concept in the ICIC formulation, the best use of resources can be done. These are different way by which the radio resources are allocated to any user equipment.

Allocation is used to be done in term of time, frequency and power domains. The use of inter-cell frequency and power arrangements it's easy to avoid the interference in the cell For Interference avoidance, the reuse of frequency plays an important role. In this frequency get fragmented into 2 or 3 parts. Higher frequency is used for edge-region, and the lower frequency is used for the center region.

The 2nd way for Interference Avoidance is power division. By the use of the power division, throughput of any network can be increased. Power is fixed for the center region by using Amplification Factor and the edge region of the cell has power relaxation.

The 3rd way for Interference avoidance is dominant interference suppression. In this hybrid of selective frequency reuse and selective power reuse takes place. By this, it increases the channel quality. 4th way to avoidance Interference is by self-organizing channel reuse for femto cells. Different frequency group is used in the macro area for UEs. So, that collision between Macrocell's and Femtocells are avoided as it is well described by ChrysovalantisKostaet.al. [13].

The total transmission power of uplink can be decreased in LTE networks where cells are mutual interference. This was purposed by Yiran li et al. [6] With the help of the power allocation and distributed resource algorithm the power minimization problem can be solved. For this SINR coupling model is used.

After this, there was a need for a framework for resource allocation.KaushikR.Chowdhury et al. [7] purposed that need of the Resource block allocation and system power requirement can be adjusted dynamically with the use of energy efficient framework. Power consumption by under-utilized eNodeBs in LTE network can be reduced. By this, it affects the downlink throughput which is solved by Two-Phase Enhanced branch and Bound Algorithm.

Another resource allocation method was purposed by Chai-Hien Gen et al. [8] in CoMP by using a two-tier spectrum and framework of scheduling. By this, it can able to manage inter-cluster CCI, not only the intro-cluster. By that, the throughput performance of UE is improved.

Control of congestion was needed so Sung-Hyung Lee et al. [9] purposed algorithm for adaptive resource allocation and control of congestion. It also purposed that no. of contending device can be measured so that the unused number of preambles can get by the number of the activated devices. After the brief knowledge about the inter-cell interference there is a need to design the system algorithm that work on the various power schemes, used for the allocation of resources in the network that helps to mitigate the issue of interference in between femto and macro cells as this is well described in [5].

III. SYSTEM DESIGN

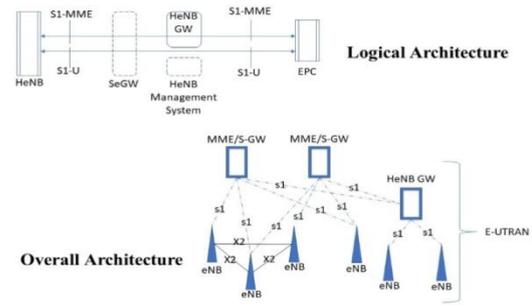


Fig. 1 Architecture of home e-NodeB's

The home eNodeB is small BS in LTE-A which are generally used in building for better indoor signal power and coverage. Home eNodeB is directly connected with the MME/S-GW. HeNB sends data/information to MME/S-GW and MME/S-GW send the data/information to eNB. S1-U and S1-MME are the interface which is used for sending data/information.

This part shows the simulation model which measures the Throughput, SINR, and Path loss at every cell of the LTE-A network contains both Femtocells and Macrocells.

A. Path Loss Model:

According to 3GPP, SINR can be estimated by calculating the path loss between a Macro Base Station and User Equipment & between Femto BS and UE. Let's take the first case as outdoor in an urban area we determine the path loss between a Macro BS and UE we need below [5] [14] Eq.:

$$PL (db) = 15.3 + 37.6 \log_{10} R [11]$$

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

$$PL (db) = 15.3 + 37.6 \log_{10} R + L_{ow} [11]$$

Path loss between a Femto BS and User Equipment can be determined by given below [5] [14] eq.:

$$PL (db) = 38.46 + 20 \log_{10} R + 0.7d_{2D,indoor} + 18.3n^{((n+2)/(n+1)-0.46)} + q * L_{iw} [11]$$

0.7d_{2d}, 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:

$$PL (db) = \max (15.3 + 37.6 \log_{10} R, 38.46 + 20 \log_{10} R) + 0.7d_{2D,indoor} + 18.3n^{((n+2)/(n+1)-0.46)} + q * L_{iw} + L_{ow}. [11]$$

B. SINR Estimation:

After calculating path-loss between base station and user equipment, SINR is calculated for every user and every subcarrier. According to 3GPP, SINR of SISO transmission mode can be calculated by below [5] [14] Eq. [5]:

$$SINR_{i,n} = \frac{P_{i,n} (|h_{i,k(i),n}|^2)}{(\sum_{l=1, l \neq i}^N P_{l,n} |h_{i,k(i),n}^H|^2) + \sigma_n^2} [11]$$

C. Throughput Calculation:

According to 3GPP, Throughput of macro user i on subcarrier can be calculated by a eq. below [5] [14]:

$$C_{i,n} : \Delta f \cdot \log_2 (1 + \alpha SINR_{i,n}) [11]$$

$$\alpha : 1.5 / \ln(5BER)$$

The overall throughput of Serving microcell M can be calculated by given ex:

$$T_M = \sum_i \sum_n \beta_{i,n} C_{i,n}$$

$\beta_{i,n}$: Subcarriers assignment for macro users.

$\beta_{i,n}$: 1 which means subcarrier n is assigned to macro user i. otherwise $\beta_{i,n}=0$.

In OFDMA every subcarrier is allocated with the single macro user in a macro cell in a time slot which is $\sum_{i=1}^{N_i} \beta_{i,n} : 1$, where N_i indicates the number of macro users in a macro cell.

IV. EXPERIMENTAL SETUP

After getting the mathematical analysis, it was 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.

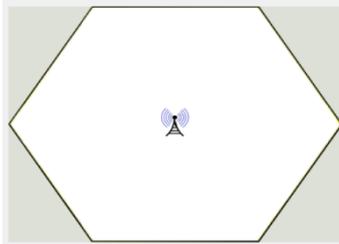


Fig. 2 Simulation Topology

After introducing the values in these parameters and applying that on map, the simulator is all set to run and with simulator results were calculated. The advanced option in the simulator, there are more system level simulation parameters which are changeable as per user required.

V. 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. But we will assign same values in parameters except for the values of the Power Scheme. Three different Power Scheme is used which are Fixed, constant FBS Radius and Target SINR.

Inserting the values in the parameters of simulator we get a table which is below (Table 1):

Table 1: values of Fixed, Constant Femto Base Station and Target SINR

Parameters	Values of Fixed	Values of Constant FBS Radius	Values of Target SINR
Number of Femtocells	5	5	5
Number of Macro users	5	5	5
Number of Femto users	10	10	10
Bndwth/Modulation	20Mhz/60QA M	20Mhz/16QA M	20Mhz/60QA M

Power Scheme	Fixed	Constant FBS Radius	Target SINR
Number of Building (x)	2	2	2
Number of Building(y)	3	3	3
Road width	15.0	15.0	15.0
Additional user	Macro User	Macro User	Macro User
Femto cell Range	10 to 50m	10 to 50m	10 to 50m

After inserting the values in the parameters, plot Femtocell, Macrocells, and Femto users into the simulator which is shown in fig.1. When all cells and users are plotted then run the simulator which gives results given in fig.2. In the next step, just click on the cell or the user and the simulator shows its Path-loss, SINR, and throughput. The same procedure is done in the next two cases where the Power Scheme is changed. Path loss, SINR, and throughput of case 1 where Fixed Power Scheme is used, given in below table.

A. Fixed Power Scheme

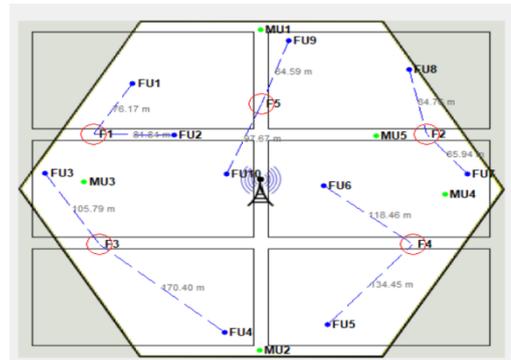


Fig. 3 Simulation Setup

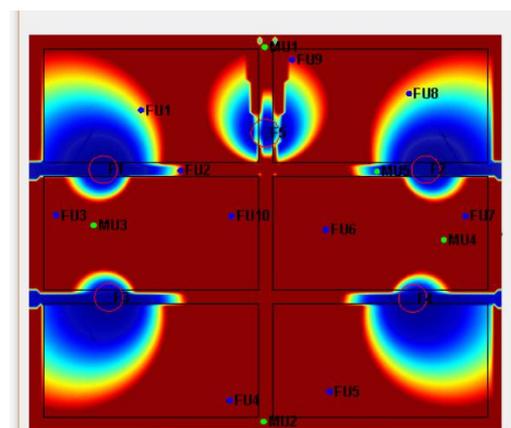


Fig. 4 Simulation Result Fixed Power Scheme

B. Constant FBS RADIUS Power scheme

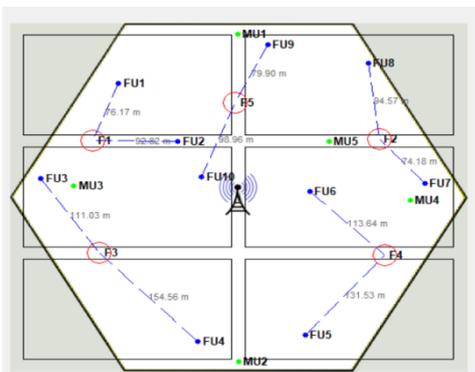


Fig. 5 Simulation Setup

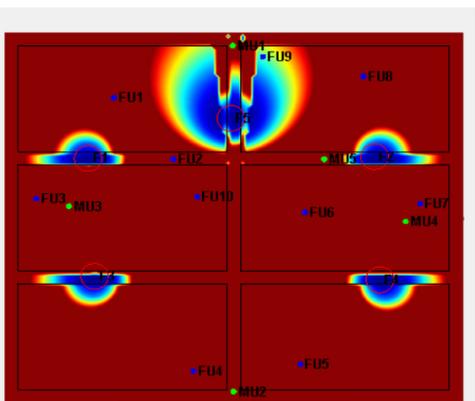


Fig. 6 Simulation Result Constant Fbs Radius

C. Target SINR Power Scheme

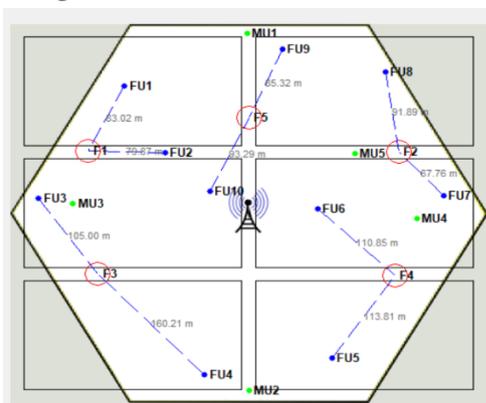


Fig. 7 Simulation Setup

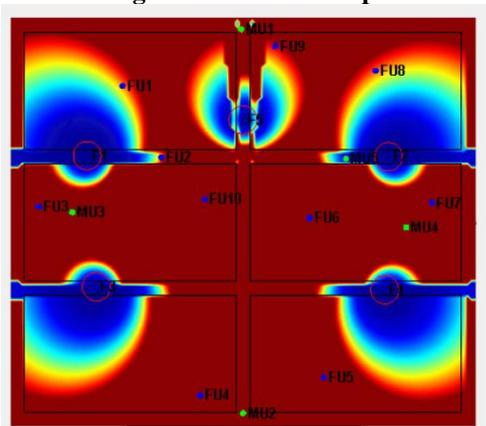


Fig. 8 Simulation Result Target Sinr

As we can see in the above fig. 4 and 8 have Path-loss is more than fig. 4. In fig. 8 Path-loss can be seen near Femtocells (f1,f2,f3,f4,f5) but in case of fig. 6 there is less

Path-loss near Femtocells (f1,f2,f3,f4) and can be said same path-loss near femto cell 5.

After calculating the values of Path-loss, SINR, and Throughput, all values are compared with each other so that we come to know that which case is the best case from the above 3. And the comparison is plotted on the graph given below:

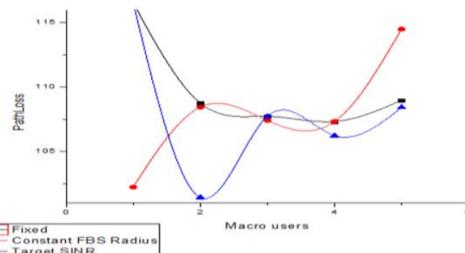


Fig. 9 Path-loss of Macro users

In fig.9, there is a comparison of Path loss between different Power Scheme. Here x-axis and y-axis denotes Macro users and Path loss respectively. Three Power Scheme is used which are Fixed, Constant FBS Radius and Target SINR. Fixed is denoted by the black line, constant FBS Radius by the red line and Target SINR by the blue line. Constant FBS behavior is comparatively alike to the other Power Scheme.

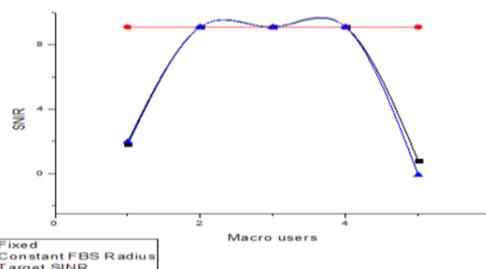


Fig. 10 SINR of Macro users

In fig.10, above graph depicts the comparison between SINR and the macro user of different Power Scheme. Fixed is denoted by the black line, constant FBS Radius by the red line and Target SINR by the blue line. SINR of Constant FBS Radius can be said that it showed a fixed graph line while others Power schemes showed an identical output graph line in the graph.

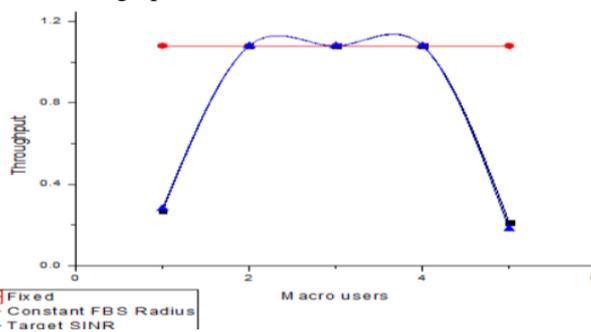


Fig. 11 The throughput of Macro users

In fig.11, explains the output comparison between the macro user and the throughput. Fixed is denoted by the black line, constant FBS Radius by the red line and Target SINR by the blue line. In this graph, this can easily be prescribed that Constant FBS Radius showed a steady throughput, while the other 2 power schemes showed the identical output.

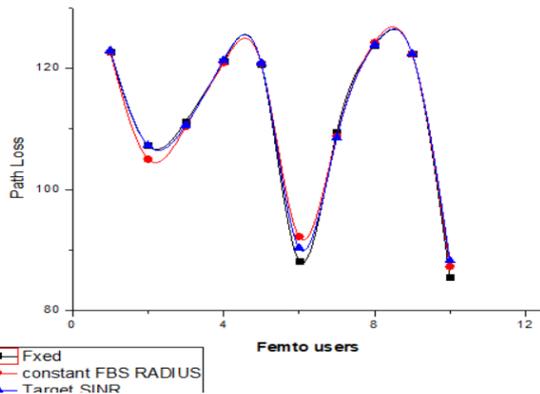


Fig. 12 Pathloss of Femto users

In fig.12, depicts a comparison of Path loss of various power schemes on femto users. Three Power Scheme is used which are Fixed, Constant FBS Radius and Target SINR. Fixed is denoted by the black line, constant FBS Radius by the red line and Target SINR by the blue line. The output graphical line of power schemes has showed the identical nature but a small variation. All power schemes has given the same output for the 1st femto user but for 2nd the value of Constant FBS Radius drops a little further than others. For the 5th femto user value of fixed power scheme was the lowest same with the 10th femto user.

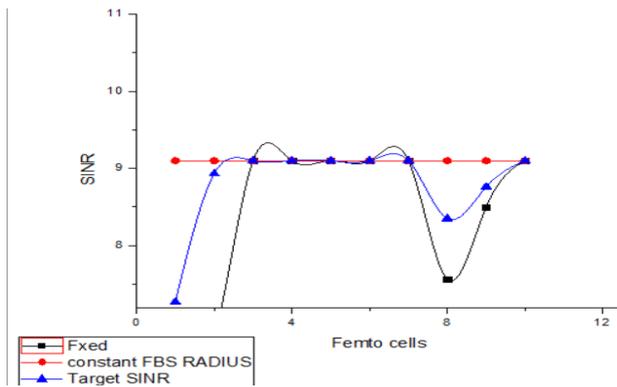


Fig. 13 SINR of Femto users

In fig.13, there is a comparison of SINR of different Power Scheme on femto cells. Fixed is denoted by the black line, constant FBS Radius by the red line and Target SINR by the blue line. In this case also the constant FBS showed and unchangeable output graph line. Fixed and Target SINR can be said that has a kind of identical graphical line from femto cell 3 to 10. On case of 8th femto cell the output of Fixed power scheme has dropped down below the target SINR and meet it at the situation when the femto cell moved to 10.

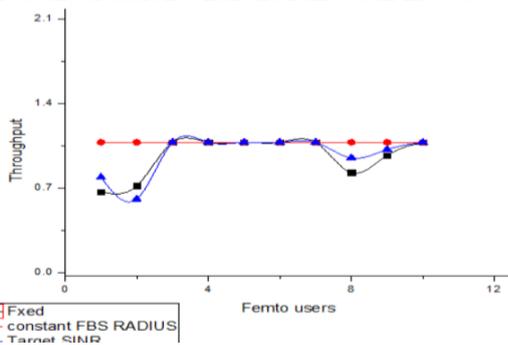
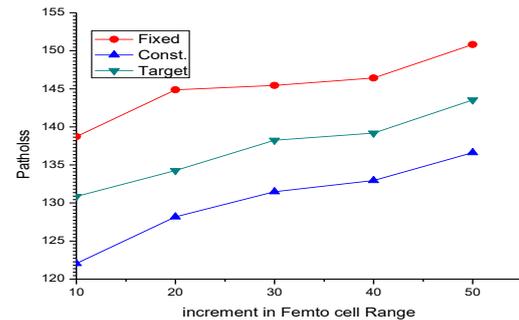


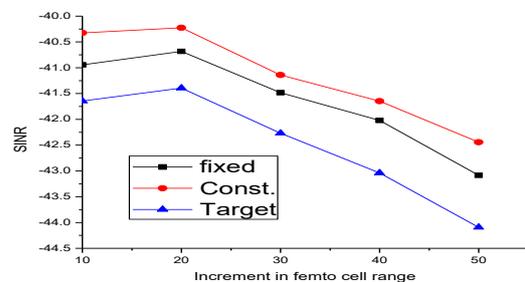
Fig. 14 Throughput of Femto users

In fig.14, there is a comparison of Throughput between different Power Scheme as the femto users increases. Three Power Scheme is used which are Fixed, denoted with black line, Constant FBS Radius, denoted with red line and Target SINR, showed by blue line. In this case also the Constant FBS Radius showed the unchanged output graphical line and the other 2 schemes has showed the identical output but with the little bit fluctuation when the femto users where 1,2, 8 and 9.

After comparing the results of these power schemes with increasing the number of femto users and macro users, now the variation in the graph will be check with the increment in size of the femto cells taking the same topologies as before.

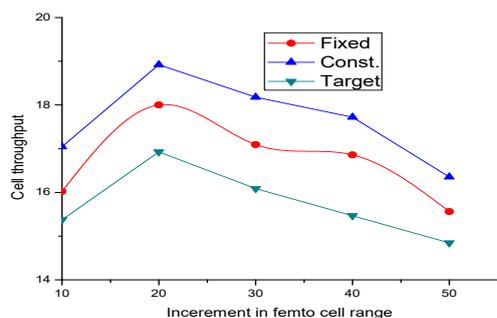


The above shown graph shows the variation in pathloss of power schemes when the range of femto cell has been increased. In this case the nature of graphical line could be identical but the constant FBS radius power scheme has performed better than the other 2. Here fixed power scheme is denoted with the red line, constant FBS radius with blue and Target SINR with the green line.



The above shown graphical representation is a comparison of the SINR values of different power schemes with increment in the range of femto cells. Here in this case the SINR value of Constant FBS Radius is the higher as compare to the other power schemes. The pattern of each power scheme is identical. The best performed among the power schemes is the Constant FBS Radius.

The below shown graphical representation is the comparison of throughput of various power schemes with the increment in femto cell range. In this case if to be discussed about the constant FBS Radius power scheme denoted in blue line has started with comparatively low initial value and achieved its maximum throughput when the cell range increased to 20 and then it starts on decreasing. The graphical line of the target SINR showed the steep downgrade after the range of 20 unlike the other 2 schemes which showed a little bit variation in between 30 to 40 cell range. In this case also constant FBS Radius power scheme has performed well.



As it can be easily predicted from the above graphs that having the same values in the parameters, but with different Power Scheme, it will give the variation in the result. The variation in the results was not such identical in case of increment in femto users and macro users but as the results were calculated on incremental values of femto cell range then the variation in results can easily be predicted in all the cases the Constant FBS Radius has performance well and the other two has underperformed.

VI. CONCLUSION

In this paper, an analysis of resource allocation techniques to evaluate how Power Scheme like Fixed, Constant FBS Radius and Target SINR, affect the SINR, Pathloss, and Throughput in LTE-A network. Power Scheme is one of the best methods in RRM for removing or decreasing the interference from any form of network. Constant FBS Radius is proved to be an effective Power Scheme then the other Power Scheme. Femtocells are very useful in increasing the capacity and data rates for the users present in the dense area or at the cell edge. And by using Constant FBS Radius Scheme, we can able to get sometimes constant SINR or comparatively better SINR, less Pathloss and efficient Throughput between Macrocell and UE or between Femtocell and UE. That helps to reduce, avoid or to mitigate the interference between different cells. The experiment in which the femto cell range was incrementing because of addition of macro users, in this case also Constant FBS Radius Scheme has performed comparatively better than other power schemes.

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