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Optimized Dynamic Cell Selection Approach towards Intercell Interference Reduction for Cell-edge Users In LTE-A Network

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***Abstract*—The demand of high data rates is increasing day by day. The user needs to access all the multimedia applications on its mobile phone anytime, anywhere. For this purpose LTE was launched. As LTE provides high data rates, better efficiency to the network, but at the same time LTE-A is affected by interference in downlink, especially at the cell edge. The degradation of connectivity occurs due to inter-cell interference, which occurs when user is receiving the signals from two neighboring base station at same frequency, so in this case the mobile phone can maximize the received signal strength by adding up these two signals coming from two base stations, here problem arises for the user for the selection of base station, so coordination is applied between the cells to reduce the interference between the cells.**

This paper focuses on coordination between the base stations. DCS (dynamic cell selection selection) is used for coordination among the base stations, which will compare the CSI (channel state information) of base stations. The interference directly affects the parameters such as noise interference, receiving diversity and system receiving gain. In this thesis, SINR of the system is analyzed when coordination is applied between the cells. Initially the SINR is compared without coordination and then SINR is compared with coordination and then the results of both scenarios are compared.

***Index Terms*— CSI, DCS, LTE-A, SINR**

I. INTRODUCTION

The mobile telecommunication evolution was started in the early 80s. 1G system was analog system, they have large mobile cells, and these devices were not available to common man but just related to the business users.

1G was then replaced by 2G systems in late 90s, the main reason for the replacement of 1G to 2G was the digitization of the data. The 2G systems were digital systems they were efficient in utilizing the radio spectrum, mobile devices were small and easily accessible to common man. The 2G systems were initially made for the voice services, but later on they became supporting for short message service(SMS).2G systems mostly named as GSM(global system for mobile communication) [1].

The requirements of internet were increasing and mobile operators introduced 2.5G systems which contains the same concepts of 2G systems. 2.5G systems allowed the user to download data onto the mobile; this technique was defined as GPRS (general packet radio service) [1].

Later on the services required by the users of internet and mobile needs high data rate and increased bandwidth, for this purpose in early 20th century 3G systems were launched, these systems have different techniques in comparison with 2G systems. The most popular 3G system is UMTS (universal mobile telecommunication system), it provided high data rate than other 2G systems [1].

In 2005, HSPA (high speed packet access) a 3.5G system was launched which provides the high data rates for uplink and downlink. As the new technology is overtaking the old technology, the need for data traffic is increasing rapidly as compare to voice traffic.

The user needs to access all the multimedia applications on its mobile phone at anytime and anywhere. For this purpose LTE was launched, it provides high data rates for the users up to 1Gbps user (while stationary) and 500Mbps for the user (in the state of motion)[1]. LTE is designed in such a way that it can be used with the variety of bandwidth ranging from 1Mhz to 20Mhz, LTE was originated by 3GPP group , for the enhancement of LTE, a new specification for the LTE was suggested known as LTE-A(long term evolution advance).[1] LTE-A is enhanced architecture of LTE. LTE was derived from 3G UMTS (universal mobile telecommunication system) and further the UMTS was derived from GSM (global system for mobile communication) [1].

II. LITERATURE REVIEW

The main drawback in LTE-A is interference in downlink, especially at the cell edge. The degradation of connectivity occurs when the user is at the edge of the cells due to interference between the cells known as intra-cell interference. It decreases the spectral efficiency and throughput of the network. Different techniques are used to overcome the intra-cell interference, such as OFDMA, but problem occurs in inter-cell interference. Inter-cell interference[3], which occurs due to the transmission of neighboring cells on the same frequency and also due to frequency reuse factor which is equal to one.

If we consider a user at the edge of the cell and receiving two signals simultaneously from two serving base stations having different carrier frequencies, so in this case the mobile phone will simply be dependent on better receiving signal quality in other words we can say better signal to noise ratio, but similarly if we consider the same scenario with one user at the cell edge and two base stations transmitting signals simultaneously but with same carrier frequency, so in this case the mobile phone can maximize the received signal strength by adding up these two signals coming from two base stations, here problem arises for the user for the selection of base station.

A. METHODS TO COMBAT INTERCELL INTERFERENCE

Intercell interference coordination is done LTE systems to improve the throughput and performance of the network. Inter-cell interference coordination (ICIC) technique is a comparative solution for the reduction of inter-cell interference in LTE-A downlink [2]. The coordination is done among different serving base stations. Different methods are used to reduce inter-cell interference and to improve the performance of cell edge user.

Other technique such as joint processing “data to a single UE is simultaneously transmitted from multiple transmission points, e.g.to (coherently or non-coherently) improve the received signal quality and/or cancel actively interference for other UEs. [4]

One method is joint preprocessing, which can be performed in a centralized manner within several transmission points. These cooperative points serve a UE-group which consists of several UEs using the same frequency at the same time. In each CoMP-MU-MIMO group, joint signal preprocessing should be implemented to mitigate inter-cell interference and subsequently improve system spectrum efficiency, especially the cell-edge user throughput. [5]

“Enhanced ICI coordination (ICIC) is exploited by the Third Generation Partnership Project, which uses the orthogonality in the time domain and is only applicable for specific scenarios, e.g., heterogeneous networks. [6]

From the spatiality aspect, the coordinated multipoint technique is used for ICIC based on joint signal processing but with high complexity and backhaul overhead”. [7]

Another technique used for the reduction of ICI is DSM dynamic spectrum management. In this technique, adaptation of dynamic traffic maps is done. For self-organizing networks (SONs) it is used as an optimization problem with multiple key performance indicators (Multi-KPIs) and uses both fractional frequency reuse (FFR) and dynamic spectrum management (DSM) schemes. [8]

Another simple technique is FFR (Fractional frequency reuse) which corresponds to partitioning and allocation of spectrum into different spatial regions of the macro cell statically. Such static allocations may not be optimal under dynamic traffic load variation (e.g., due to the mobility of UE) and may increase the blocking probability. [9]

CoMP JP (Coordinated Multi-Point Joint Processing) is regarded as a promising technique to improve both cell edge user throughput and cell average user throughput in LTE-A downlink. [10]

Self-organized particle swarm optimization (PSO)-based joint component carrier selection and scheduling (JCCS) algorithm for the downlink. [11]

Self-optimization which is performed automatically. [12]

In multiple input multiple output precoding and beamforming method is used in which advanced physical layer techniques are joined together with multiple antennas equipment. [42]

In wireless networks, to increase the performance of the network and to achieve higher spectral efficiency in those areas where the signals do not reach properly (cell edges), the coordination is done among the different cell. Due to which the interference reduces, and this coordination is done by making full use of radio resources across a cluster of cooperative or coordinated cells with respect to the current cellular network architecture [43], [44].

The interference coordination is responsible for optimization of whole network resources, for the improvement of network capacity and providing better signal quality to the users who are located at the cell edge areas. For this purpose, two techniques were investigated, the joint coordination and distributed coordination among neighboring base stations in a cluster. These techniques have great impact on interference at cell edges [45--49].

Joint cooperation is used to combat the problem of intercell interference. In this method, user scheduling and power control is addressed as main parameters to investigate the overall throughput and enhancement of the network, [45]

While performing interference coordination, in some scenarios there is bulky traffic on network. This traffic not only includes CSI (channel state information), but full data messages as well, so reduce the traffic from the network, another interference coordination scheme is applied. [46]

In paper [47] , there is no exchange of data, the coordination is done by a single parameter CSI, CSI contains the whole knowledge, so for coordination only transmission methods are required [48],[49].

As joint cooperation and coordination are little complex methods, so to minimize this complexity, optimization and maximizing the internal resources of the network started.

In [50], the research started for local information of network with a distributed scheduling policy.

In [51] the writers researched deeper and pointed out a solution with a rate scaling law under a distributed power control and user scheduling strategy.

Another method used for the reduction of interference in [52] is Distributed signal processing. In this method multicell environment is analyzed and the data rate is improved by designing decodable interference signals at each transmitter, known as the common message decoding [53] or the optimized data sharing [54].

One method is to perform distributed solutions with partial or imperfect information. [55]

A multicell orthogonal frequency division multiple access (OFDM) network, where a frame level is used to formulate joint and a distributed resource coordination problem, to improve the sum rate of the network. [57]

Searching for a proper solution, the problem in [57] is decomposed into a discrete user scheduling and a continuous power control sub problems. [56]

In disparity with uplink, the intercell interference in the downlink depends on different factors such as the position of the user in the cell and transmits power at the base station [60].

There are different factors due to which the performance of LTE system degrades. These factors may be noise, interference and quality of the transmission and reception signals. The deployment scenarios of cells In LTE are advancing day by day, as a result of this new types of degradations and interference are starting to appear [40]. Here only the interference is observed. LTE is mostly limited by two types of interferences, intracell interference and intercell interference. When the user is at the edge of the cells due to interference between the cells known as intra-cell interference, it decreases the spectral efficiency and throughput of the network. Different techniques are used to overcome the intra-cell interference, such as OFDMA. The problem occurs in inter-cell interference. Inter-cell interference, which occurs due to the transmission of neighboring cells on the same frequency and also due to frequency reuse factor which is equal to one. It decreases the system capacity [3], [41].

Further if we see environments like large shopping malls, cinemas etc. the number of users may increase rapidly and if there is no coordination among the cells, the network performance gets lower and lower. Different techniques are used for the reduction of inter cell interference to improves the network performance overall. In most cases, the coordination is applied between two neighboring cells and often between three cells.

Intercell interference mostly occurs in downlink [3]. Gaussian broadcast channel is responsible for the modeling of downlink in non-cellular communication systems like WLAN [58]. But if we observe the scenario of cellular communication, the channel used in [58] is not applicable anymore for downlink cellular communication system. Dynamic cell selection is done using femtocells for cell edge users. [13] In comparison with this, it can be seen that using femto cells in the cell edge area is much more complex as they cover few meters. And similarly three base stations are used and coordination scheme is applied between the cells through a central controller [13], while in this paper five base stations are generated and capacity of the system is analyzed. By increasing the number of cells, the capacity of the system improves and performance of the network becomes better in comparison with three cells."For more than 125 users, the system with femto cells installed but without implementing coordination scheme has the best bandwidth utilization, while the system with coordination scheme implemented but without installing femto cells has the worst bandwidth utilization "[13]. The system capacity using femto cells with coordination is almost 26 Mbps for 200 users [13], whereas the system capacity using microcells with coordination can be increased.

Another method for the reduction of inter-cell interference is Enhanced Dynamic Cell Selection with Muting Scheme for DL CoMP in LTE-A. An enhanced DCS with muting method improves the frequency and power efficiency, by using adaptive muting mode selection based on capacity calculation and flexible power allocation based on muting mode selection status [3]. In this method, the throughput of the system is analyzed. Using the DCS with muting scheme provides the throughput up to 18.35 Mbps. As the number of users in a cell increases rapidly and decreases the performance of the network. By muting the parameters value for the cell edge users means to block the power of cell towards the UE, which may sometimes affect the cell center users as well. While in comparison with this technique, this paper analyzes the simple dynamic cell selection technique, in which the threshold value of CSI is set up in central controller, the values of five cells will be analyzed and the best valued base station will serve the users at cell edges. By doing this, all the sectors of the cell will serve their areas and the cell center users may not be affected.

Another method to improve the system's capacity is to add more frequency streams, [37] but this solution has its own limitations in a sense that for extra frequency use the service providers do not have license for use and if they buy the additional frequency band for this purpose so it will be very costly. At the same time, the additional frequency streams may cause more interference and more importantly the frequency reuse factor must be taken into consideration once again which is much more complex for the service providers.

In comparison with this technique, this paper focuses on the installation of microcells in these areas to increase the system capacity and overall performance of the network. In this paper microcells are proposed. Coordination is done among five base stations with varying number of users and then SINR, system capacity and throughput is analyzed using optimized dynamic cell selection technique. The proposed work will maximize the throughput by combating the inter-cell interference, due to which the performance of the network will be better and the connectivity of the network will be available every time at high data rates.

III. METHODOLOGY

Coordination is done among five base stations with varying number of users. Optimized dynamic cell selection technique is used. The proposed work will maximize the capacity by combating the inter-cell interference.

Simulation work is carried out in Matlab. First we input the simulation parameters into the Matlab program.

System parameters are shown in the table.

Carrier frequency	1GHz
Base station power	0.25mW
Base Station height	10m
User equipment height	1.5m
Pathloss	Micro
User equipment antenna gain	0dbi
Bandwidth	15MHz
Base station antenna gain	17dbi

A. CELL, eNB (Base station) AND USERS DESIGNING;

In first step, five eNBs (base stations) are generated through Matlab program, to analyze the better performance of network, the number of users are varied for each case i.e. N= 100, here N represents number of users. The users are generated randomly in the first coverage area (cell). As this paper provides the analysis on small coverage area (microcell) so the radius of cell is 1000m recommended by 3GGP release 9. The users will be located in the range of 10m to 1000m from eNB (base station). In following figure, the first eNB is generated at the center and at position (0, 0) in cartesian coordinate system. The second eNB is generated at the right side of first eNB and at position (1400, 0). The third eNB is generated below the first eNB and at position (0, -1400). The fourth eNB is generated at the left side of first eNB and at position (-1400, 0) and the fifth eNB is generated above the first eNB and at position (0, 1400)

In following figure eNB (base station) is represented by a star and numbers of users are represented by user by delta sign. To distinguish between cell edge users and cell center users, there is an inner circle created in the first coverage area, 700 meters is the radius of this inner circle as shown in following figure

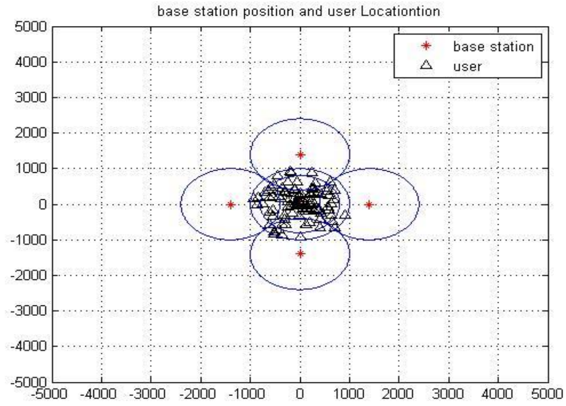

Figure 1; Representation of cell, eNB and users location, when N=100, where N represents number of users

B. ANALYSIS OF RECEIVED POWER FROM DIFFERENT eNBs (BASE STATIONS)

Summarily, the received signal strength at User equipment / Base Station can be estimated from the equation below.

P(dBm) = Pt + Gt + Gr + PL

where,

P_t = Transmitting power of UE/BS (dBm).

G_t = Transmitter Antenna gain of UE/BS (dBi).

G_R = Receiver Antenna gain of UE/BS (dBi).

PL = Path loss (dB).

PL is the path loss in dB and has value as shown in the equation below as recommended by 3GPP Release.9 for line of sight, micro urban base station [14].

PL = 40log10*(d1) + 7.8–18log10*(h'BS)–18log10*(h'UE) + 2*log10*(fc) … [14]

In following figure, the power of each eNB is observed when it is transmitting the signals to the users. The received power is shown in dbm. As there are five eNBs are generated, so the power of first eNB is denoted by BS1 and in figure its power is shown from a line circle sign. Second eNB is denoted by BS 2 and in figure its power is shown from doted hysteric sign. Third eNB is denoted by BS 3 and its power is shown from line triangle sign. Fourth eNB is denoted by BS 4 and its power is shown from doted circle sign in figure. Fifth eNB is denoted by BS 5 and its power is shown from red hysteric line in figure. The received power is shown on Y-axis and users are shown on X-axis.

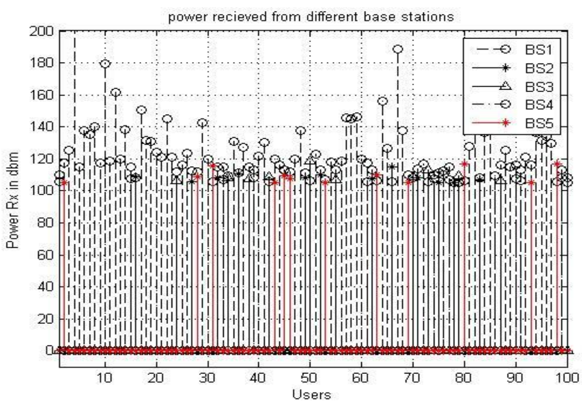

Figure 2; Representation of received power from different eNBs, when N=100, where N represent number of users

C. eNBs (BASE STATIONS) SERVING USERS

In following figure, different numbers of user are served from varying number of eNBs (base stations). A user may not be dependent or receiving signals from one eNB (base station) only, it may be served from more than one eNB (base station) at a time. Users from 1 to just before 20, are served by 2 eNBs (base stations) and users from 20 onwards are also served by two and in some cases from 3 as well, so we can say that interference is likely to affect the performance of the network

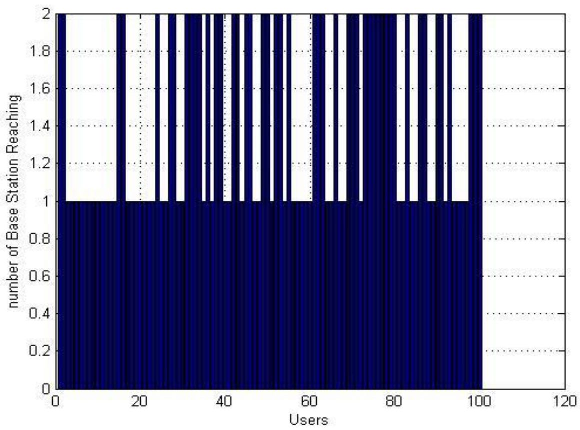

Figure 3; Number of base stations serving 100 users

D. REPRESENTATION OF CELL CENTER USERS AND CELL EDGE USERS

As discussed in figure 1 that the total coverage area of a cell is 1000m and to distinguish the cell edge and cell center users, we defined a boundary of 700m within a cell. The boundary specifies that the users in range of 700m are cell center user and users from 800m to 1000m are cell edge users.

Now in the following figure, the number of cell edge and cell center users are specified, when total number of users are 100, so there are approximately up to 75 cell center users shown from a bar at 0 to 0.1. And there are approximately up to 25 cell edge users shown from a bar at 0.9 to 1.

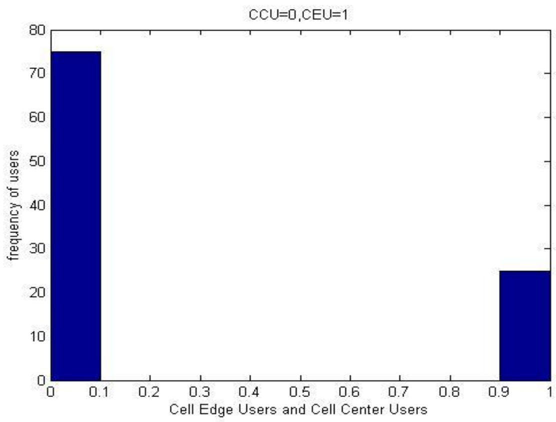

Figure 4; Representation of Cell edge users and cell center users, when there are 100 users

In the following figure, the number of cell edge and cell center users are specified, when total number of users are 200, so there are approximately up to 150 cell center users shown from a bar at 0 to 0.1. And there are approximately up to 50 cell edge users shown from a bar at 0.9 to 1.

IV. RESULTS AND COMPARISON

A. SINR COMPARISON AND RESULTS OF DIFFERENT SCENARIOS

In this step, The SINR is compared for different scenarios.
Scenario 1;
In first scenario the users are served from single cell, as the users are served from a single cell so there will be no interference and the SINR is computed from the following formula

$$SINR_{UE} = \frac{P_{ds}(t)}{P_{noise}(t) + P_{IUI}(t) + P_{ICI}(t)}$$

Where

P_{ds} (t) = power received by single serving BS
P_{noise} (t) = power of additive white Gaussian noise
P_{IUI}(t)=power of orthogonal frequency (intracell interference)
P_{ICI} (t) = power of inter cell interference
In case of single cell, there will be no neighboring cells so there will be no intercell interference and also there will be no intracell interference, so the only thing which will affect the signal is noise known as white Gaussian noise, so the formula of SINR for single cell is as follows

$$SINR_{UE} = \frac{P_{ds}(t)}{P_{noise}(t)}$$

Scenario 2;
In second scenario the users are served from multiple eNBs (base stations) and there is no coordination among the eNBs (base stations), so in this case there will be interference from neighboring eNBs (base stations) as users are served from more than one eNB (base station). So the signal is affected by intercell interference, the factor PIUI is zero because it is terminated by OFDMA, so the formula of SINR in this scenario is as follows

$$SINR_{UE} = \frac{P_{ds}(t)}{P_{noise}(t) + P_{ICI}(t)}$$

Scenario 3;
In third scenario the users are again served from multiple eNBs (base stations) and in this case there is coordination among the eNBs (base stations), so in this case there will be no interference from neighboring eNBs (base stations) as the coordination is responsible for the reduction of intercell interference. So the signal is not affected by intercell interference, so the factor P_{ICI} is zero and at the same time the factor PIUI is also zero because it is terminated by OFDMA, so the formula of SINR in this scenario is as follows.

$$SINR_{UE} = \frac{P_{ds}(t)}{P_{noise}(t)}$$

For above three scenarios, the SINR is compared in the following figure. SNR in single cell in denoted by red dotted line, SINR in multiple cells without coordination is denoted by black dotted line and SINR with coordination is denoted by black hysteric line. Is following graph is analyzed it can be seen clearly that the SINR with coordination is providing the best SINR as compared to other two scenarios. In following figure, the maximum SINR noted is above 300dB, which is due to coordination between the cells. In following figure there are 100 users and in accordance with that the SINR is computed for three scenarios.

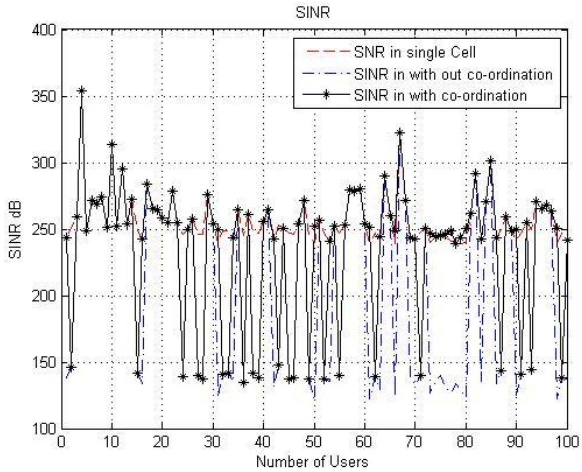

Figure 5; SINR comparison of three different scenarios, when N=100, where N represents number of users

B. OPTIMIZED DYNAMIC CELL SELECTION ALGORITHM

```
SINR=zeros(1,N);

for n=1:N

 if Ut(n)==0;
   S=Pr_bs(1,n);
   I=sum(Pr_bs(:,n))-S;
   SINR(n)=Pr_bs(1,n)-(I+NdB(n));
  end

 if Ut(n)==1;
   S=max(Pr_bs(:,n));
   I=(sum(Pr_bs(:,n))-S);
   SINR(n)=S-(NdB(n));
  end
```

C. CAPACITY COMPARISON OF DIFFERENT SCENARIOS

The capacity of three different scenarios is calculated by Shannon's capacity formula

$$C=BWlog_2(1+SINR)$$

In above formula there are two parameters BW is bandwidth and SINR. The bandwidth is taken 15MHz for these scenarios and SINR is computed as well. Here again the capacity is compared of three scenarios as discussed earlier, the SINR in single cell, SINR without coordination and SINR with coordination.
In figure 6, the users are shown on X-axis and capacity is shown on Y-axis, there are 100 users and in accordance with this the capacity of the system is calculated. Capacity is measured in GB. The dotted green line is showing the capacity of system when the users are served from single cell, dotted red line shows the capacity of the system when users are served from multiple cell and there is no coordination among the cells and the line denoted with small stars shows the capacity of the system when user are served from multiple cells and there is coordination among the cells. The green line

is showing the best system capacity as there is no intercell interference and if the other two cases are compared here so capacity of the system with coordination is showing the better results as compared with the scenario when there is no coordination among the cells.

If these three scenarios are compared specially in scenario where there is no coordination among the base station and when there is coordination among the base stations, we can see clearly that when there is coordination among the base stations, so this case is providing better system capacity to the users. In first case when there is a single cell there is no interference that's why the results of single cell is better than other two scenarios, but here main purpose is to coordinate the base stations and to compute the capacity which provides better results.

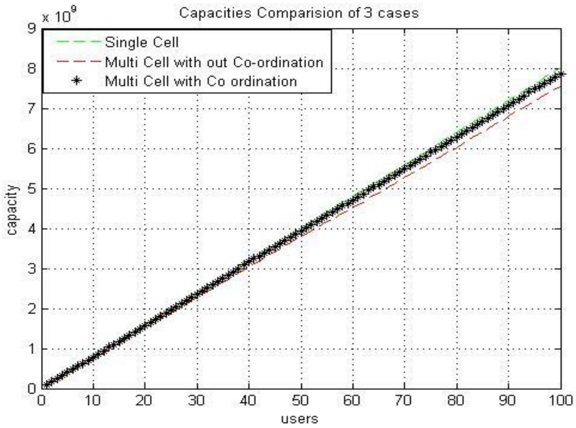

Figure 6; Capacity comparison of three different scenarios, when N=100, where N represents number of users

V. Conclusion

This paper focuses on coordination among the base stations and reduction of interference among the base stations. Here microcells are used because in large macrocells the cell edge areas do not receive good signal strength, so to improve the performance at cell edge and provide the users with better signal quality we use microcells for better coverage. Still the problem of interference arises between microcells, so for this purpose interference reduction is done. In future, for this purpose there might be hybrid network which will consist of different cells in a same coverage area.

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