Interference Management using Fractional Frequency Reuse in 4G Cellular System

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Abstract—The trend in OFDMA based 4G cellular wireless cellular technology is to allot complete system bandwidth in each cell, so that more number of users can be supported. But such allotment of whole bandwidth to each cell would make all other cells contributing to interference. Interference Management in the issue considered here thereby leading to enhancement in channel capacity and spectral efficiency of each user in systems in context with 4G systems. In this work Fractional Frequency Reuse (FFR) has been employed in OFDMA system to improve the throughput per user and to bring more users in coverage especially the cell edge users affected by reuse-1.

Keywords—*4G; OFDMA; FFR, bandwidth; ICIC*

I. INTRODUCTION

The trend in LTE Advanced/4G cellular technology is to use maximum bandwidth (i.e complete system bandwidth - Reuse 1) in each cell, so that more number of users can be supported. Even though due to the the use of OFDMA in 4G there won't be intra cell interference but there would be inter cell interference. This inter cell interference would lead to lesser signal to Interference + noise ratio (SINR), thereby leading to fall in spectral efficiency as well as less users would be in coverage, particularly cell edge users.

Employing Fractional Frequency Reuse in OFDMA systems improves the channel capacity [1-5]. FFR achieves higher capacity than the non-FFR equivalent when the outage rate is low. The neighbouring base stations transmitting at the same frequency in the first and second tier of the cellular system are the major source of interference to the desired base station. Inter-cell interference coordination can even be done simply by a priori frequency planning.

Inter-cell intra-frequency interference is the main interference in LTE. This interference is severe in intra-frequency networking (i.e. frequency reuse 1) . In order to mitigate this kind of interference, the simplest way is inter-frequency networking (e.g. frequency reuse 3 for topology of 3-sector per site). But inter-frequency networking decreases the channel capacity. Therefore ICIC (Inter Cell Interference Coordination) need to be done. Goal identified is how to keep the interference to as low as possible while allocating the whole bandwidth to each cell. Goal identified is how to keep the interference to as low as possible while allocating the whole bandwidth to each cell. The objective of this work is (1) To design a frequency planning so that less interference is encountered by cell edge users even after using the whole alloted bandwidth. (2) To decrease the blockage probability and thereby improving the overall system coverage and hence improving the system capacity.

The rest of the paper is as follows: Section II deals with frequency reuse schemes. Section III deals with cellular tier structure and received power and interference. Results have been analysed in section IV while the last section V deals with conclusions.

II. FREQUENCY REUSE SCHEMES IN LTE AND THEIR C OMPARATIVE ANALYSIS

There are several solutions to realize ICIC. ICIC can be classified as static ICIC, semi-static ICIC and dynamic ICIC according to resource coordination period. ICIC can also be classified as Fractional Frequency Reuse, Soft Frequency Reuse, and Full Frequency Reuse according to resource coordination type. No matter which ICIC solution is used, frequency allocation for cell edge users needs to be specially considered and planned. In real networking, cell edge frequency reuse can be 3 while cell center frequency reuse is 1.

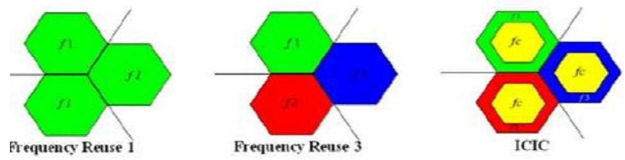

Fig. 1. Frequency Reuse and ICIC

Careful management of inter-cell interference is particularly important in systems such as LTE which are designed to operate with a frequency reuse factor of one. The scheduling strategy of the eNB (evolved node Base Station) may therefore include an element of inter-cell interference coordination, whereby interference from and to adjacent cells is taken into account in order to increase the data rates which can be provided for the users at the cell edge.

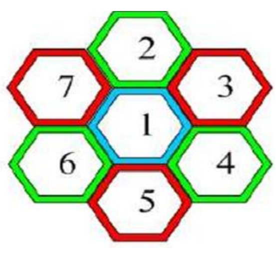

Fig. 2. Interference Co-ordination

This implies for imposing restrictions on what resources in time and/or frequency are available to the scheduler, ,or what transmit power may be used in certain time/frequency resources. The impact of interference on the achievable data rate for a given user can be expressed analytically.

If a user k is experiencing no interference, then its achievable rate in a RB m of subframe f can be expressed as

$$R_{k,no-Int}(m,f) = (B/M)log[1 + P^s(m,f)!H_k^s(m,f)!^2/No]$$

where the channel gain is

$$H_k^s(m,f)$$

III. TWO TIER CELLULAR ARCHITECTURE

In this work I have considered Two Tier-19 cells, UEs under study are at centre cell. They are getting interfered from the other 18 base stations which are transmitting at the same frequency what the intended centre base station is transmitting.

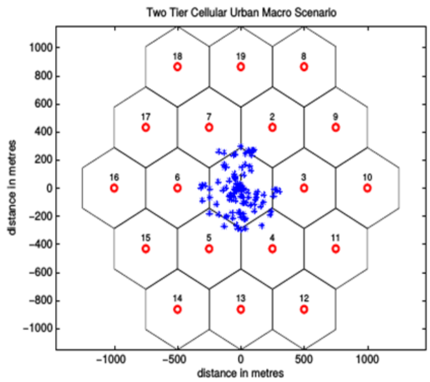

Fig.3 Two Tier Cellular Architecture

Here downlink of the multicellular system is considered. Key performance indicators considered are i) SINR (signal to interference + noise ratio) vs distance from Base station ii) Spectral efficiency vs distance iii) Channel capacity iv) SINR vs spectral efficiency v) Coverage/outage.

IV. RESULTS AND ANALYSIS

The simulation parameters [6-7] used for analysis are given in table below:

TABLE I : SIMULATION PARAMETERS FOR FFR AND INTERFERENCE CO- ORDINATION IN LTE

Parameters	Values
Transmitted Power	46dBm
Intersite distance	1732metres
Frequency of operation	0.8 GHz
Shadowing factor	0
Pathloss Exponent	3.76
Bandwidth	10MHz
Noise figure	7
Antenna Pattern	omni-directional

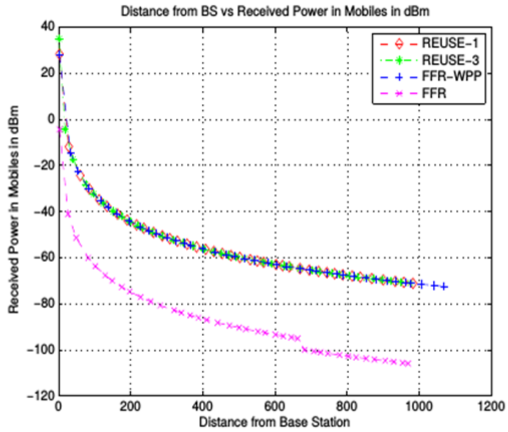

Fig. 4. Received Signal Strength in UEs in dBm

This figure 4 shows the plot of the received signal by UEs in dBm as they move away from the base station.

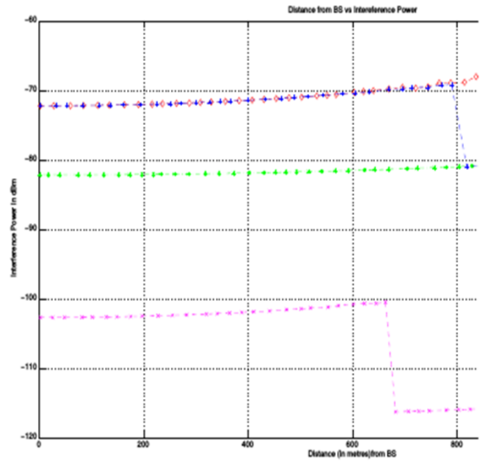

Fig. 5. Interference faced by UEs

The figure 5 is indicating that FFR(fractional frequency reuse) outperforms in terms of less interference from neigbouring base stations (cochannel), particularly the cell edge UEs which are prone to interference,are having appreciably less interference

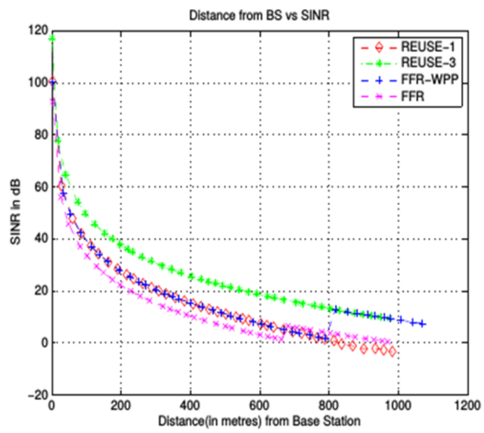

Fig. 6. SINR in UEs

The figure 6 shows the received SINR of UEs with respect to distance from base station (eNB). Conclusions from this figure are that FFR has better SINR for cell edge users, which is the need of designers.

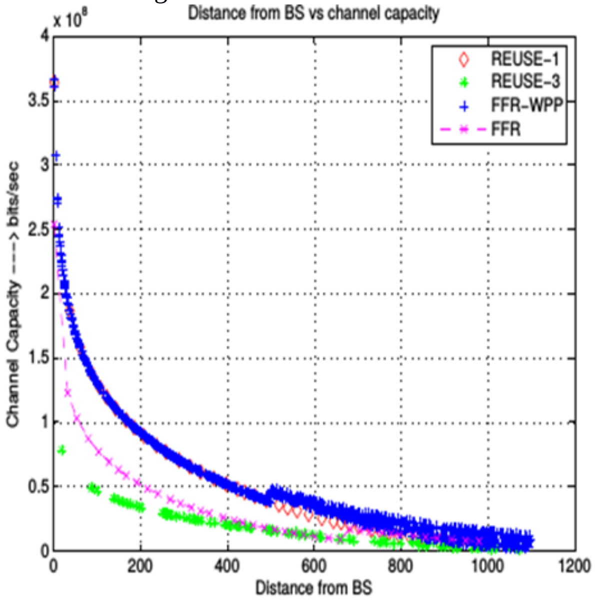

Fig. 7. Channel Capacity

The figure 7 shows the channel capacity of UEs under different reuse schemes. From the figure it is seen that FFR has the channel capacity in between Reuse-1 and Reuse3

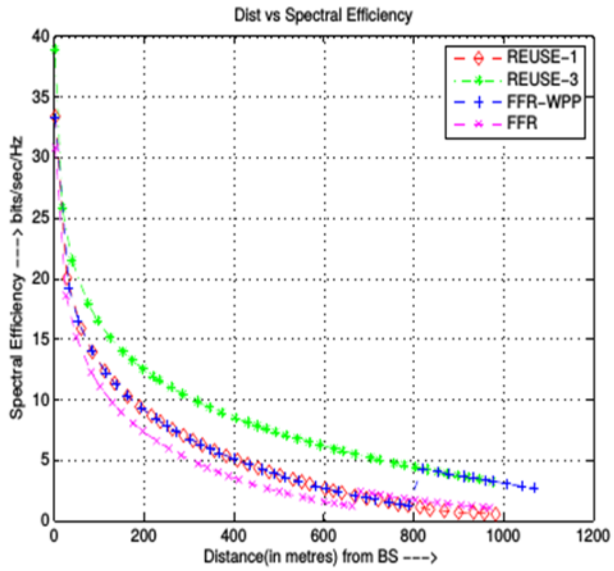

Fig. 8 Spectral Efficiency

The figure 8 shows the spectral efficiency of UEs under different reuse schemes. Conclusion from this figure is that cell edge users have better spectral efficiency just like reuse 1 while maintaining lesser interference from cochannel interferers.

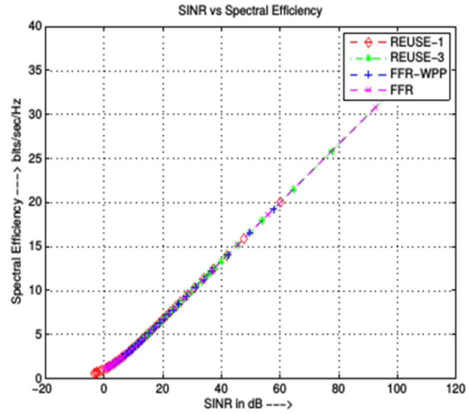

Fig. 9. SINR vs Spectral Efficiency

The figure 9 is plot of spectral efficiency vs SINR. The conclusion from this figure is that in terms of spectral efficiency FFR is equivalent to other schemes.

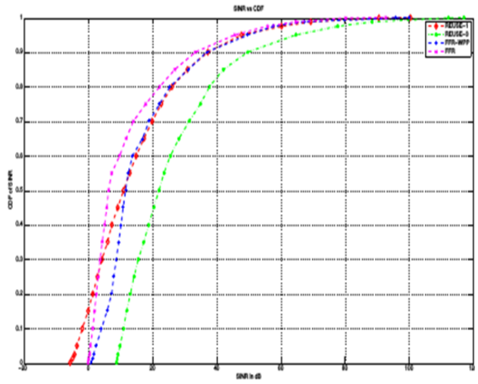

Fig. 10. CDF of SINR of UEs.

The figure 10 shows the plot of cumulative distribution function (CDF) of SINR of UEs under reuse schemes. Conclusion from this figure is that 99.999 percentage UEs are under coverage. This is the strongest point with FFR along with least interference from cochannel interferers.

V. CONCLUSIONS

FFR(fractional frequency reuse) outperforms in terms of less interference from neigbouring base stations(cochannel), particularly the cell edge UEs which are prone to interference,are having appreciably less interference. Conclusions re are that FFR has better SINR as compared to Reuse1 for cell edge users, which is the need of designers. FFR has the channel capacity in between Reuse-1 and Reuse3 Further conclusions are that cell edge users have better spectral efficiency just like reuse 3 while maintaining lesser interference from cochannel interferers. Conclusion from the last figure is that 99.999 percentage UEs are under coverage. This is the strongest point with FFR along with least interference from cochannel interferers.

VI. REFERENCES

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