Intercell Interference Coordination and Link Adaptation

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Abstract**—**In a multicellular scenario link adaptation cannot be treated as an isolated phenomenon, intercell interference coordination (ICIC) affects link adaptation. In this paper link adaptation has been analysed for different ICIC techniques.

Keywords—ICIC Techniques; Link Adaptation; Fractional Frequency Reuse

I. INTRODUCTION

LTE networks use a whole chunk of bandwidth allocated so that system capacity is better, but using single frequency in all base stations leads to interference from other BSs. Fractional Frequency Reuse in LTE uses a whole chunk of allocated bandwidth at the center whereas at the edges fractional frequency, is used to avoid interference from neighboring BSs, shown through simulation in [1], [2] and [3] and analytically in [4]. A comparative analysis of the various ICIC techniques and comparison between ICIC coordination vs ICIC non-coordination has been done by authors in [5] showing that coordinated ICIC enhances the overall throughput.

Link adaptation cannot be treated as an isolated mechanism to maximize spectral efficiency with fluctuating wireless channel conditions, it heavily depends on frequency planning and interference from other BSs. In [6], the authors have dealt with the relationship between ICIC, PS and LA, the improvement observed is at the stake of complexity involved. CSI (Channel state information) and static ICIC have been jointly considered in [7] using outdated CSI, aiming to improve the throughput. The authors have assumed CQI lifetime equal to 15ms to avoid prediction. Hence a joint ICIC and link adaptation needs to be studied to better look into inter-relationship between ICIC and LA and and the approach to further enhance spectral efficiency.

II INTER CELL INTERFERENCE COORDINATION

The current technology in cellular communication in order to increase the system capacity is moving towards the complete system bandwidth in each and every cll. But such an arrangement would lead to heavy interference from the neighboring cells. In order to mitigate this inter cell interference fractional frequency reuse (FFR) has been proposed [1-5]. The basic concept behind this is that the cell centre users are less affected by inter cell interference whereas the cell edge users are predominantly affected by inter cell interference. FFR is of two approaches i) Strict FFR and ii) Soft FFR.

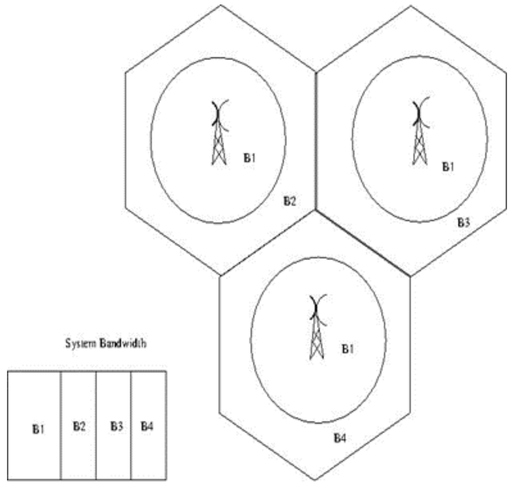

Fig .1 Depicting Strict FFR

In the above figure which depicts strict FFR. The system bandwidth is divided into four parts B1, B2, B3 and B4. The center part of each cell is assigned B1 whereas B2, B3 and B4 to the outer parts of the cells, B2 to one, B3 to the second outer cell and B4 to the third outer cell. In soft FFR there is flexibility in the use of B1, B2,B3 and B4 or combination of these can be used.

The purpose of single frequency reuse or FFR is to support more number of users. Ultimately there should be enhancement in the system capacity. As the user user capacity depends on signal to Interference + noise ratio (SINR).

On one hand we are implementing single frequency reuse or FFR to support more users but on the other hand interference is increasing. ICIC management effects link adaptation.

Dynamic ICIC (i.e dynamic FFR) and link adaptation can be done in a coordinated way to enhance spectral efficiency. Using link adaptation we do optimize the spectral efficiency subject to bit error rate constraint.

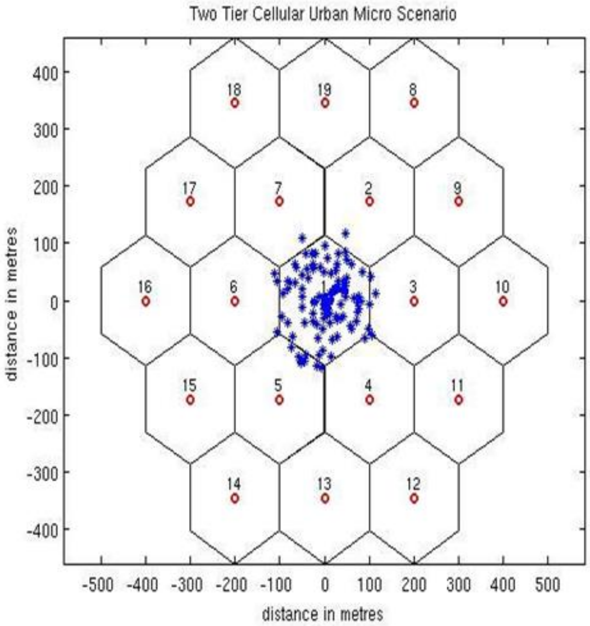

Figure 2

III. SYSTEM MODEL

In this work I have considered the downlink multicellular scenario. The dominant interferers I took in this work are from first and second tier.

The above figure 2 shows the two tier cellular network employed in this work.

The received SINR at a UE can be expressed as

$$\gamma(d_M) = \frac{P_M d_M^{-\eta}}{P_i d_i^{-\eta} + N_o B_c}$$

where P_M is the power from the intended eNB and Pi is power from the interfering eNB, d is the distance of UE from eNB . Here N_0 is the AWGN power spectral density and B_c is the bandwidth under consideration.

Based on this SINR, we need to optimize the link performance between eNB and UE called as link adaptation. In link adaptation we optimize the bit rate than be loaded into the frame corresponding the bandwidth being utilized. In this work I have optimized the link by optimizing the power and then ultimately optimizing the rate as in [8] and [9] as

$$\max_{P(\gamma)} E \sum_{k=1}^{k=N_{used}} [\log_2(M[\gamma])] = \max_{P(\gamma)} E \sum_{k=1}^{k=N_{used}} [\log_2(1 + K\gamma \frac{P(\gamma)}{\bar{P}})]$$

solving for power as in [8,9]

$$\frac{P(\gamma)}{\bar{P}} = \frac{1}{\gamma_0} - \frac{1}{\gamma K} \qquad for \quad \gamma \geq \frac{\gamma_0}{K} = \gamma_K$$

$$\frac{P(\gamma)}{\bar{P}} = 0 \qquad else$$

$$R(\gamma) = \log_2(\frac{\gamma}{\gamma_K})$$

Then plugging the value of power adaptation we get the optimized rate as

Simulation Parameters Used

Parameters	Values
Transmitted Power	41dBm
Intersite distance	200 meters
Frequency of operation	2.5 GHz

IV. RESULTS AND THEIR ANALYSIS

In figure 3 we have plotted the power adaptation for i) Reuse1 ii) FFR and iii) Reuse 3. In the ordinate is power adaptation and in the abscissa is SINR. The plot is basically for each SINR how much optimum power

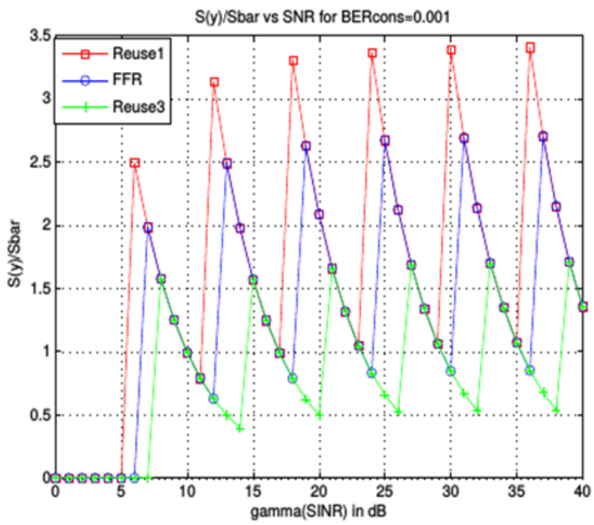

Figure 3 Power adaptation with SINR

It is seen from the results that for each reuse technique more the SINR higher the power can be pumped. It is seen from the results that in Reuse one highest power can be pumped. In case of FFR less power can be pumped as comparison to Reuse 1. In Reuse 3 least power can be pumped. Thus from the power perspective Reuse1 outperforms all whereas Reuse3 has least . FFR allows neither more nor less.

In figure 4, I have plotted rate adaptation which itself is how much data rate can be pumped for each SINR. In the ordinate is rate adaptation and in abscissa is SINR.

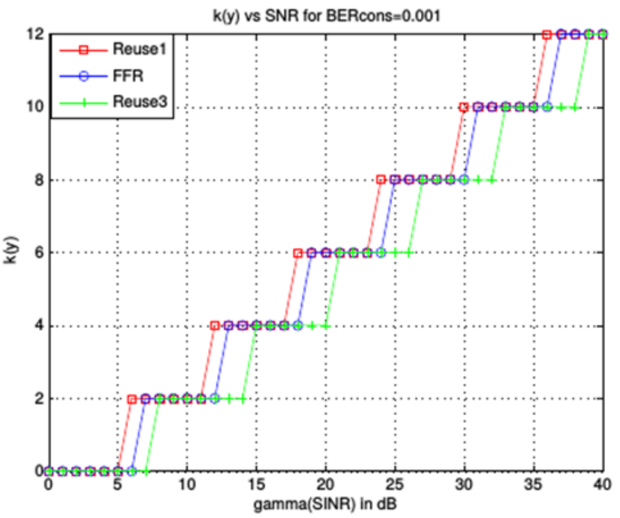

Figure 4 Rate adaptation vs SINR plot

It is seen from the figure that Reuse has highest data rate . Whereas in order to get same data rate more SINR is needed in FFR and further more in Reuse3. Thus it can be said that Reuse 1 implies better capacity but more outage probability as compared FFR.

VII. C ONCLUSION

The conclusion from this work is that ICIC management effects link adaptation. Hence bit loading along with power adaptation needs to be taken care while doing ICIC management and vice versa.

VIII. REFERENCES

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