

Agenda Item: 10.2.1
Source: Huawei
Title: Further Analysis of Soft Frequency Reuse Scheme
Document for: Discussion & Decision

1. Introduction

At the RAN1#41 meeting we proposed the soft frequency reuse scheme in [1]. The soft frequency reuse scheme can suppress the inter-cell interference and improve cell edge data rate. It can be employed as one possible solution for inter cell interference mitigation. This contribution further analysis soft frequency scheme by the provision of detailed simulation results. The soft frequency reuse scheme for inter-cell interference mitigation is briefly described in Section 2. The simulation assumptions are given in the Section 3. And then in Section 4, we provide simulation results and basic analysis. Finally, conclusions are drawn in Section 5.

2. Soft frequency reuse scheme for inter-cell interference mitigation

In the proposed soft frequency reuse scheme, sub-carriers are divided into two groups in every cell. One group is called major sub-carriers group, and the other one is called minor sub-carriers group. For each group of sub-carriers, one maximum allowed transmission power is set for them. Normally, the maximum allowed transmission power for major sub-carriers is higher than minor sub-carriers. The transmission power on each sub-carrier shall not exceed this limitation. The major sub-carrier can be used to cover the whole cell area, while the minor sub-carrier is used only in the inner part of the cell, as is showed in figure 1 (the blue represents the inner zones and the other colors represent the cell edges). Major subcarriers in neighboring cell are orthogonal (i.e. no overlap). The so called “Power Ratio” is the ratio between transmit power limitation of minor sub-carriers and major subcarriers. Power Ratio adjusted gradually from 0 to 1, the effective reuse factor changes from 3 to 1 smoothly. So, the SFR is the compromise of reuse 1 and reuse 3.

By adjusting the power ratio, SFR can adapt the variation of the service distribution in each cell. When the high traffic happens at the cell edge, the power ratio should be set to a relatively small value to get a high cell edge bit rate. On the contrary, when the traffic is mainly located at the inner part of the cell, a relatively large value for the power ratio is reasonable.

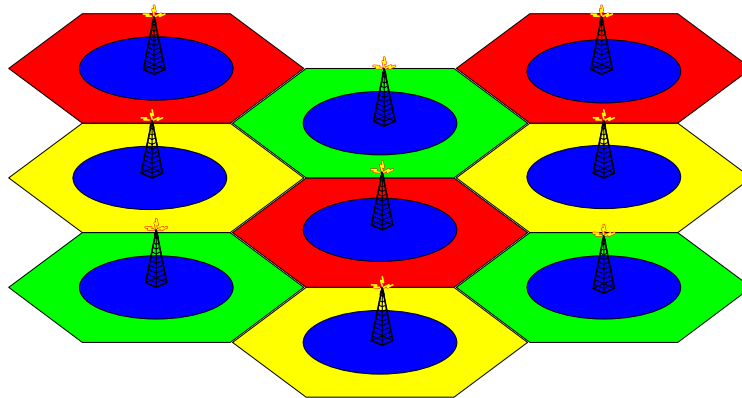


Figure 1, Cell deployment

3. Simulation assumption

Simulation parameters are listed in **Error! Reference source not found.** These are in-line with 25.814[2].

Parameter	Value
Carrier frequency	2GHz
System bandwidth	5MHz
Cellular Layout	Hexagonal grid, 19 cell sites
Inter-site distance	1000m
Distance-dependent path loss	$L=128.1 + 37.6\log_{10}(R)$, R in kilometers
Lognormal Shadowing	Log Normal Fading with 0 mean, 8dB standard deviation
BS transmit power	43dBm
UE Noise Figure	9dB
Tx antennas (BS)	1
Rx antennas (UE)	1
Traffic model	Full buffer
Link Adaptation	Perfect
Modulation	QPSK and 16-QAM
Coding	Rate 1/3, 1/2, 2/3, 3/4, 4/5 Turbo
Number of total sub-carriers	300
Number of Major sub-carriers	100
Number of Minor sub-carriers	200
UE number per cell	6
Cell edge UE number	2
Inner zone UE number	4
White noise power density	-174 dBm/Hz

Table1: simulation parameters

4. Simulation results

A network with 19 cells, 300 sub carriers per cell and the total bandwidth 5 MHz is used. 100 sub-carriers are defined as major sub-carriers which are assigned only to the cell edge users and the other 200 as minor sub-carrier only to the inner zone users. 1/3 users are uniformly and randomly distributed in cell edge areas (1/3 of the total area), whereas 2/3 users in inner zone. In the simulation, the same number sub-carriers are assigned to each user, the number of UE in each cell is 6, 2 UE is located at so-called cell edge.

The figure 2, 3, 4 shows the cell edge throughput, the inner zone throughput and the total cell throughput varieties curves with the different Power Ratio. The X coordinate represents the transmission power ratio. When the power ratio is 1, the soft frequency reuse scheme is the same as the reuse factor 1, which means that the powers limitation for all the sub-carriers are same, when the power ratio is 0, it is equal to the reuse factor 3, which means that minor sub-carriers do not exist.

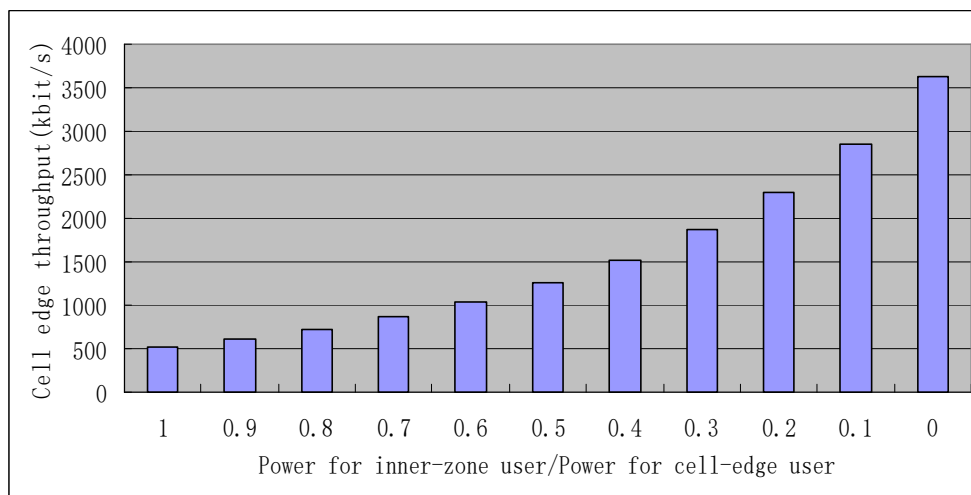


Figure 2, cell edge throughput in soft frequency reuse scheme

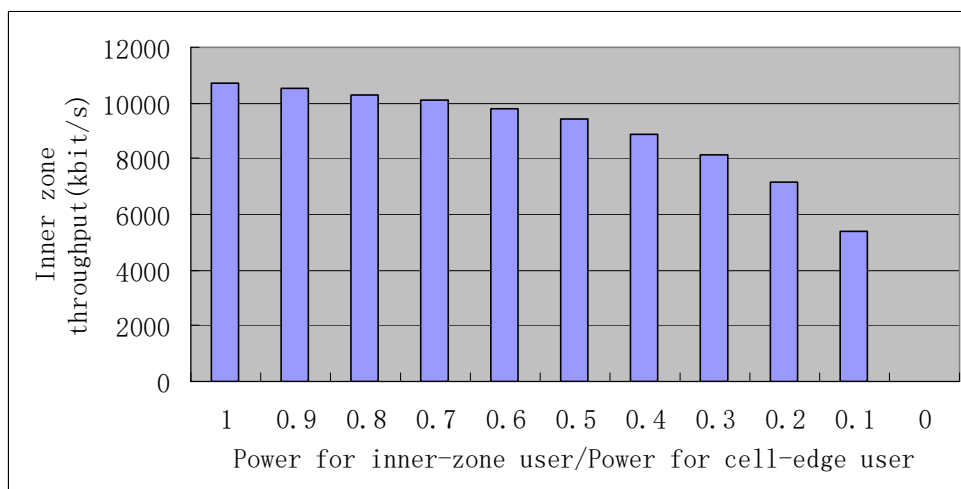


Figure 3, inner zone throughput in soft frequency reuse

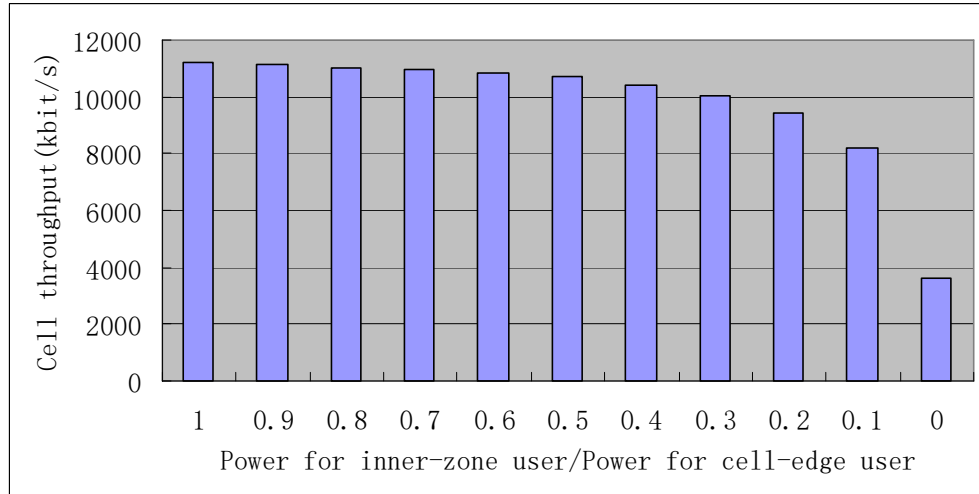


Figure 4, cell throughput in soft frequency reuse scheme

These figures show:

1. When the power ratio decreases, the cell edge throughput increases due to the increasing transmission power for cell edge users and the mitigation of co-channel interference. When the power ratio is 1, the throughput for cell edge is about 500kbit/s, when the power ratio decreases to 0.4, the throughput can reach 1.5Mbit/s, and when the power ratio is 0, the throughput can reach 3.5Mbit/s.

2. When the power ratio decreases, the inner zone throughput decreases. When the power ratio is 1, the inner zone throughput is about 10.7Mbit/s, when the power ratio moves 0.4, the value decreases to 8.9Mbit/s, which decreases 16.8%.

3. When the power ratio decreases, the total cell throughput decreases also. When the power ratio is 1, the total cell throughput is about 11.2Mbit/s, when the power ratio is 0.4, the value decreases to 10.4Mbit/s, which decreases 7.1%. This figure also show that, when power ratio is large that 0.3, the cell throughput reduces slightly along with power ratio decreasing.

Then, we give the CDF curves to illustrate the performance of frequency soft reuse scheme compared with conventional OFDM (Reuse factor =1). In this simulation, we assume the power ratio is 0.4.

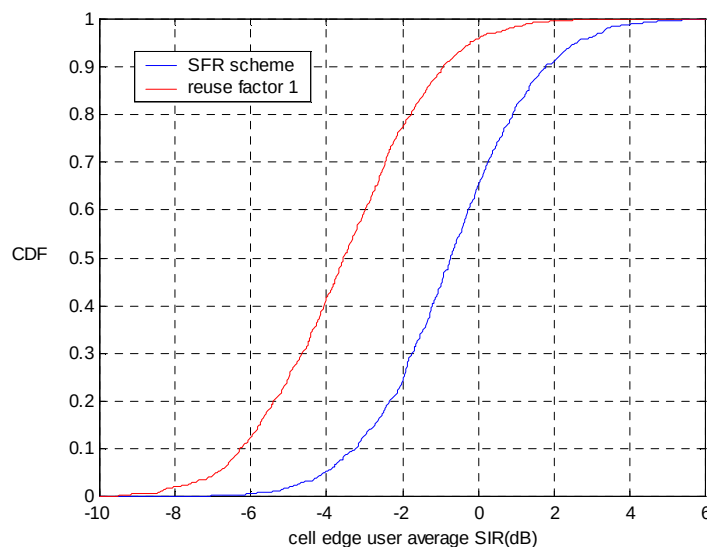


Figure 5, CDFs of the cell edge user average SIR

Figure 5 shows the CDF curves of the cell edge user average SIR with soft frequency reuse scheme and without it. From the figure, the cell edge user average SIR can be improved by 3dB for the probability of 90%.

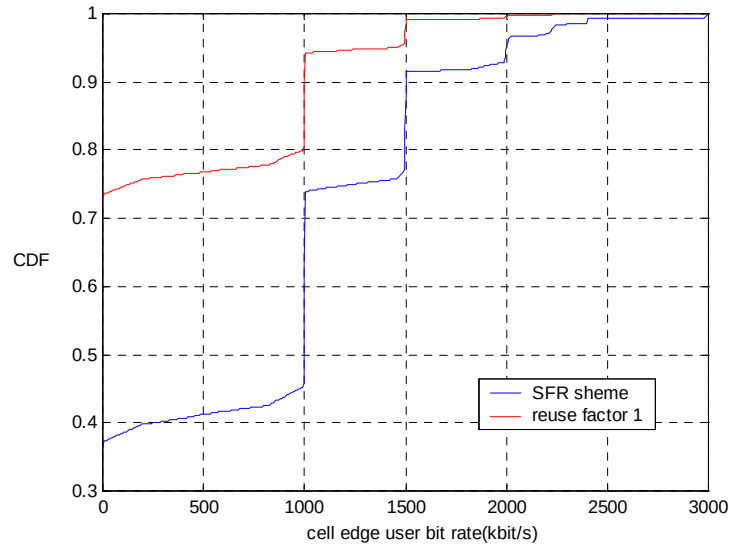


Figure 6, CDF of cell edge user bit rate

Figure 6 shows the CDF curves of the cell edge user bit rate. When CDF value is equal to 0.9, the probability that the cell edge user bit rate is not less than 1.5Mbit/s is 10% for soft frequency scheme, whereas, when reuse factor=1, the corresponding value is only 1Mbit/s.

5. Conclusion

The soft frequency reuse scheme can reduce the inter-cell interference and improve cell edge data rate. By rightly adjusting the power ratio, the soft frequency reuse scheme can adapt the variation of location based traffic distribution. So, we propose that soft frequency reuse scheme should be thought as one candidate solution for inter-cell interference mitigation.

6. Text Proposal

----- Start of Text Proposal -----

7.1.2.6 Inter-cell interference mitigation

Inter-cell interference is suppressed by processing/coding gain in combination with cell-specific scrambling (randomization) of the coded data streams. The alternative use of cell-specific interleaving as a means for randomization should also be considered. Receiver technologies suppressing inter-cell interference may also be considered.

To further reduce the downlink inter-cell interference, constraints can be imposed on the Node B scheduler. The scheduler may e.g. be limited to schedule data only on a sub-set of the total set of sub carriers or have a limit in the allowed maximum transmit power on some sub carriers. If these scheduler constraints are coordinated between cells in such a way that the

sub-sets mentioned above are orthogonal, each cell can then experience reduced inter-cell interference and, potentially, improved cell-edge coverage. This also include means to orthogonalize pilot between cells

Operation with a frequency reuse larger than one should also be considered as part of the Study Item.

The soft frequency reuse scheme, in which effective reuse factor can be changed gradually according to traffic distribution by adjusting power ratio of minor and major sub-carriers, should be considered as a possible solution to suppress inter-cell interference and improve cell edge data rate.

----- *End of Text Proposal* -----

7. Reference

- [1] R1-050507, Soft Frequency Reuse Scheme for UTRAN LTE, Huawei
- [2] TR25.814 v011, "Physical Layer Aspects for Evolved UTRA", Sophia Antipolis, France, June 2005