3GPP TSG-RAN WG4 meeting #52 **R4-093170**
Shenzhen, P. R. China, 24 – 28 August, 2009

Agenda item: **8.2**

Source: **Nokia, Nokia Siemens Networks**

Title: **Evaluation of Ec/Io based triggering to handle non-allowed CSG cells in UTRAN**

Document for: **Discussion**

1. Introduction

In previous meetings the issue related to mixed carrier deployment of CS cells has been considered [1],[2]. This issue has been raised also in RAN2, which has sent an LS to RAN4 [3] asking WG4 view on the issue for both LTE and UTRA. In this contribution we evaluate the performance of UTRA Ec/Io based triggering for handling the possible interference issues in mixed carrier CSG deployment and non-allowed cells. These results are comparable to those in [4], which were using similar simulation assumptions, just for LTE.

2. System simulation assumptions

This study has been performed using a fully dynamic time driven HSDPA system simulator. We have used Ec/Io measurements for evaluating the best cell and for making the actual cell selection and cell reselection decisions. In the simulations the UE makes Ec/Io measurements with predefined period ("measurement interval"). The collected measurement results are then non-coherently averaged over a predefined sliding window ("measurement period"). It is also assumed that cells are automatically detected by UE, thus no cell search procedure is modelled.

These studies have been done in a combined macro-CSG scenario with one frequency layers presented in Figure 1. All users are located inside an active macro area, which is situated in the middle of three sites with total of 6 macro cells (area border indicated with dotted line in Figure 1). Users are able to connect only to the grey cells indicated in the figure. The surrounding white macro cells are interferers, i.e. they only create same kind of interference as middle 6 cells and a UE cannot do cell selection or reselection to them.

Inside the active macro area there are 37 buildings having uniform separation to their neighbouring buildings. UEs created to the surrounding macro area can enter to the buildings and exit from them. The layout of each building is depicted in Figure 2. The building walls do not restrict users' mobility but they do affect the signal propagation. A CSG cell with isotropic antenna is created in the middle of each building. The macro and CSG parameters are presented in Table 1 in annex.

Although these simulations are used to evaluate idle mode performance, all UEs are receiving one packet per 2.56 seconds to have an estimate for the Signal-to-Interference-and-Noise-Ratio (SINR) UE would have in downlink when starting a call.

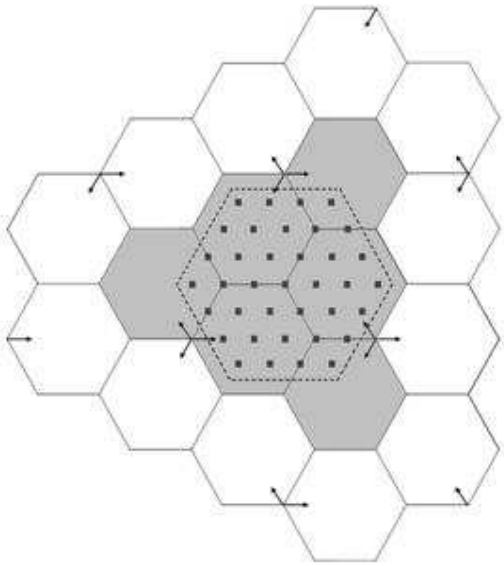

Figure 1. Simulation scenario

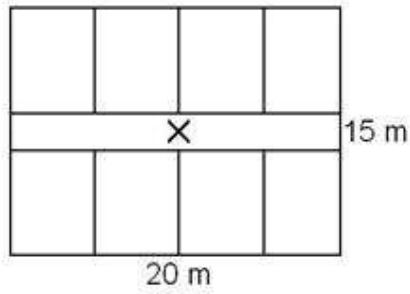

Figure 2 Building layout

3. Simulation results

In this section we present the simulation results for the scenario described in previous section. For CSG cells 15 dBm maximum transmission power is used and CSG cells have varying load with average 50% resource utilization.

In these simulations different Ec/Io thresholds are used to trigger inter-frequency re-selection to lower priority frequency layer. So if UE measured Ec/Io is lower than given threshold inter-frequency re-selection is initiated for that UE. Then HS-DSCH SINR is gathered for users who remain on high priority frequency layer. Simulated Ec/Io thresholds are -3, -6, -9, -12, -15 and -18 dB.

3.1 All users

HS-DSCH SINR for Macro scenario and combined Macro-CSG scenario is presented in Figure 3 when inter-frequency re-selections are not used. Degradation of SINR values due to CSG cell interference is clearly visible in case of combined Macro-CSG scenario.

Figure 4 shows the probability of inter-frequency re-selectionr from higher priority layer to lower priority frequency layer for different Ec/Io thresholds. When Ec/Io threshold is lowered, the inter-frequency re-selection probability decreases clearly . The effect of CSG cells is visible as inter-frequency re-selection probability in combined Macro-CSG scenario is higher than in Macro scenario with all simulated thresholds. Also the difference in terms of inter-frequency re-selection probability between Macro scenario and combined Macro-CSG scenario increases when Ec/Io threshold is lowered.

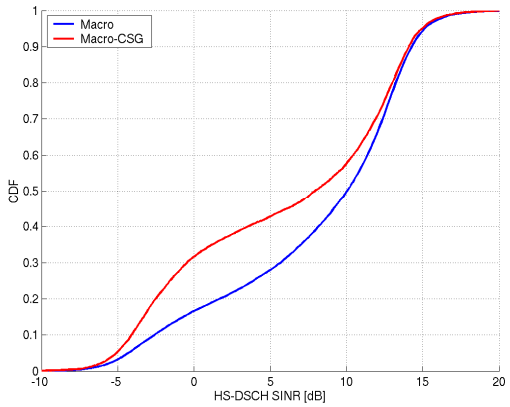

Figure 3. HS-DSCH SINR for Macro scenario and combined Macro-CSG scenario

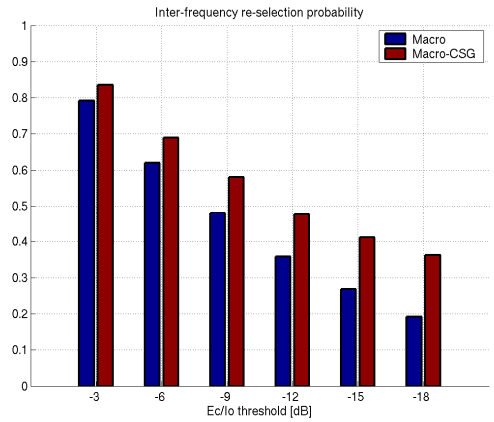

Figure 4. Probability of inter-frequency re-selection for different Ec/Io thresholds

Figure 5 and Figure 6 show HS-DSCH SINR CDF for users who will remain on high priority frequency layer in Macro scenario and combined in Macro-CSG scenario, correspondingly. When Ec/Io threshold is lowered SINR values for users on high priority frequency layer decreases, although with simulated Ec/Io thresholds low SINR values are clearly removed as less than 4 % of the SINR values are below 0 dB in Macro scenario and less than 8 % in combined Macro-CSG scenario.

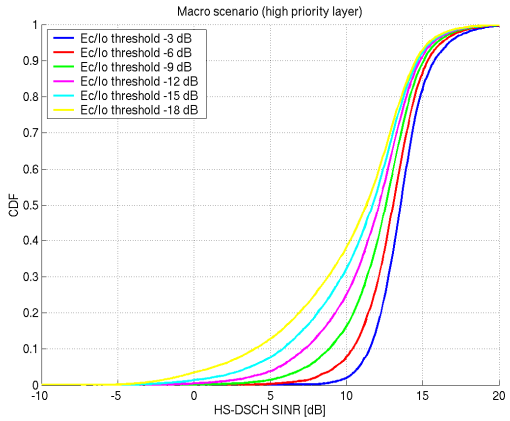

Figure 5. HS-DSCH SINR for user that will remain on high priority frequency layer in Macro scenario

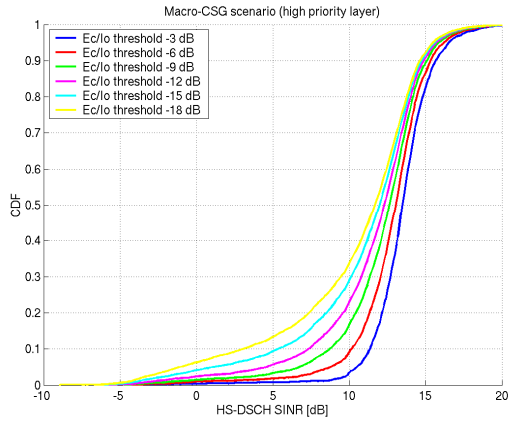

Figure 6. HS-DSCH SINR for user that will remain on high priority frequency layer in combined Macro-CSG scenario

Figure 7 shows CDF of Macro NodeB transmit power for Macro scenario and combined Macro-CSG scenario. Macro cell loading remains at quite low level and 80 % of the time Macro NodeBs are only transmitting pilot and associated DCH. In Macro-CSG cases, there is more interference due to the presence of the CSG cells, which causes somewhat more macro transmit power usage even though minimum power (i.e. pilot + associated DCH) is still used for about 80% of time (compared to the 95% of time without the CSG cells). The increase in transmit power is mostly caused by users who are located indoors, close to the CSG cells.

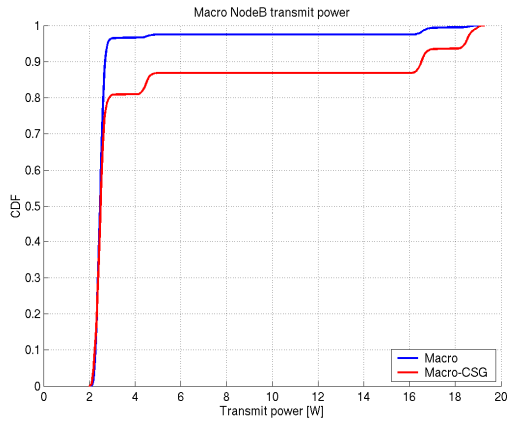

Figure 7. NodeB transmit power for Macro scenario and combined Macro-CSG scenario

3.2 Indoor users only

HS-DSCH SINR for indoor users is presented in Figure 8 when inter-frequency re-selection triggering is not used. Indoor users suffer from higher interference from CSG cells and when inter-frequency re-selection triggering is used re-selection probability is over 80 % for all simulated Ec/Io thresholds as shown in Figure 9.

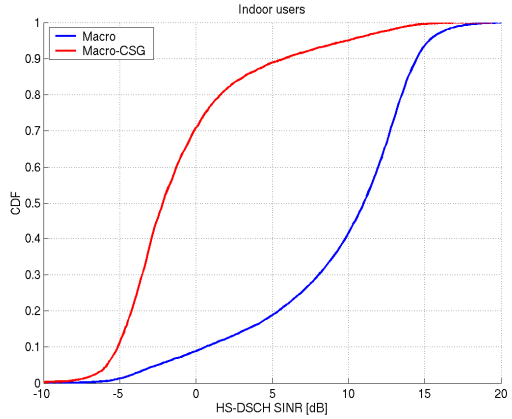

Figure 8. HS-DSCH SINR for Macro scenario and combined Macro-CSG scenario

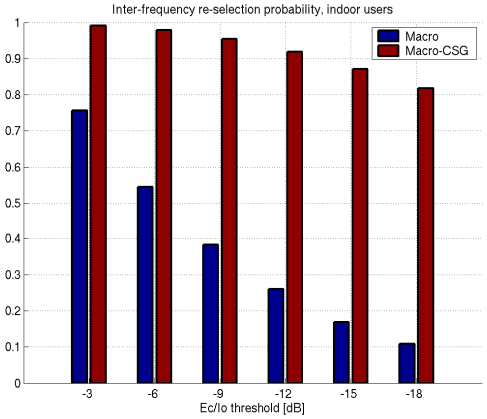

Figure 9. Probability of inter-frequency re-selection for different Ec/Io thresholds

Figure 10 and Figure 11 show CDF of HS-DSCH SINR with different Ec/Io thresholds for users who remain on high priority frequency layer. In case of combined Macro-CSG scenario (Figure 11) most of the users are moved to lower priority frequency layer, especially with highest Ec/Io thresholds. For the lower simulated Ec/Io thresholds (≤ -9dB) the HS-DSCH SINRs are worse, with over 30% probability of having worse SNR than 0dB.

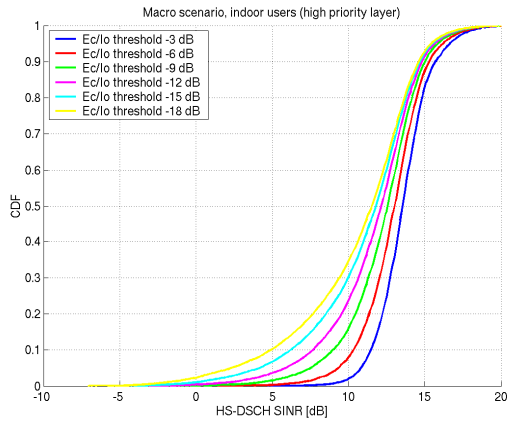

Figure 10. HS-DSCH SINR for user that will remain on high priority frequency layer in Macro scenario

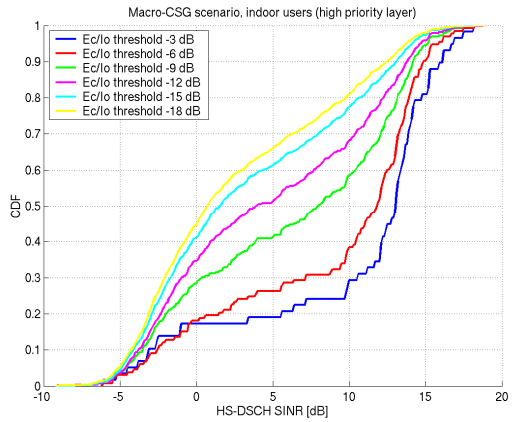

Figure 11. HS-DSCH SINR for user that will remain on high priority frequency layer in combined Macro-CSG scenario

Figure 12 shows CDF of Macro NodeB transmit power for Macro scenario and combined Macro-CSG scenario. Macro cell loading remains at quite low level for Macro scenario, but for combined Macro-CSG transmit powers are clearly higher due to additional CSG interference. Compared to the transmit power statistics in Section 3.1 where users were located in both indoors and outdoors, the interference from (non allowed) CSG cells leads to higher transmission powers from the macro cells especially to indoor users. Due to the higher average transmission power from macro cells the observed interference is more stable in Macro-CSG scenario, thus variations in Ec/Io should be reduced.

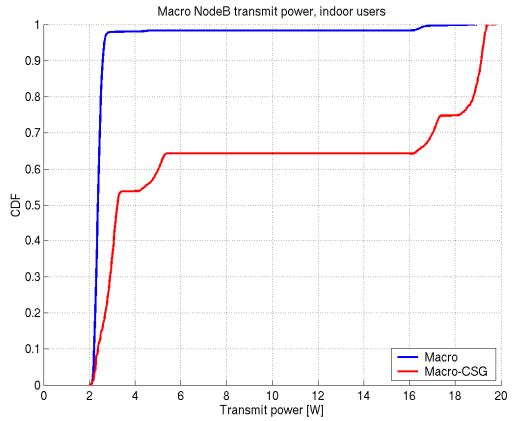

Figure 12. NodeB transmit power for Macro scenario and combined Macro-CSG scenario

4. Conclusions

In this contribution we have evaluated the effectiveness of Ec/Io based re-selection triggering against interference raising from non allowed CSG cells in mixed deployment scenario. It would seem that the Ec/Io based triggering is able to detect most of the cases where strong interference from non-allowed CSG is present if the threshold is set high enough.

As UTRA networks are already extensively deployed, there may be some risks associated with retuning the $Q_{qualmin}$ suitability thresholds in macro cells from their current settings, which has been based on experiences gained with coordinated and planned networks. Thus, if it is found that $Q_{qualmin}$ needs to be increased to ensure satisfactory performance for indoor users in the presence of non allowed CSG cells, this may also lead to a reduction in the 3G coverage for users who are not in the vicinity of non allowed CSG cells.

For this reason, we believe that there could still be some benefit in providing an additional mechanism specifically targeted to mitigating non allowed CSG interference, for example similar to proposals which have been considered for E-UTRA. We would welcome operator feedback on the risks seen by them in modifying $Q_{qualmin}$ in existing commercial networks, and whether they would see benefits in specifying a complimentary mitigation procedure which might reduce the need to adjust $Q_{qualmin}$.

5. References

[1] R4-091896, Inter-Frequency Reselection Indicator (IFRI) Simulation Results, Qualcomm Europe

[2] R4-091895, RSRQ measurement requirement in idle mode, Qualcomm Europe

[3] R2-093592, “LS on handling of non-allowed CSG cells”, RAN WG2

[4] R4-093169, “Further evaluation of methods to handle non-allowed CSG cells in LTE”, Nokia & Nokia Siemens Networks

Annex

A.1 Parameters

Table 1. Key simulation parameters

Feature/Parameter		Value/Description
Operation Bandwidth		5 MHz
TTI		2 ms
Number of slots per TTI		3
Simulations Scenario	Combined macro-CSG scenario	55 cells (18 macro cells and 37 CSG cells)
	Macro cell ISD	933 m
	Antenna pattern	Macro cells: 70-degree sectored beam CSG cells: Omni directional antennas
Max Tx Power	Macro cell	43 dBm

	CSG cell	15 dBm
Pilot Power	Macro cell CSG cell	33 dBm 4 dBm
HS-DSCH Power		70 % of Max Tx Power
HS-SCCH		Power controlled following DCH power with offset, Max 10% of total Tx power
Distance-dependent path loss	Outdoor	$128.1 + 37.6\log_{10}(r)$
Distance-dependent path loss	Indoor	$37 + 30\log_{10}(r) + \sum k_w L_w$, k_w is number of penetrated wall and L_w is wall loss (5 dB)
Shadowing standard deviation		8 dB
Shadowing correlation distance		50m
Shadowing correlation between macro sites		1.0
Shadowing correlation between macro cells		0.5
Multipath delay profile		Modified Vehicular A between outdoor UE and macro cell, Modified Pedestrian A between indoor UE and CSG cell
UE Speed		3 kmh
Receiver		1RX Rake
Ec/Io Measurement	Measurement Interval Measurement Period	1.28 s in idle mode 2 measurement samples