3GPP TSG-RAN WG4 meeting #52-bis **R4-093857**
Miyazaki, Japan, 12 – 16 October, 2009

Agenda item: **6.1.1.7**

Source: **Nokia, Nokia Siemens networks**

Title: **Additional analyses of methods to handle non-allowed CSG cells in LTE**

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 release 8 E-UTRA reselection, and non allowed CSG cells, it was concluded in [8] not to change the behaviour already specified in 36.304 and RAN4 informed RAN2 that RAN4 plans to continue to evaluate alternative solutions that take into account the DL outage caused by non-allowed CSG cells and to provide a response to for release 9 E-UTRA.

Contributions [6], [7] examining the performance of different options of handling the interference issues in mixed carrier CSG deployments and non-allowed cells have been was submitted to previous RAN4 meetings. In this contribution we continue to evaluate the performance of different options for handling the interference issues related to mixed carrier CSG deployments.

2. System simulation assumptions

This study has been performed using a fully dynamic time driven system simulator which simulates UL and DL directions simultaneously with a symbol resolution. We have used RSRP measurements for evaluating the best cell and for making the actual cell selection and cell reselection decisions. In the simulations the UE makes RSRP measurements with predefined period (“measurement interval”). The collected measurement results are then non-coherently averaged over a predefined sliding window (“measurement period”). Cell search model has been introduced to these simulations, requiring that the cells Es/Iot need to be above -6 dB and RSRP needs to be above -127 dBm for the cell is considered indentified; Only cells that are identified are measured and considered in reselection evaluation.

These studies have been done in a combined macro-CSG scenario with two frequency layers presented in Figure 1. Both frequency layers have co-located macro cells and there are CSG cells only on the higher priority layer. 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.

In the simulations both CSG and macro network loads are varied to see the performance of each algorithm in different kind of conditions in the network. Low CSG loads were considered together with CSG transmission power of 8 dBm. Although these simulations are used to evaluate idle mode performance, all UEs are sending one packet per 10 seconds to have an estimate for the Signal-to-Interference-and-Noise-Ratio (SINR) UE would have in downlink when starting a call.

Four different inter-frequency handover algorithms are simulated and compared to each others. The algorithms are presented in the next sub-sections. Basically these can be divided to two classes RSRP only or RSRP+RSRQ without barring, and RSRP only or RSRP+RSRQ with barring.

2.1 Reselection algorithm 1 (RSRP)

RSRP based cell selections and reselections are done according to following criteria (the normal Rel'8 reselection criteria):

1. If UE is camped to a lower priority layer cell and there is another cell that is better than absolute threshold ($S_{nonServingCell,x} > Thresh_{x,high}$) on highest priority frequency layer, UE performs a cell reselection to that cell
2. If another cell is $Qhyst_s$ better than serving cell on the current frequency layer, perform reselection
3. If UE is camped to a higher priotity frequency layer cell and serving cell is worse than absolute threshold ($S_{ServingCell} < Thresh_{serving,low}$) and another cell is better than another absolute threshold ($S_{nonServingCell,x} > Thresh_{x,low}$) on a lower priority frequency layer cell, perform reselection to lower priority frequency layer cell

2.2 Reselection algorithm 2 (RSRP and RSRQ)

This algorithm behaves as the first one except, when the best suitable cell is found to be a non-allowed CSG-cell. In thi case an RSRP and RSRQ based cell selections and reselections are done according to following criteria (based on criteria proposed in [2]):

1. If UE is camped to a lower priority layer cell and there is another cell that is better than absolute threshold ($S_{nonServingCell,x} > Thresh_{x,high}$ AND $RSRQ_{nonServingCell,x} > Q_{qualmin}$) on highest priority frequency layer, UE performs a cell reselection to that cell
2. If another cell is $Qhyst_s$ better than serving cell on the current frequency layer, perform reselection
3. If UE is camped to a higher priority frequency layer cell and
    a. serving cell is worse than absolute threshold ($S_{ServingCell} < Q_{qualmin}$) and another cell is better than another absolute threshold ($S_{nonServingCell,x} > Thresh_{x,low}$) on a lower priority frequency layer cell OR
    b. serving cell is worse than absolute threshold ($RSRQ_{ServingCell} < Q_{qualmin}$) and another cell is better than another absolute threshold ($RSRQ_{nonServingCell,x} > Q_{qualmin}$) on a lower priority frequency layer cell perform reselection to lower frequency layer cell

2.3 Reselection algorithm 3 (RSRP and barring)

RSRP and barring based cell selections and reselections are done according to the following criteria (same as Rel'8 but added barring criterion):

1. If UE is camped to a lower priority layer cell and there is another cell that is better than absolute threshold ($S_{nonServingCell,x} > Thresh_{x,high}$) on highest priority frequency layer, UE performs a cell reselection to that cell
2. If another cell is $Qhyst_s$ better than serving cell on the current frequency layer, perform reselection
3. If UE is camped to a higher priority frequency layer cell and serving cell is worse than absolute threshold ($S_{ServingCell} < Thresh_{serving,low}$) and another cell is better than another absolute threshold ($S_{nonServingCell,x} > Thresh_{x,low}$) on a lower frequency layer cell, perform reselection to lower priority frequency layer cell
4. If the UE is camped on the highest priority frequency layer, and the cell with the strongest RSRP is a non-allowed CSG cell, then move to the lower priority layer and bar the highest priority frequency layer for T_{barred}=300 seconds.

2.4 Reselection algorithm 4 (RSRP, RSRQ and Barring)

RSRP+RSRQ and barring based cell reselections are done according to the algorithm 2 and in addition RSRP based frequency barring is utilized as in algorithm 3.

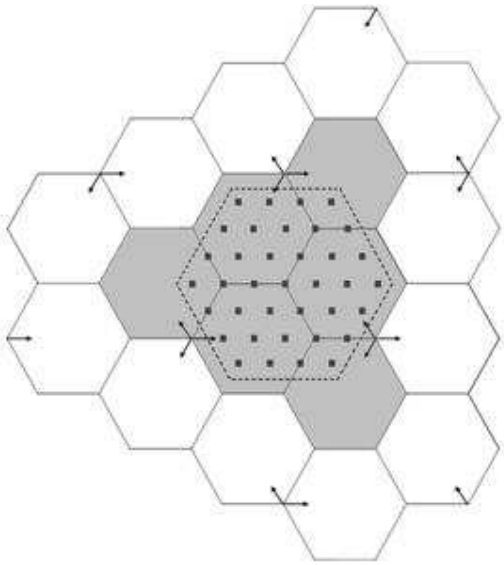

Figure 1. Simulation scenario

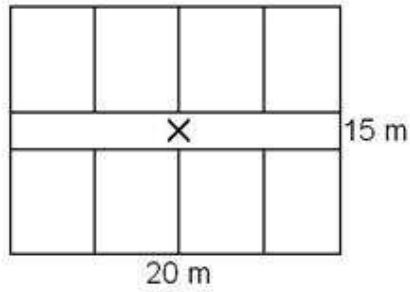

Figure 2 Building layout

3. Simulation results

In this section we present the simulation results for the scenario described in previous section.

In the previous contributions [6] [7], plenty of simulation results have already been presented and each of them have shown that according to the SINRs, barring always provides the best performance. Since it is assumed that the CSG cells are to be inactive most of the time, these results include also cases where the CSG cell load is very low. However, the CSG cells are never completely idle because of the pilots and other broadcast control signalling. In addition to the broadcast transmission, CSG activities of 0%, 10% and 50% are simulated. The average continuous activity time is 100 ms and inactivity time is then varied based on the average activity time. Macro load is assumed to be either 50% or 100% meaning that macro base stations are continuously transmitting with corresponding load. These result very stable loading conditions in over all thus the variations at observed RSSI level are minimized.

RSRP and RSRP+RSRQ algorithms, with and without barring, are then compared with each other. Different barring times from 0 to 5 minutes are also considered. To limit the number of cases only selected thresholds for RSRP and RSRQ for these simulations were simulated. RSRP threshold of -97dBm and RSRQ threshold of -7dB were used. These c provide the best SINRs disctributios(see [7]), with the down side of providing larger amount of reselections, especially for RSRP

Figures from 3 to 8 show the SINRs from all of the cases , with the simulation results as expected: If there is very light load on the CSG cells, the probability for CSG-caused interference decreases and there are only small differences between the cases. But the more the CSG activity is increased, the worse the SNR distribution gets for the cases where no barring is used. Thus in considered low CSG load conditions, even in presence of constant macro level interference the barring improves the performance of both approach, RSRP and RSRP&RSRQ.

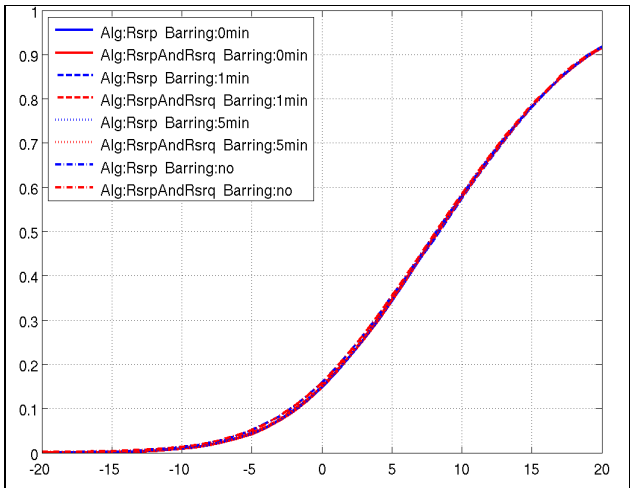

Figure 3. SINRs (Macro load: 50%, CSG Activity: 0%)

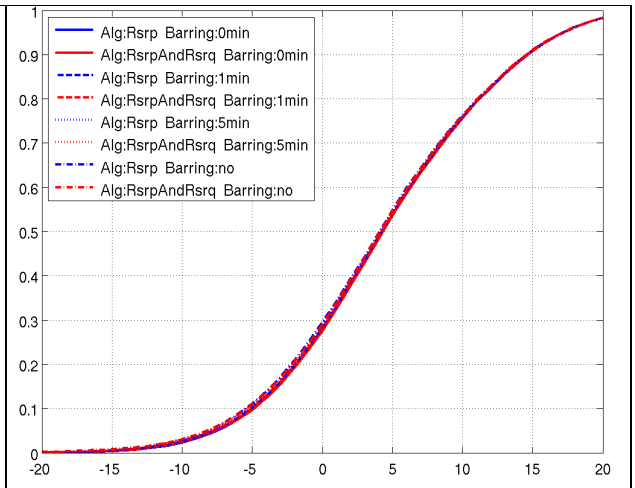

Figure 4. SINRs (Macro load: 100%, CSG Activity: 0%)

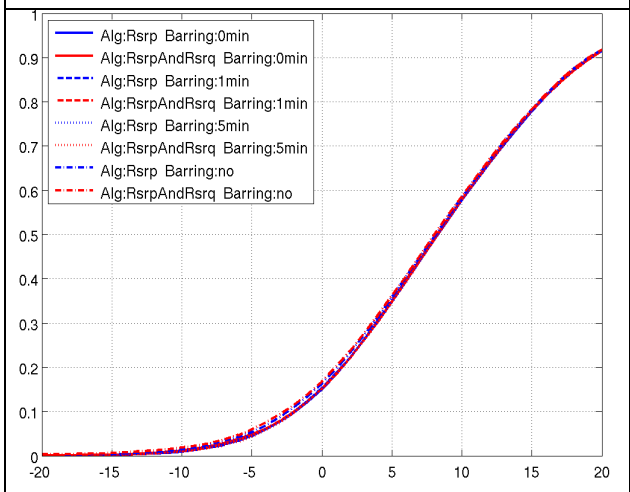

Figure 5. SINRs (Macro load: 50%, CSG Activity: 10%)

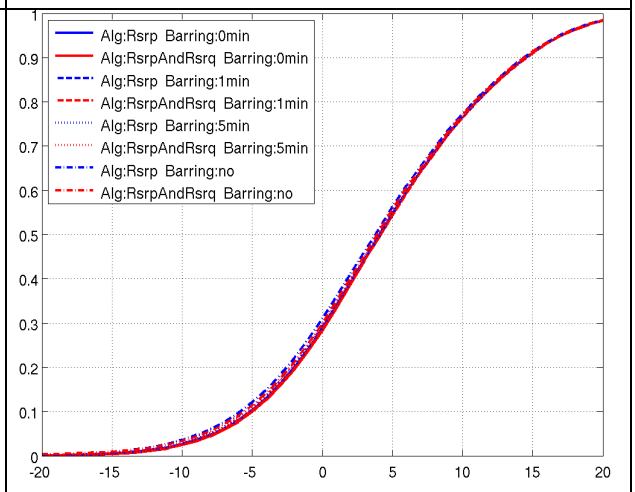

Figure 6. SINRs (Macro load: 100%, CSG Activity: 10%)

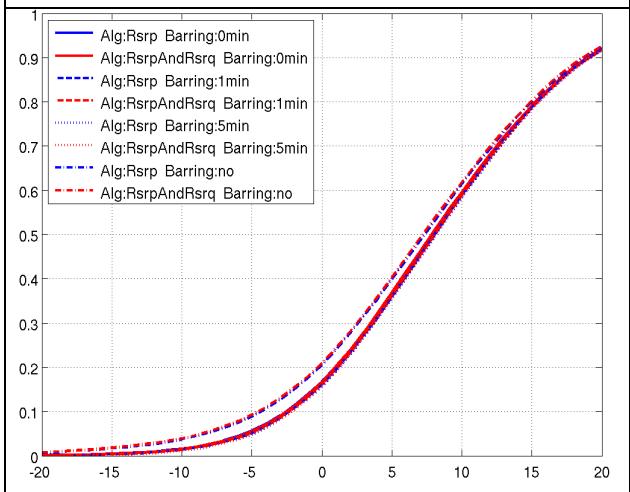

Figure 7. SINRs (Macro load: 50%, CSG Activity: 50%)

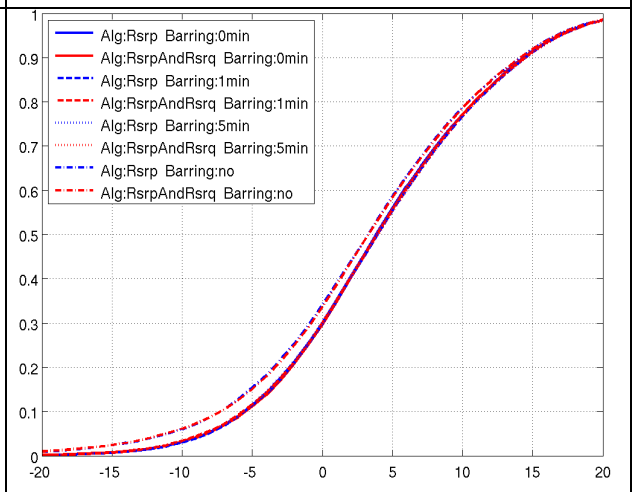

Figure 8. SINRs (Macro load: 100%, CSG Activity: 50%)

Figures 9 and 10 show the proportion of users in high priority network in the end of the simulation scenario, i.e. the converged user distribution between the networks for these scenarios. It can be seen that the barring time has quite big influence to the proportions.

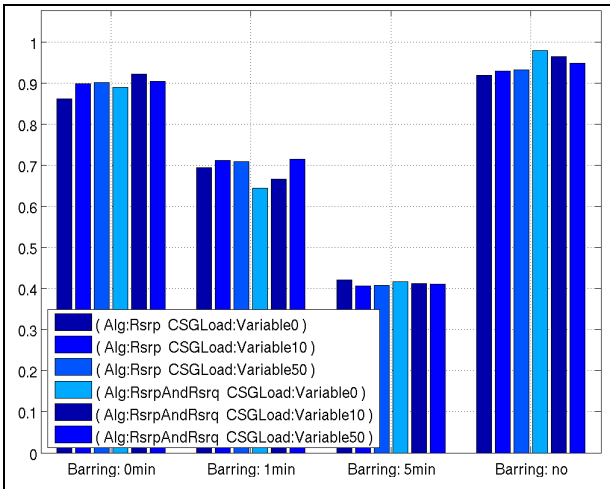

Figure 9. Proportion of users in high priority network in the end of the simulation (Macro load: 50%).

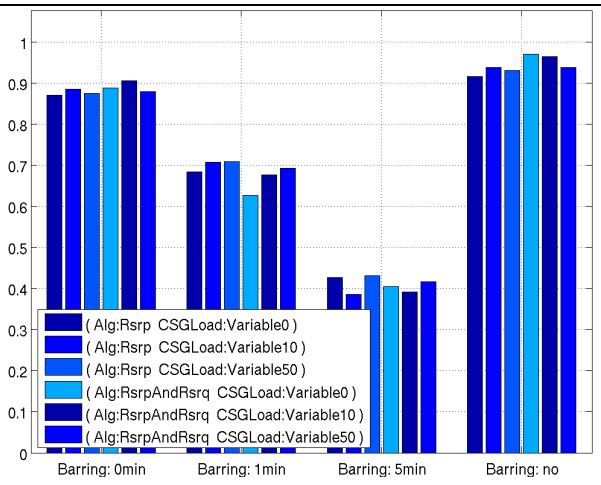

Figure 10. Proportion of users in high priority network in the end of the simulation (Macro load: 100%).

Figures from 11 and 12 present the numbers for inter-frequency reselections. Trend of intra-frequency re-selections also show that barring reduces the re-selections, but comparison between schemes is not possible due to limited set of thresholds.

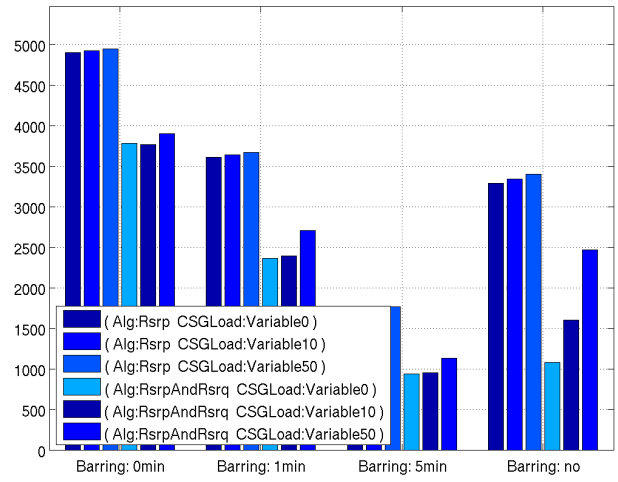

Figure 11. Number of inter frequency reselections from low priority to high priority (Macro load: 50%).

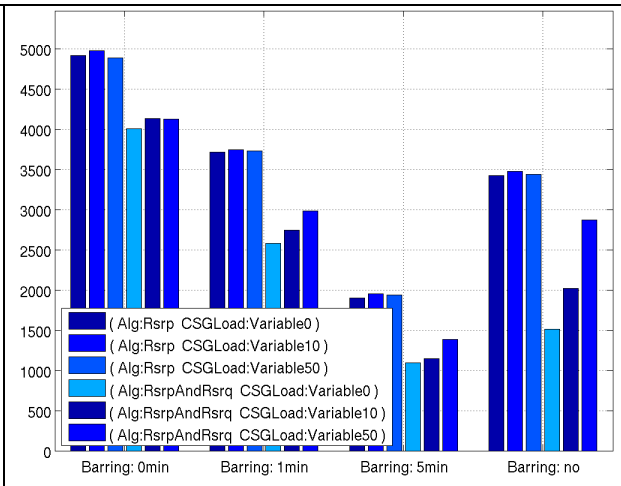

Figure 12. Number of inter frequency reselections from low priority to high priority (Macro load: 100%).

4. Conclusions

In this contribution we have presented further evaluation the performance of different reselection schemes to avoid possible interference from (non-allowed) CSG cells. The evaluation was done in combined macro-CSG scenario with two frequency layers. On both frequency layers had co-located macro cells and a number of indoor cells were introduced to the higher priority layer modelling the CSG cells. The performance of different schemes was evaluated in terms of number of reselections and observed SNIR. Low CSG loads together with constant macro cell loads were considered in order to evaluate scenarios where the CSG interference would be minimal and interference conditions

otherwise would be stabile. Only on set of thresholds was evaluated, chosen based on previous results, to give the best SNR distribution.

Based on the results presented it can be seen that best performance in terms of SNIR can be obtained with barring based approach, where UE reselects to lower priority layer if the strongest cell at the given frequency layer is non-allowed CSG cell. Due to limited number of evaluated thresholds overall re-selection performance cannot be evaluated, but barring shows constant trend of reducing the re-selections.

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] R4-092183, Handling of non-allowed CSG cells, Nokia & Nokia Siemens Networks

[5] R4-092601, Reply LS (IFRI, RSRQ measurement requirement in idle mode), Qualcomm Europe

[6] R4-092450, Evaluation of methods to handle non-allowed CSG cells, Nokia & Nokia Siemens Networks

[7] R4-093169, Further evaluation of methods to handle non-allowed CSG cells in LTE, Nokia & Nokia Siemens networks

[8] R4-093132, “Reply LS (IFRI, RSRQ measurement requirement in idle mode)”, Qualcomm Europe

Annex

A.1 Parameters

Table 1. Key simulation parameters

Feature/Parameter		Value/Description
Operation Bandwidth		10 MHz
IFFT/FFT length		1024
Duplexing		FDD
Number of sub-carriers		600
NW synchronicity		Asynchronous NW
Sub-carrier spacing		15 kHz
Resource block bandwidth		180 kHz

Sub-frame length		1 ms
Reuse factor		1
Number of symbols per TTI		14
Number of data symbols per TTI		11
Number of control symbols per TTI		3
Simulations Scenario	Combined macro-CSG scenario with 2 frequency layers	High priority layer: 55 cells (18 macro cells and 37 CSG cells) Low priority layer: 18 macro cells
	Macro cell ISD	500 m
	Antenna pattern	Macro cells: 70-degree sectored beam CSG cells: Omni directional antennas
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 for indoor walls, 15 dB for outdoor walls)
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		TU
UE Speed		3 kmh
Receiver		2RX MRC
RSRP Measurement Treselection $Qhyst_s$	Measurement Bandwidth Measurement Interval Measurement Period	6 PRBs 1.28 s in idle mode 2 measurement samples 0 3dB