3GPP TSG-RAN WG4 Meeting #52bis **R4-093858**

Miyazaki, Japan, 12th – 16th October, 2009

Source: Nokia, Nokia Siemens Networks

Title: Evaluation of $S_{intrasearch}$ enhancements

Agenda Item: 6.1.1.7

Document for: Discussion

1. Introduction

During RAN4 meeting #52, there was discussion of handling of open access hotspots [1, 2]. It was concluded that RAN4 should continue to study whether enhancements should be considered in release 9. This paper presents results comparing the performance of $S_{intrasearch}$ with both (Rel'8) RSRP-based and RSRQ-based threshold mechanism.

2. $S_{intrasearch}$ Simulations

We have simulated two possible idle mode reselection schemes: The reference scheme is RSRP-based $S_{intrasearch}$ – threshold, which is compared against RSRQ-based $S_{intrasearch}$ – threshold. The main simulation assumptions are summarised in section 2.1 and in Appendix A and the results are analysed in sections 2.2. and 2.3.

The focus of the simulations was to compare the reselection performance when $S_{intrasearch}$ is used. We show results in this section for both macro and combined macro-indoor scenario described below.

Downlink SINR distributions, amount of cell reselections and ping-pong reselections are presented to evaluate the performance effect of $S_{intrasearch}$ with different threshold values. A range of values is evaluated also to see how the $S_{intrasearch}$ value could be optimised in each case, and also to compare the optimal value in both macro and macro-indoor case. Also serving cell measurement ratios are presented to evaluate the possible power savings.

2.1 Simulation scenario

The used scenarios were 3GPP macro Case 1 (57 cells with ISD 500 m, modified so that penetration loss = 0 dB, see Figure 1) and a scenario including both macro and indoor cells (see Figure 2) where the indoor cells were approximately 83 meters apart and macro ISD 500 m was utilized. With 37 indoor cells in the scenario, there are roughly 12 indoor hotspots within the area of each of the studied eNBs. The penetration loss of 20 dB, used normally in 3GPP Case 1 propagation, was modified to 0 dB for both scenarios: The indoor cell propagation formula calculates penetration (=wall) loss already separately, so having the macro propagation include a penetration loss would have resulted in too good separation of interference for the indoor cells. Further, to have comparable results for pure macro and macro-indoor scenarios, both scenarios had to use the same (macro) propagation formula. The exact pathloss calculation is detailed in Appendix B.

In macro-indoor case, two different UE placements were simulated, by forming an 'hotspot' area within which the UEs were generated. First hotspot was placed close to a macro BS and second on the macro cell-edge. In the Case 1 scenario both 3 and 30 km/h UE velocities were simulated, but in macro-indoor scenario only 3 kmph was simulated. All UEs were operating in idle mode, with set background level of interference assumed in each case, but each UE was scheduled once every 10 seconds to obtain a distribution of the SINR for the DL.

The measurement interval for RSRP and RSRQ was 1280 ms and the measurement filtering was over 2 measurement samples. No measurement error was used for RSRP or RSRQ measurements. Qhyst was set to 3 dB.

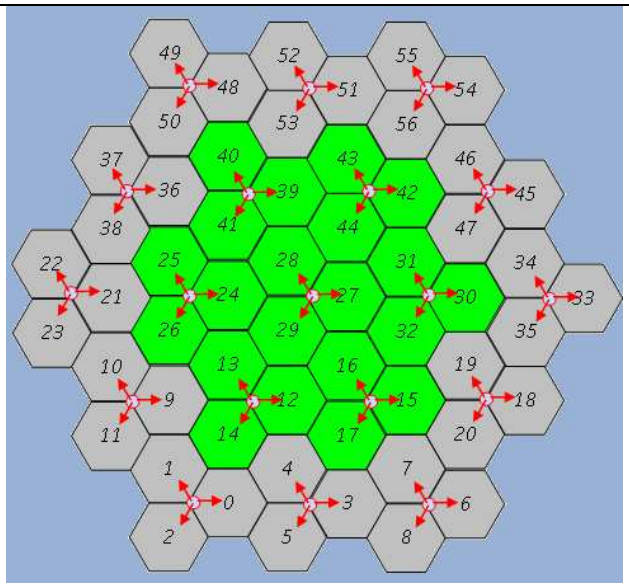

Figure 1. Case 1 scenario

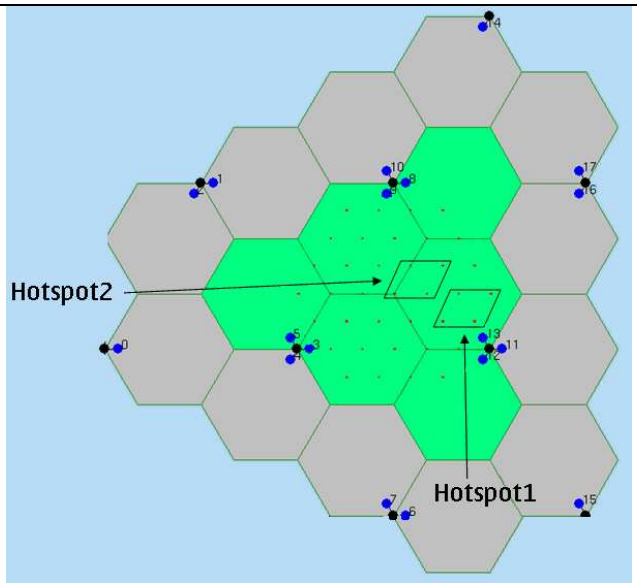

Figure 2. Macro-indoor scenario

2.2 Simulation results for Macro-indoor scenario

Figure 3 to Figure 6 show downlink SINR distributions for hotspots 1 and 2 with RSRP or RSRQ based $S_{intrasearch}$ in macro-indoor scenario. In Hotspot1 scenario the RSRQ-based scheme shows slightly more variation in the SINR value with different threshold values, while the RSRP-based scheme leads to almost the same SINR distribution with $S_{intrasearch}$ values over -70 dBm. In configuration Hotspot2 case the lower RSRP threshold setting effects strongly to the SNR distribution, implying that they would not seem suitable thresholds. The average SINR level is different for hotspot 1 and 2 as they are placed on a different distance from macro BSs.

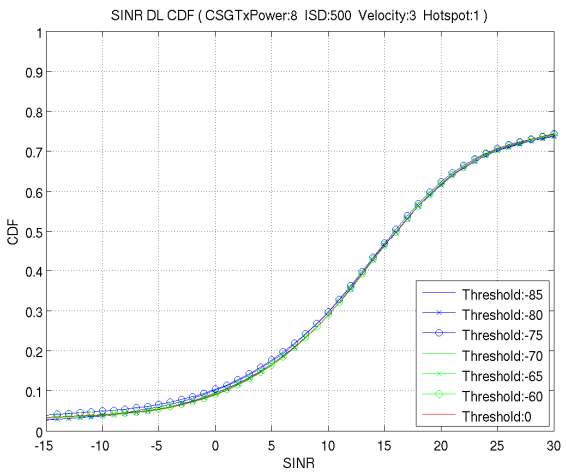

Figure 3. SINR DL distribution with RSRP $S_{intrasearch}$ in Hotspot1.

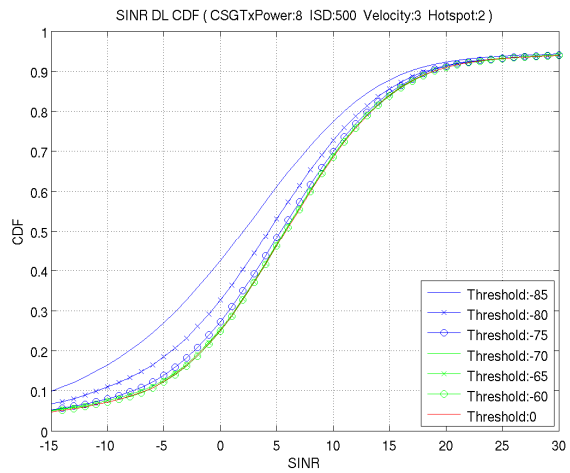

Figure 4. SINR DL distribution with RSRP $S_{intrasearch}$ in Hotspot2.

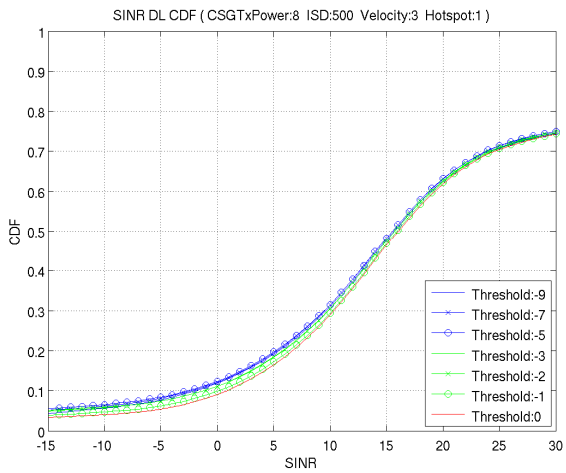

Figure 5. SINR DL distribution with RSRQ $S_{intrasearch}$ in Hotspot1.

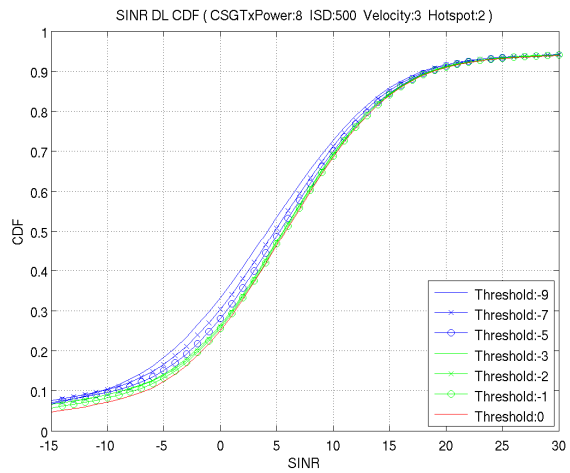

Figure 6. SINR DL distribution with RSRQ $S_{intrasearch}$ in Hotspot2.

Figure 7**Error! Reference source not found.** and Figure 8 show that the behaviour of average number of reselections is roughly equal with both RSRP- and RSRQ $S_{intrasearch}$. It is noted that the location of the generated UE (hotspots) affects the number of reselections quite heavily, reflecting the different situations of the hotspots.

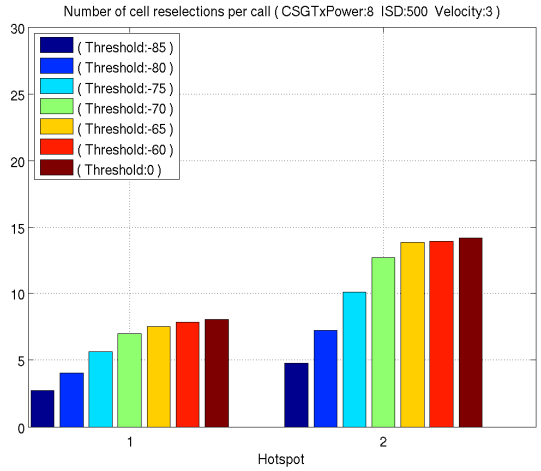

Figure 7. Average number of cell reselection per UE during 350 second call with RSRP $S_{intrasearch}$.

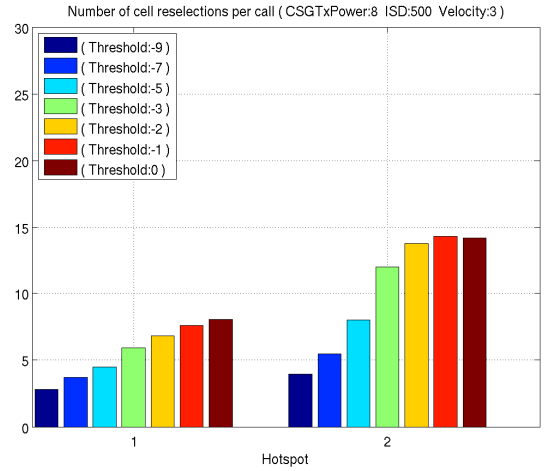

Figure 8. Average number of cell reselection per UE during 350 second call with RSRQ $S_{intrasearch}$.

Figure 9**Error! Reference source not found.** and Figure 10 show the proportions ping-pong reselections (a reselection is deemed a ping-pong if it is done faster than 5 seconds since the previous reselection) within the hotspots. The RSRP-based $S_{intrasearch}$ leads to higher number of ping-pongs with low threshold values, and the amount is not very dependent on the threshold, while the RSRQ-based scheme shows a clear dependence on the used threshold value, and has a similar performance to the RSRP-based scheme if the RSRQ threshold is set to a high value.

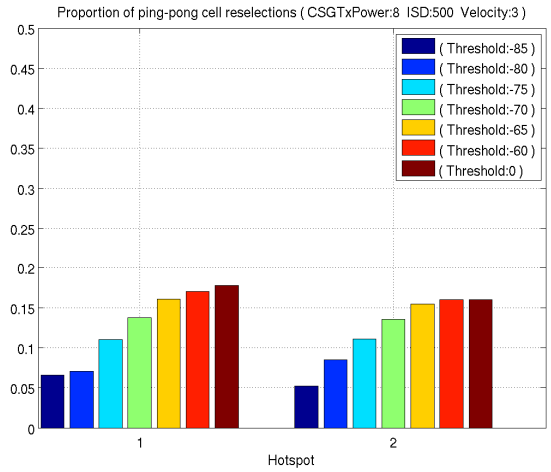

Figure 9. Proportion of ping-pong cell reselections with RSRP $S_{intrasearch}$.

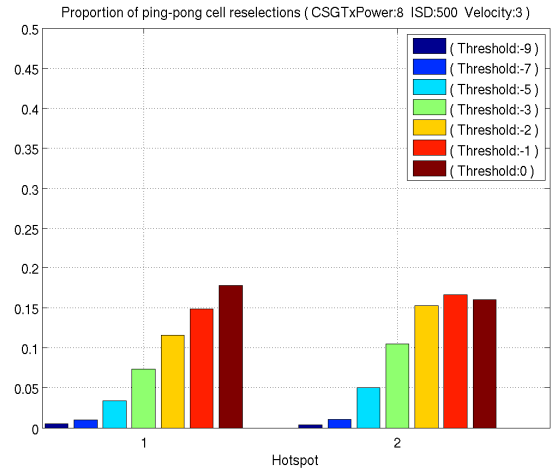

Figure 10. Proportion of ping-pong cell reselections with RSRQ $S_{intrasearch}$.

The average serving cell measurement ratio, shown in Figure 11 and Figure 12 illustrates the impact of different $S_{intrasearch}$ -thresholds to potential saving in power consumption. If larger portion of the time is spent on measuring only the serving cell, less power the UE is expected to consume on measurements. The results indicate that the attained power savings differ quite significantly depending on the $S_{intrasearch}$ –threshold as could be expected. With RSRP $S_{intrasearch}$ set -70 dBm only serving cell is measured on average 55% of time in hotspot 1 and 30% in hotspot 2. With this threshold SINR level was almost the same compared to the reference case without $S_{intrasearch}$ utilization. With RSRQ $S_{intrasearch}$-thresholds -1 and -2 only serving cell is measured 60-80% of time in hotspot 1 and 20-40% of time in hotspot 2. SINR levels are very close to reference case.

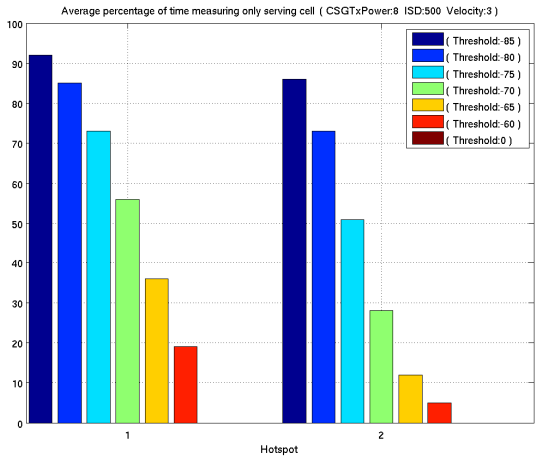

Figure 11. Average only serving cell measurement ratio with RSRP $S_{intrasearch}$.

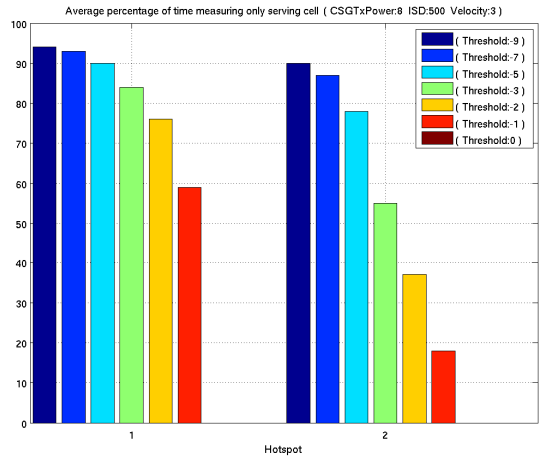

Figure 12. Average only serving cell measurement ratio with RSRQ $S_{intrasearch}$.

2.3 Simulation results for Case 1 scenario

The Case 1 results are shown to have a benchmark of the performance of macro-indoor against macro-only deployment. Purpose was to identify possible advantages or disadvantages obvious in either solution when inspecting the $S_{intrasearch}$ in a coordinated deployment.

SINR distributions are shown in Figure 13 to Figure 16. Each UE in the simulation received one message every 10 seconds, and the ensuing SINR is logged. The curves indicate that quite high $S_{intrasearch}$ –thresholds (RSRP over -70 and RSRQ over -5) have quite a small effect on SINR level. Also it can be noted that lowest evaluated RSRP thresholds have strongest (negative) impact to the SNR distribution, as noted in Hotspot 2 case in previous section. As expected, with 30kmph velocity the thresholds have bigger effect on SINR than with 3 kmph.

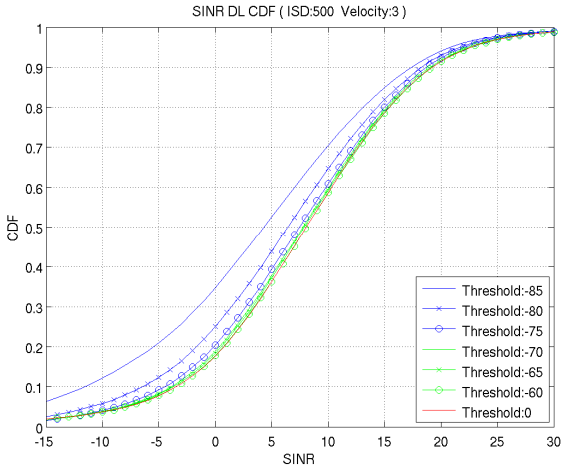

Figure 13. SINR DL distribution with RSRP $S_{intrasearch}$ in 3kmph case.

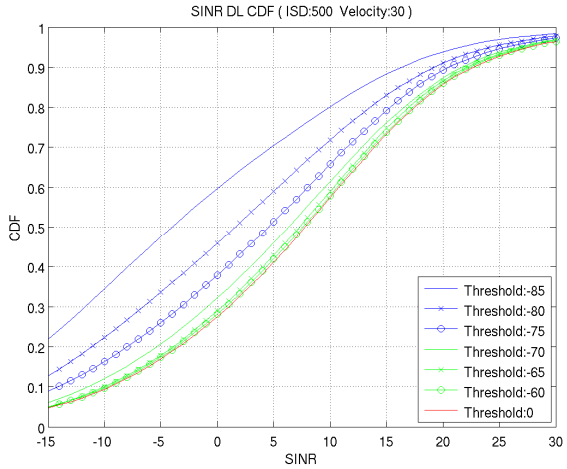

Figure 14. SINR DL distribution with RSRP $S_{intrasearch}$ in 30 kmph case.

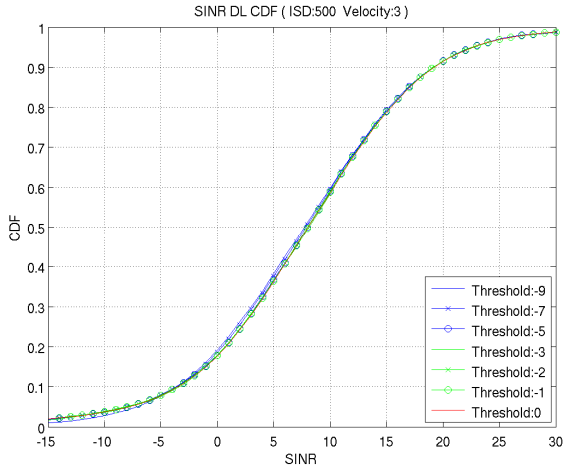

Figure 15. SINR DL distribution with RSRQ $S_{intrasearch}$ in 3 kmph case.

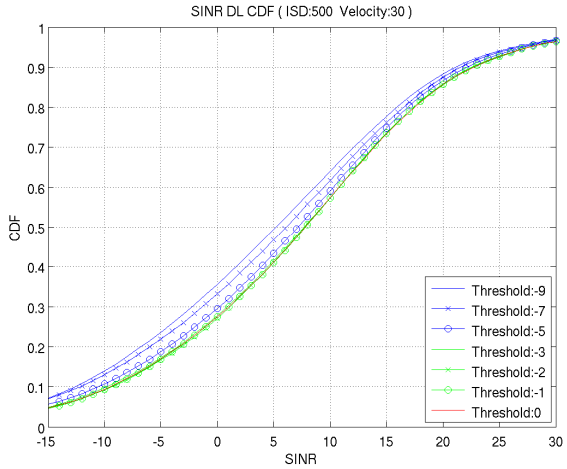

Figure 16. SINR DL distribution with RSRQ $S_{intrasearch}$ in 30 kmph case.

The reselection statistics for macro case are given in Figure 17 to Figure 20. The amount of reselections and ping-pongs are approximately at the same level with both RSRP and RSRQ based $S_{intrasearch}$.

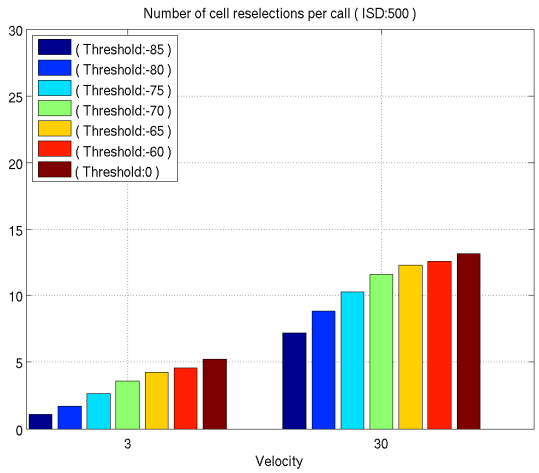

Figure 17. Average number of cell reselection per UE during 350 second call with RSRP $S_{intrasearch}$.

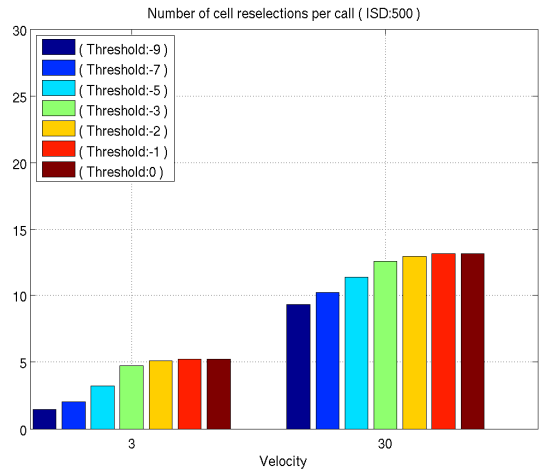

Figure 18. Average number of cell reselection per UE during 350 second call with RSRQ $S_{intrasearch}$.

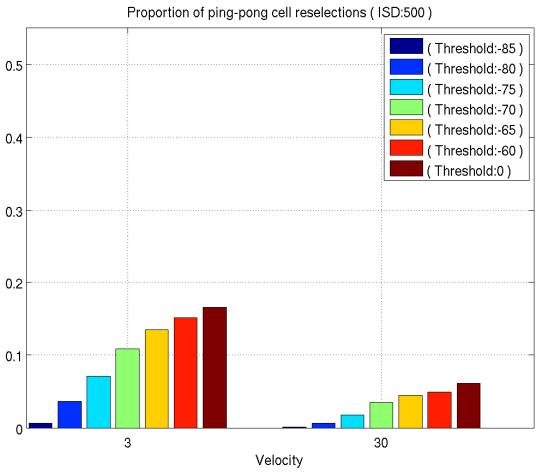

Figure 19. Proportion of ping-pong cell reselections with RSRP $S_{intrasearch}$.

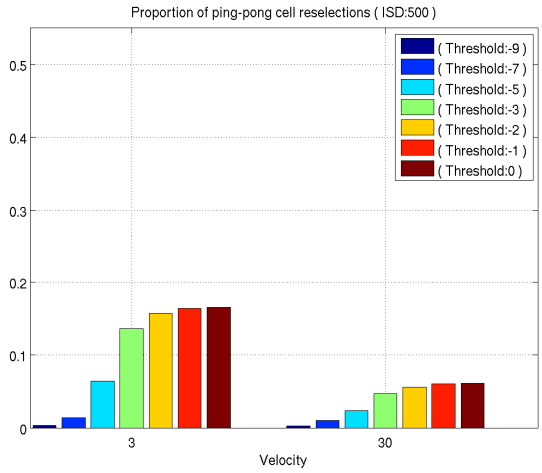

Figure 20. Proportion of ping-pong cell reselections with RSRQ $S_{intrasearch}$.

Finally, the serving cell measurement rations show that at such level for of $S_{intrasearch}$ that would keep the SINR level least negatively affected, maximum time of only serving cell measurement is around 50%, so some power saving gains would still be possible.

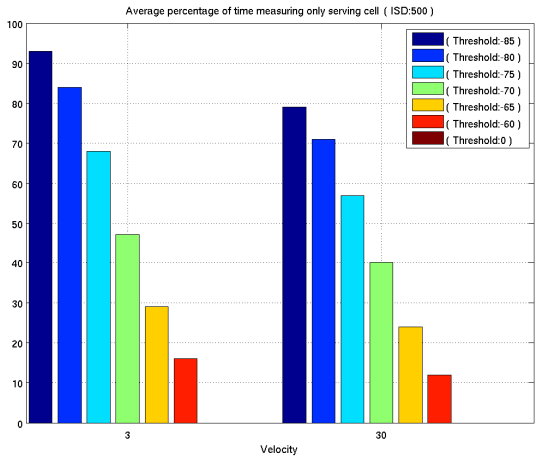

Figure 21. Average only serving cell measurement ratio with RSRP $S_{intrasearch}$.

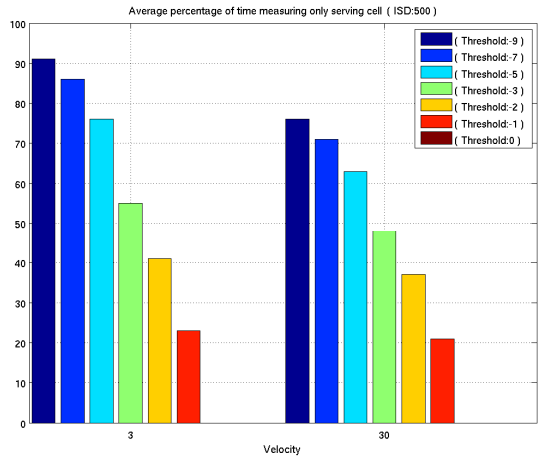

Figure 22. Average only serving cell measurement ratio with RSRQ $S_{intrasearch}$.

3. Conclusion

In this contribution we have evaluated the difference of RSRP and RSRQ based $S_{intrasearch}$ thresholds in different scenarios. The results we have shown indicate that in terms of DL SNR and re-selections nearly equal performance can be achieved with both schemes while properly selecting the threshold. However in terms of power saving opportunities, RSRQ-based $S_{intrasearch}$ scheme could have some benefits over the RSRP-bases $S_{intrasearch}$ RSRP-based scheme. It would seem to allow easier setting of the $S_{intrasearch}$ –threshold to achieve comparable re-selection performance awhile allowing higher power saving opportunities.

The conclusions from this paper are further discussed in [3].

References

[1] R4-093233, LTE Idle Mode Improvements (for Release 9 and beyond), Vodafone

[2] R4-092832, Issues on RSRP-based cell reselection, NTT DOCOMO

[3] R4-093690, Idle mobility enhancements for E-UTRA release 9, Nokia & Nokia Siemens Networks

Appendix A: Simulation parameters

Feature/Parameter		Value/Description
Bandwidth		10 MHz
IFFT/FFT length		1024
Duplexing		FDD
Number of sub-carriers		600
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
3GPP Macro Cell Scenario	Cell layout	57 sectors/19 BSs
	Inter site distance (ISD)	500 m
	Minimum distance between UE and cell site	35 m
	Antenna pattern	70-degree sectored beam
Modified Macro-indoor scenario	Cell layout	6 macro cells + 37 indoor cells
	Macro ISD	500 m
Distance-dependent path loss	Macro cell model (TS 25.848)	$128.1 + 37.6\log_{10}(r)$
	Indoor model (Cost 231 multi wall; n_w is the number of walls crossed)	$38.4 + 20 \log_{10}(r) + n_w L_w$
	L_w	15 dB
Shadowing standard deviation		8 dB
Shadowing correlation between cells/sectors		0.5 / 1.0
Multipath delay profile		Typical Urban
UE Velocity		3, 30 kmph
RSRP and RSRQ Measurement	Measurement period	1280 ms
	Measurement bandwidth	6 RBs
	Measurement error	0 dB
	Sliding window size	2 samples
	Qhyst	3 dB
Receiver diversity		2RX MRC
Number of UEs/active cell	Macro scenario	20 (420 UEs in the whole network)
Number of UEs	Macro-indoor scenario	140 UEs
Interference load		50% of full RB load

Appendix B: Pathloss calculations in macro-indoor scenario

The pathloss calculation used in simulations depends on the eNB location. The macro eNBs are assumed to have 15m antenna height and located outdoors, while the indoor cells use 2m antenna height and are located indoors. The propagation models are as follow:

- Macro cell model is separated to outdoor and indoor models:
    - 128.1 + 37.6 log10(R) for 15 m antenna height (Outdoor macro cell)
    - 143.9 + 39.7 log10(R) for 2 m antenna height (Indoor cell)
    - No penetration loss (see below)
- Indoor model (Cost231 multi wall)
    - 38.4 + 20 log10(R) + nwLw
    - Nw is the number of crossed walls, and Lw is the wall loss for one wall

The pathloss calculations depend on both the UE and eNB locations:

- BTS and UE outdoors: (Outdoor) Macro cell model

- BTS and UE indoors in same house: Indoor model
- BTS outdoors and UE indoors: (Outdoor) Macro cell model + external wall loss
- BTS indoors and UE outdoor: max (Indoor model + external wall loss, Indoor macro cell model + external wall loss)
- BTS indoors and UE indoors, but in different houses: Indoor macro cell model + 2 * external wall loss