3GPP TSG-RAN WG4 meeting #52 **R4-093166**
Shenzhen, China, 24th – 28th August, 2009

Agenda item: **8.1.3.3**

Source: **Nokia, Nokia Siemens Networks**

Document for: **Discussion**

1. Introduction

RAN4 is currently finalizing *Long Term Evolution (LTE) Channel Quality Indicator (CQI)* requirements for the 3GPP specifications (to be included in [1]). One of these requirements is related to how tightly the *Block Error Rate (BLER)* operation point should be set. Operation point and system performance could potentially be affected by non-consistent CQI reporting by the *User Equipment (UE)*. In other words non-consistent CQI reporting could lead to having suboptimal BLER operation point. Non-consistent CQI reporting by the UE can be caused by e.g. hardware inaccuracy, misconfiguration or calibration.

The purpose of this study is to further deepen the analysis presented in R4-092157 [2] of how system level performance is affected if UEs reports biased (more aggressive and/or non-aggressive) CQI values that they actually should in their current radio channel conditions. The bias is, thus, directly related to the initial offset value of *Outer Loop Link Adaptation (OLLA)* which is then being corrected. In this study bias is referred also as initial LA/OLLA offset.

2. System simulation assumptions

This study has been performed using a fully dynamic time driven system simulator which simulates uplink and downlink directions with a symbol resolution. In this study only downlink direction is simulated in detail and uplink traffic is considered as ideal to keep the scope of this study within reasonable limits.

We have used periodically reported full CQI in these studies to show the impact of bias in worst-case scenario as very accurate CQI information would be available without the bias. CQI related assumptions are listed in the Annex at the end of this document. A few changes to CQI assumptions when compared to [2] are made to better align the results with other companies, namely 6 PRB resolution, 8 ms reporting delay. Moreover, this study includes analyses the impact of CQI bias with different CQI measurement intervals as well as different network load levels.

The bias is assumed to be random between users as it simulates the performance of the real network more accurately. With random bias the terminals have their bias set according to uniform distribution.

As implied earlier, in this study we assume both an inner loop and an outer loop LA unit. The OLLA algorithm imposes an offset margin that is subtracted from the SINR measurements in the CQI manager before being used by the inner loop LA to estimate the supported data rate, and modulation and coding scheme. The OLLA algorithm aims to control the experienced average BLER for the first transmissions, and it follows the same principle as the traditional outer loop power control algorithm for dedicated channels in IS-95 and WCDMA and for HSDPA. Hence, if an Ack is received for a first transmission, the offset factor, A, is increased by A_{up} decibels (defined with a parameter), while it is decreased by A_{down} decibels if a Nack is received. Offset factor has limit for maximum and minimum to prevent situations where channel conditions change significantly and OLLA would take very long time to shift the offset back to the other way. The ratio between the step up/down determines the average BLER that the OLLA converges to, i.e.

$$BLER = \frac{1}{1 + \frac{A_{up}}{A_{down}}}.$$

Simulations have been conducted with two different types of traffic. First of which is *Constant Bit Rate (CBR)* type of service which has certain amount of source data and thus certain amount of packets (varied throughout the simulations) while the other one is conventional HTTP traffic model with several documents and packets. See more detailed parameters from Annex.

These studies have been conducted in a macro cellular scenario presented in Figure 1. The scenario consists of 19 base stations where two inner tiers (i.e. the orange and green areas) are the one were mobiles are allowed to move. Statistics are collected from the innermost tier (orange cells). Third tier (i.e. cells indicated with light blue colour) are normal active BSs which have background load adapting to statistic BS load.

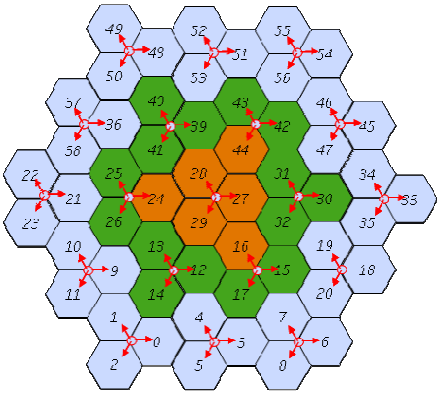

Figure 1: Simulation scenario

2. Simulation results

The performance is evaluated in this contribution mainly through L3 *Spectral Efficiency (SE)* and L3 user throughput in addition to L1 first transmission BLER per call and OLLA offset collected at the end of the call.

2.1 Performance with CBR service

The spectral efficiency with different background loads and random bias values is illustrated in Figure 2 through Figure 7. As those figures show the system load 0-100 % does not have noticeable impact to how bias impacts the performance. Similarly to the results shown in [2] the impact of bias to SE remains insignificant. Moreover, with reasonable amount of source data the OLLA has enough samples and has time to fix the bias and thus it is not visible in SE.

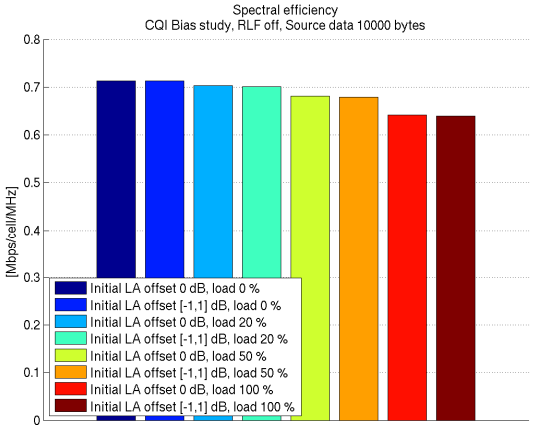

Figure 2 Spectral Efficiency, 10 Kb data, Bias [-1,1] dB

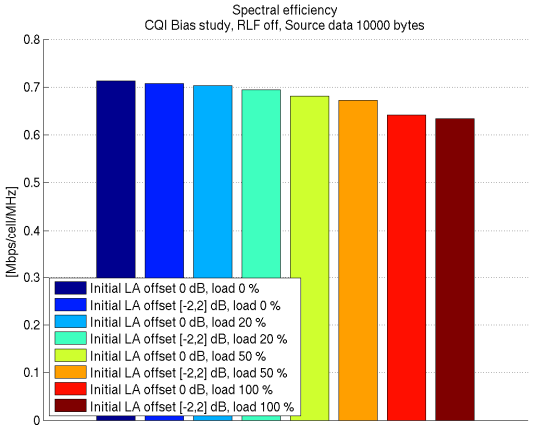

Figure 3 Spectral Efficiency, 10 Kb data, Bias [-2,2] dB

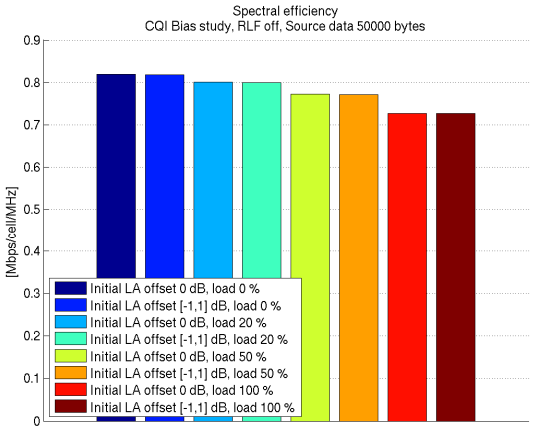

Figure 4 Spectral Efficiency, 50 Kb data, Bias [-1,1] dB

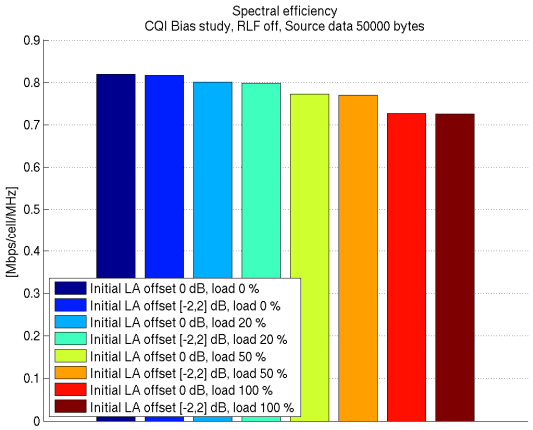

Figure 5 Spectral Efficiency, 50 Kb data, Bias [-2,2] dB

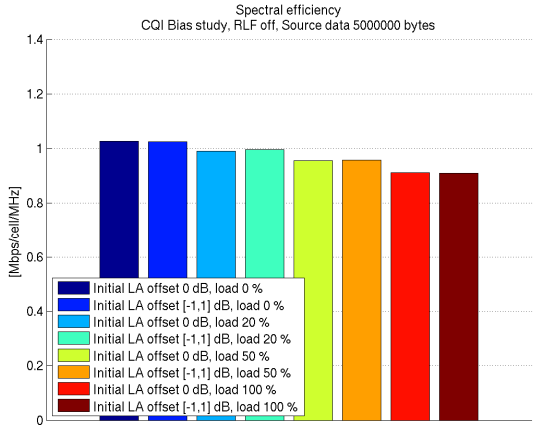

Figure 6 Spectral Efficiency, 5 Mb data, Bias [-1,1] dB

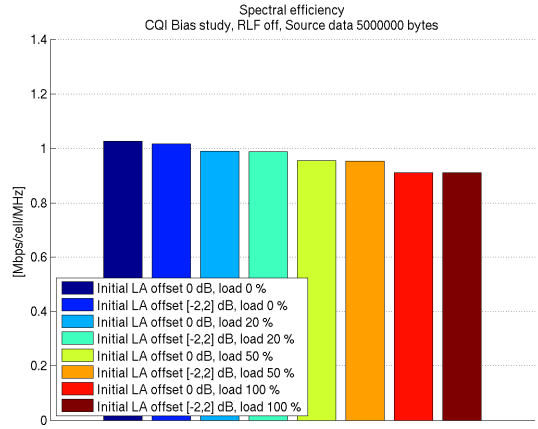

Figure 7 Spectral Efficiency, 5 Mb data, Bias [-2,2] dB

Figure 8 through Figure 13 show the user throughput distributions with different loads and bias values. As those figures show, corresponding curves are nearly on top of each other and load does impact only to the absolute user throughput numbers.

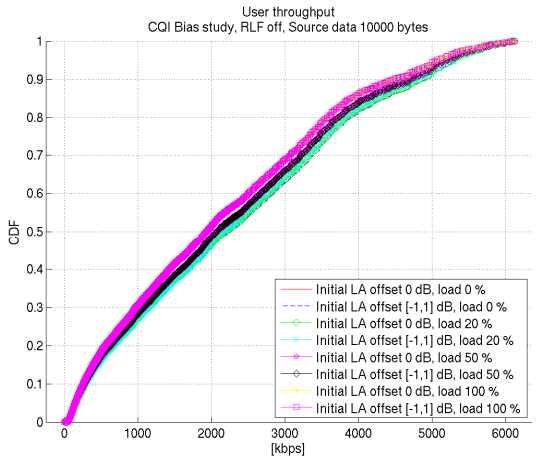

Figure 8 User throughput, 10 Kb data, Bias [-1,1] dB

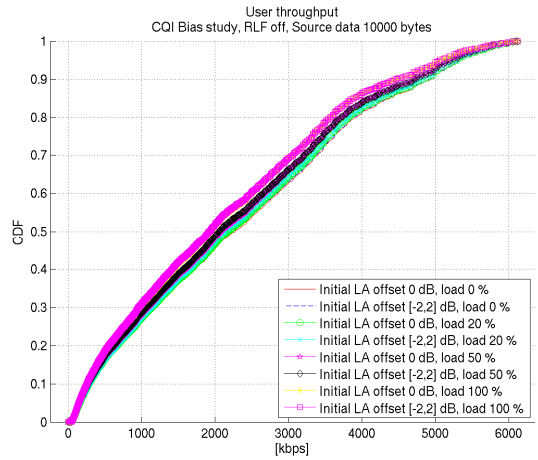

Figure 9 User throughput, 10 Kb data, Bias [-2,2] dB

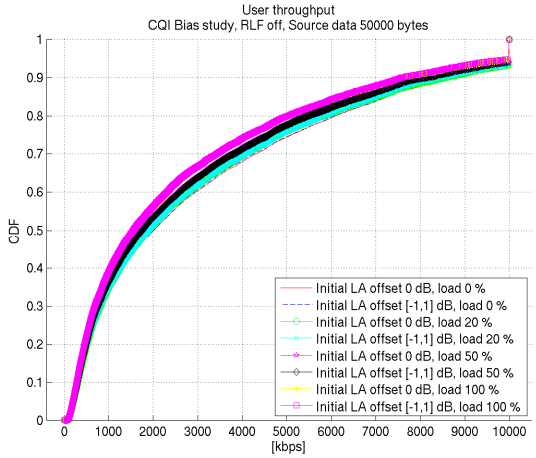

Figure 10 User throughput, 50 Kb data, Bias [-1,1] dB

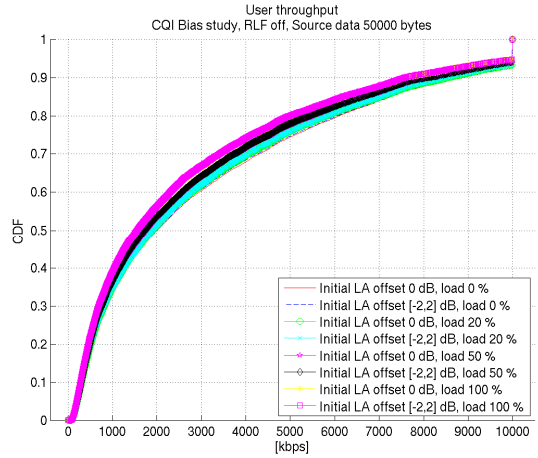

Figure 11 User throughput, 50 Kb data, Bias [-2,2] dB

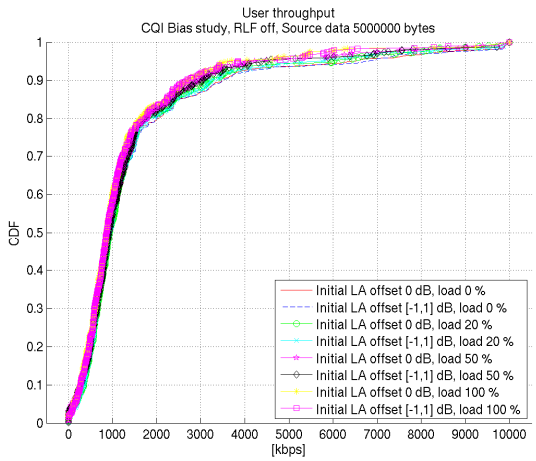

Figure 12 User throughput, 5 Mb data, Bias [-1,1] dB

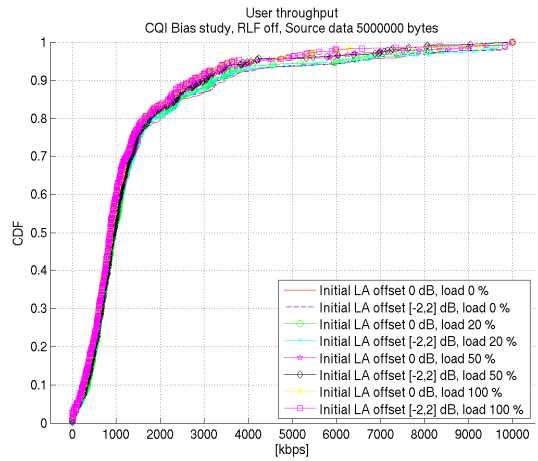

Figure 13 User throughput, 5 Mb data, Bias [-2,2] dB

First transmissions BLERs with random bias are illustrated in Figure 14 through Figure 19. As it can be seen from those figures, the bias or load do not significantly impact to the user (or system) experience.

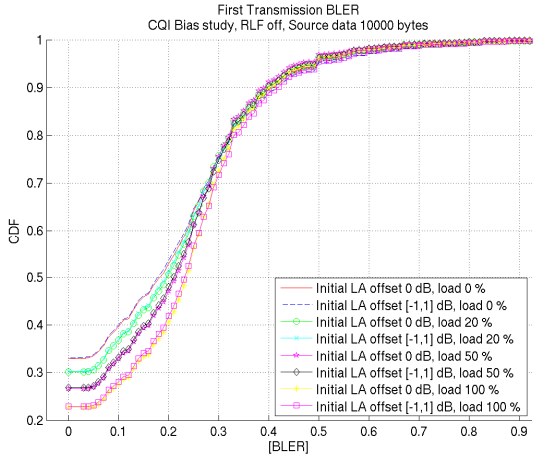

Figure 14 First transmission BLER per call, 10 Kb data, Bias [-1,1] dB

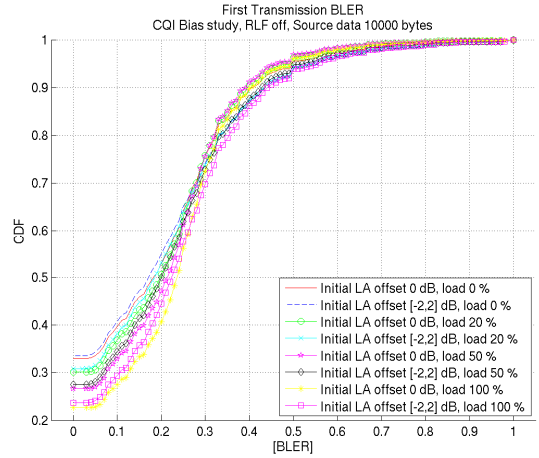

Figure 15 First transmission BLER per call, 10 Kb data, Bias [-2,2] dB

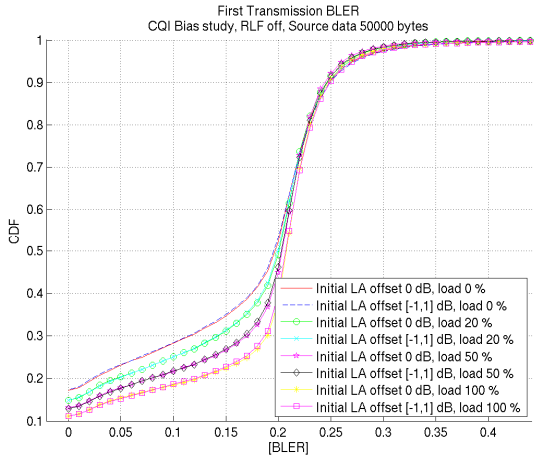

Figure 16 First transmission BLER per call, 50 Kb data, Bias [-1,1] dB

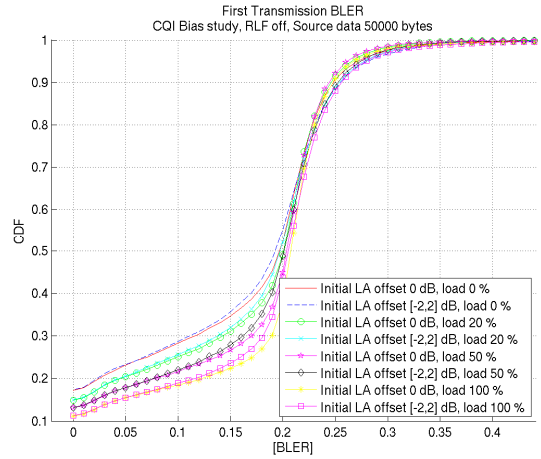

Figure 17 First transmission BLER per call, 50 Kb data, Bias [-2,2] dB

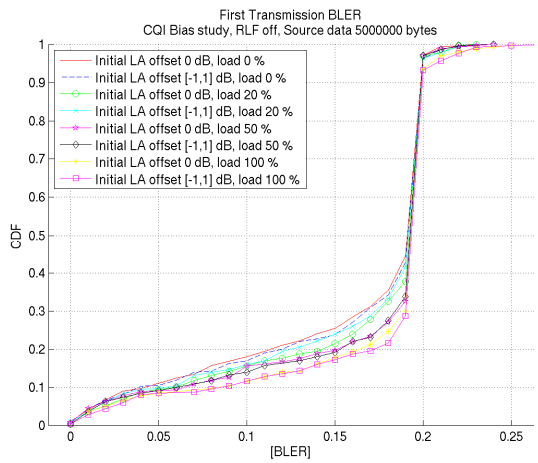

Figure 18 First transmission BLER per call, 5 Mb data, Bias [-1,1] dB

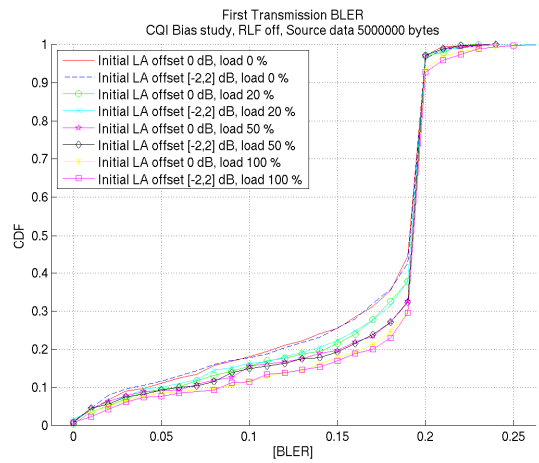

Figure 19 First transmission BLER per call, 5 Mb data, Bias [-2,2] dB

2.1 Performance with HTTP service

The spectral efficiency with random bias and different system load levels is illustrated in Figure 20 and Figure 21. Figure 22 shows the SE with different CQI measurement periods i.e. how often CQI is measured and sent to the e-NodeB. As those figures show bias, system load and measurement period do not have impact to the SE when sole HTTP traffic is considered.

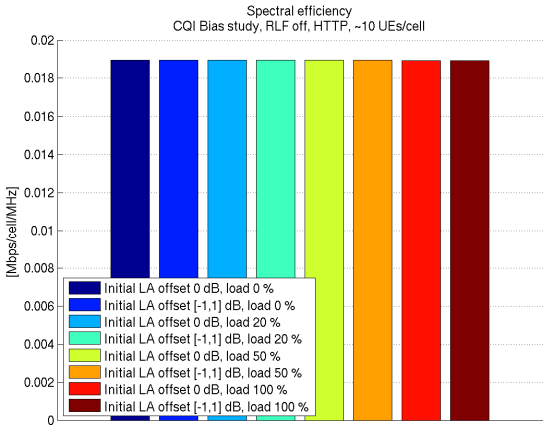

Figure 20 Spectral Efficiency, ~10 HTTP UEs/Cell, Bias [-1,1] dB

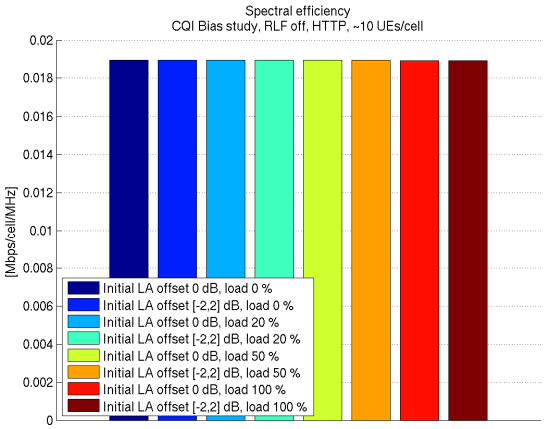

Figure 21 Spectral Efficiency, ~10 HTTP UEs/Cell, Bias [-2,2] dB

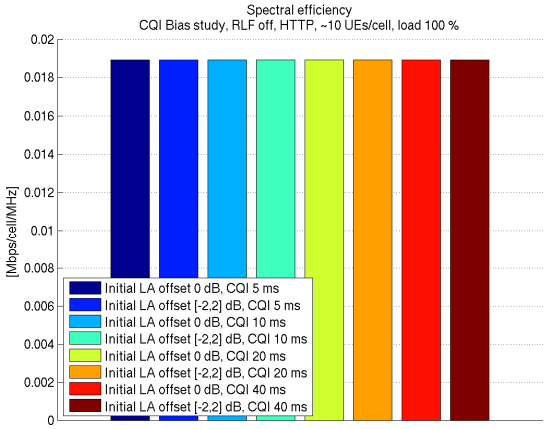

Figure 22 Spectral Efficiency, ~10 HTTP UEs/Cell, different CQI reporting intervals, Bias [-2,2] dB

Similarly to CBR results above the user throughput is only slightly, if any, impacted from the bias. This is shown in Figure 23 through Figure 25.

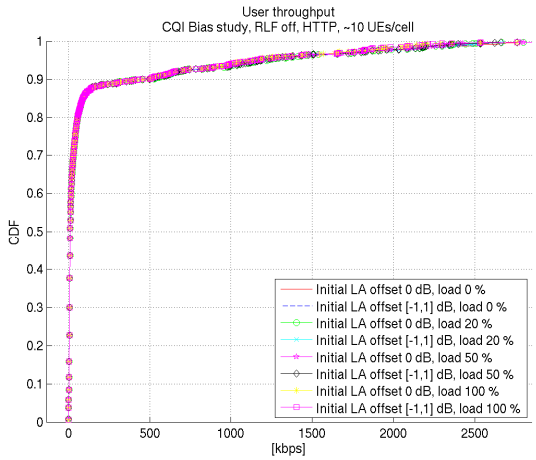

Figure 23 User throughput, ~10 HTTP UEs/Cell, Bias [-1,1] dB

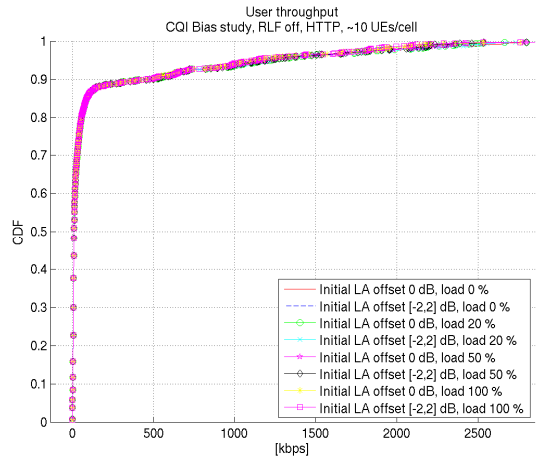

Figure 24 User throughput, ~10 HTTP UEs/Cell, Bias [-2,2] dB

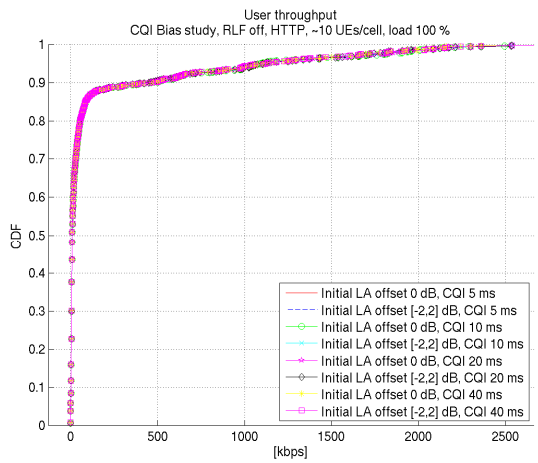

Figure 25 User throughput, ~10 HTTP UEs/Cell, different CQI measurement intervals, Bias [-2,2] dB

First transmissions BLERs with random bias are illustrated in Figure 26 through Figure 28. As earlier results already implied only the absolute values are changed with different configurations and the impact of bias remains on very minor level.

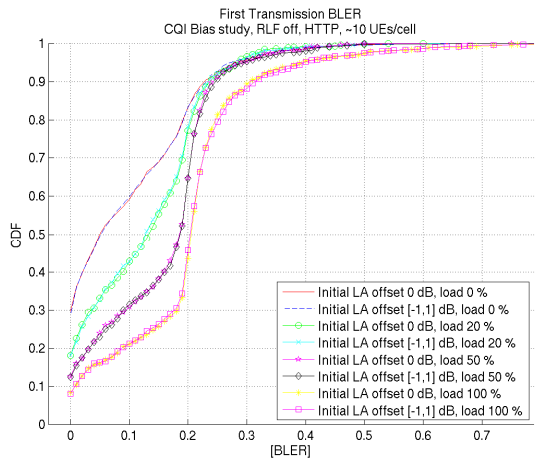

Figure 26 First transmission BLER per call, ~10 HTTP UEs/Cell, Bias [-1,1] dB

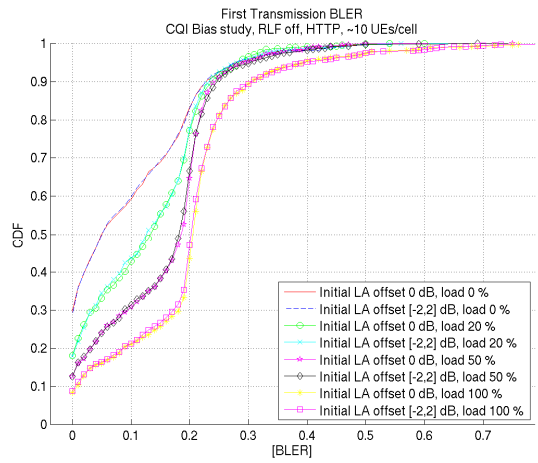

Figure 27 First transmission BLER per call, ~10 HTTP UEs/Cell, Bias [-2,2] dB

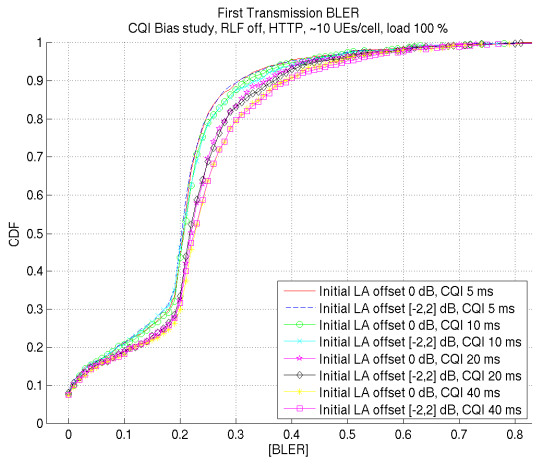

Figure 28 First transmission BLER per call, ~10 HTTP UEs/Cell, different CQI measurement intervals, Bias [-1,1] dB

3. Conclusions

In this contribution we have show with fully dynamic simulations how non-consistent CQI reporting by the UE impacts to the system level performance. Performance was evaluated with different combinations of traffic types, CQI settings, bias settings and system loads. The results showed us that the system level performance is not significantly impacted by biased CQI values.

4. References

[1] 3GPP TS 36.101, User equipment (UE) Radio transmission and reception, v. 8.6.0.

[2] 3GPP R4-092157, System performance impact of the CQI bias setting, Los Angeles, 29 June – 2 July, 2009.

Annex

A.1 Simulation 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
Network 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		55 cells (18 macro cells)
	Macro cell ISD	500 m
	Antenna pattern	Macro cells: 70-degree sectored beam
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 km/h
Receiver		2RX MRC
Outer Loop Link Adaptation	BLER target	0.2
	Step Up [dB]	0.5
	Max offset [dB]	15
	Min offset [dB]	-15
Channel Quality Indicator	Measurement Period	[5,10,20,40] ms
	Number of PRBs Per CQI	6
	Reporting delay	8 ms

	SINR error variance	1 dB
	Sliding window size	1
	Quantization step	1
	Bias	+-[0,1,2]

Table 2. HTTP Parameters

Feature/Parameter		**Value/Description**
Inter-document period [s]	Geom. distributed	mean 4 s
Number of documents	Geom. distributed	mean 5
Number of packets	Geom distributed	mean 25
Packet size [bytes]	Cut-off pareto distribution	alpha = 1.1 (Pareto exponent) beta = 81.5 (minimum value) cut-off value = 66666 => Mean value = 480 bytes
Packet inter-arrival time [ms]	Geom. distributed	mean 2 ms

Table 3. Constant bit rate service parameters

Feature/Parameter		**Value/Description**
File size		[10, 50, 5000] Kbytes
Packet size		1500 bytes
Packet inter-arrival time		1 step