3GPP TSG-RAN1 #56-BIS **R1-091498**
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Agenda Item: **15.7**

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Title: **DL System Level Performance Evaluation with 3-Dimensional Antenna Pattern for Advanced E-UTRA**

Document for: **Discussion**

1. Introduction

In the last Ljubljana meeting, we finally reached the agreement on antenna pattern for system level evaluation, including front-to-back ratio for both horizontal and vertical patterns and combining method in 3D antenna [1]. It seemed that the system performance improvement by involving 3D antenna pattern is fairly large in terms of sector throughput and user coverage [2].

In this contribution, we attempt to clarify the system impact by comparing the performances between 3D antenna pattern and horizontal antenna pattern. The intention of this work is to reveal the system level results and provide some solid justifications whereby a clear understanding will be given that in order to reach the target [3], how much additional system performance is still need to be improved.

2. System Level Simulation Summary

To simplify our discussion, this section summarizes the system level performance under the antenna configurations of 1x2 and 2x2 with single-user (SU) MIMO and multi-user (MU) MIMO[1]. The detailed information associated with system level simulation assumptions, link to system mapping MCS table, system level results are elaborated in the appendix 4.

Table 1 and Table 2 briefly summarizes the system performance results in terms of sector aggregated throughput and user coverage with 5%tile outage requirement for horizontal antenna pattern and 3D antenna pattern, respectively.

Table 1: Comparison results in terms of sector aggregated throughput and user coverage for simulation case-1 and case-3, using horizontal antenna pattern.

Simulation Case	Antenna Configuration	Aggregated Sector Throughput (bps/Hz)	User Coverage (bps/Hz)
1	1 × 2	1.48776	0.04978
3		1.43984	0.04260
1	2 × 2 SM, SU	1.44956	0.03770
3		1.39370	0.03183
1	2 × 2 SM, MU	1.63401	0.04510
3		1.58011	0.03830

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[1] In both SU and MU MIMO, the pre-coding mechanism is not involved.

Table 2: Comparison results in terms of sector aggregated throughput and user coverage for simulation case-1 and case-3, using 3D antenna pattern.

Simulation Case	Antenna Configuration	Aggregated Sector Throughput (bps/Hz)	User Coverage (bps/Hz)
1	1 × 2	2.00097	0.07440
3		1.51586	0.04360
1	2 × 2 SM, SU	2.15984	0.06140
3		1.51661	0.03460
1	2 × 2 SM, MU	2.35660	0.07290
3		1.70542	0.04058

The gain achieved by introducing 3D antenna pattern over horizontal antenna pattern is summarized in Table 3, accordingly.

Table 3: Relevant gain of 3D antenna pattern over horizontal antenna pattern.

Simulation Case	Antenna Configuration	Aggregated Sector Throughput (bps/Hz)	User Coverage (bps/Hz)
1	1 × 2	1.345	1.495
3		1.053	1.023
1	2 × 2 SM, SU	1.490	1.629
3		1.088	1.087
1	2 × 2 SM, MU	1.442	1.616
3		1.079	1.059

3. Conclusions

In this contribution, DL performance comparison has been evaluated between horizontal antenna pattern and 3D antenna pattern by means of a system level simulation. As a consequence, the performance impact is quite significant, particularly for case-1. For case-1, the gain for sector throughput is between 34~50% and the gain for user coverage is between 50~63%. For case-3, however, the gain is below the single digit. Compared to the requirement targeted for case-1 in LTE-A [3], by only involving 3D antenna pattern with SM and MU MIMO, the target can be simply reached, and new technologies are not necessarily considered.

4. Appendix: System Level Simulation Details

The detailed simulation assumptions, link to system mapping MCS table, and elaborated simulation results are described in what follows.

4.1. Simulation Assumptions

The system level simulation assumptions are referred to [1] with simulation case-1 and case-3 (see Table 4) in which the CF, inter-site distance (ISD), operating bandwidth (BW), penetration loss (PLoss), UE speed, and channel model are specified.

Table 4: UTRA and EUTRA simulation case minimum set.

Simulation Cases	**CF (GHz)**	**ISD (meters)**	**BW (MHz)**	**PLoss (dB)**	**Speed (km/h)**	**Channel Model**
1	2.0	500	10	20	3	TU
3	2.0	1732	10	20	3	TU

The system level simulation focuses on the down-link with the detailed assumptions listed in Table 5.

Table 5: System Level Simulation Assumptions.

Number of Cells	19
Number of Sectors per Cell	3
Number of UEs per sector	10
Antenna Configuration	1x2 and 2x2
Transmit Antenna Correlation	10λ
Receive Antenna Spacing	0.5λ
Maximum Retransmission Number	3
HARQ Type	Incremental Redundancy (IR)
Centre Frequency	2 GHz
Transmission Power	40 Watts (46 dBm)
Lognormal Shadowing	8dB
Noise Figure	9 dB
Transmit Antenna Gain	14 dBi
Receive Antenna Gain	0 dBi
Maximum CIR	30 dB
Path-Loss	$128.1+37.6\log_{10}(R)$, R in km
Scheduler	Proportional Fair
Channel Estimation	Ideal
Traffic Model	Full Buffer
MCS Table	29 Levels, see Table 6 in section 4.2
Effective SINR	Mutual Information Basis [4]
Overhead	25% for 1x2, and 28.57 for 2x2
MCS Determination	Common Reference Signal Basis
MCS Feedback Interval	5msec
Number of HARQ Process Channel	8
Number of RBs per Tx per UE	10
Channel Model	SCM
Bandwidth	10MHz
Number of Useful Sub-carriers per Symbol	600
FFT Size	1024
Receiver Type	LMMSE
A_m for Horizontal Antenna	25dB
SLA_V for Vertical Antenna	20dB

4.2. MCS Table

The MCS format is tabulated in Table 6, with 29 MCS levels considering QPSK, 16QAM and 64QAM, and many different code rates.

Table 6: MCS Format.

MCS Index	Modulation	Code Rate	MCS Index	Modulation	Code Rate
0	QPSK	0.117333333	15	16QAM	0.608
1	QPSK	0.152	16	16QAM	0.64
2	QPSK	0.186666667	17	64QAM	0.426666667
3	QPSK	0.245333333	18	64QAM	0.458666667
4	QPSK	0.298666667	19	64QAM	0.508444444
5	QPSK	0.373333333	20	64QAM	0.551111111
6	QPSK	0.437333333	21	64QAM	0.608
7	QPSK	0.512	22	64QAM	0.643555556
8	QPSK	0.586666667	23	64QAM	0.700444444
9	QPSK	0.661333333	24	64QAM	0.760888889
10	16QAM	0.330666667	25	64QAM	0.803555556
11	16QAM	0.368	26	64QAM	0.871111111
12	16QAM	0.421333333	27	64QAM	0.896
13	16QAM	0.474666667	28	64QAM	0.920888889
14	16QAM	0.544			

Figure 1, Figure 2 and Figure 3 show the BLER results as a function of SNR associated with QPSK, 16QAM, and 64QAM, respectively. These MCSs are used for interface between link-level and system level mapping based on mutual information mapping manner.

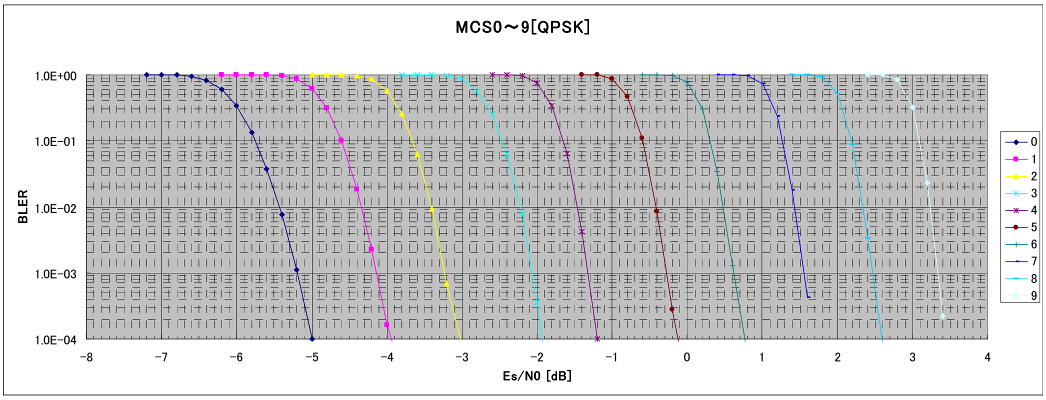

Figure 1: MCSs for QPSK.

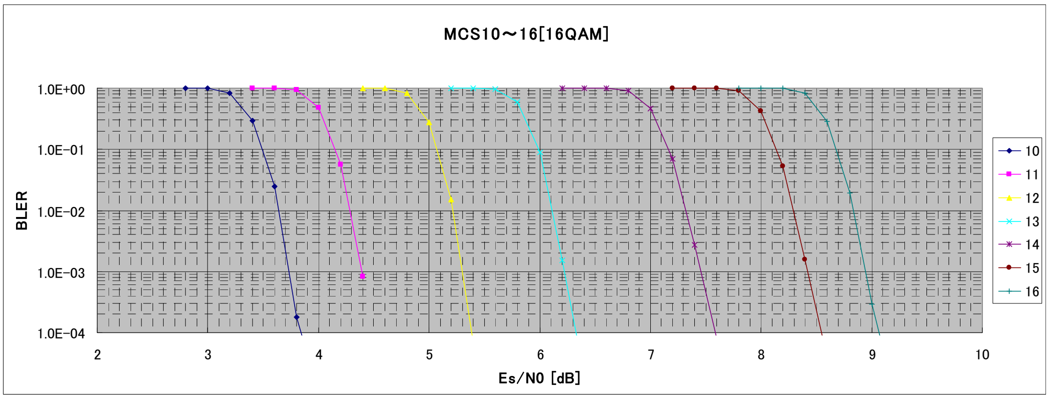

Figure 2: MCSs for 16QAM.

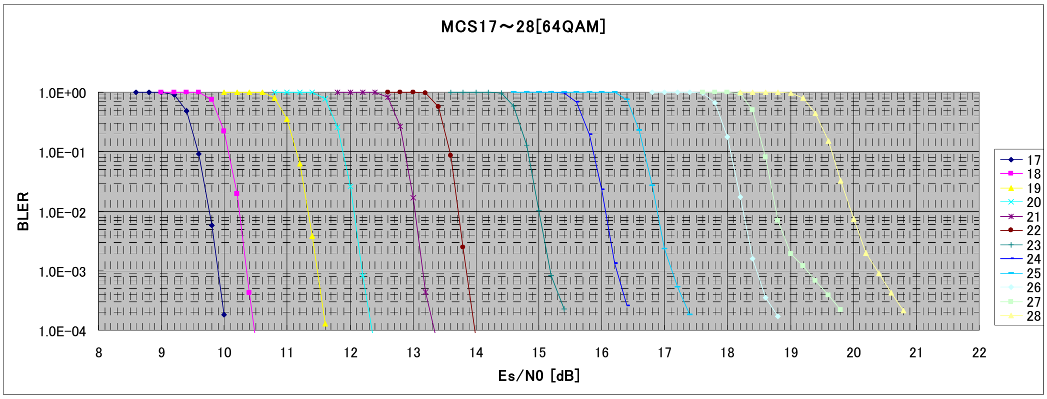

Figure 3: MCSs for 64QAM.

4.3. System Level Simulation Results

Here, we plot the detailed system level simulation results for case-1 and case-3, in terms of Geometry CDF, SINR CDF, and user throughput CDF.

Figure 4 and Figure 5 illustrate the geometry as a function of distance between UE and serving cell, comparing between horizontal antenna pattern and 3D antenna pattern in two different simulation case-1 and case-3, respectively.

Figure 6 and Figure 7 show the CDF of SINR pertaining to selected data sub-carriers, for case1 and case3 with horizontal antenna pattern and 3D antenna pattern, respectively.

Figure 8 and Figure 9 show the CDF of user throughput, for case1 and case3 with horizontal antenna pattern and 3D antenna pattern, respectively

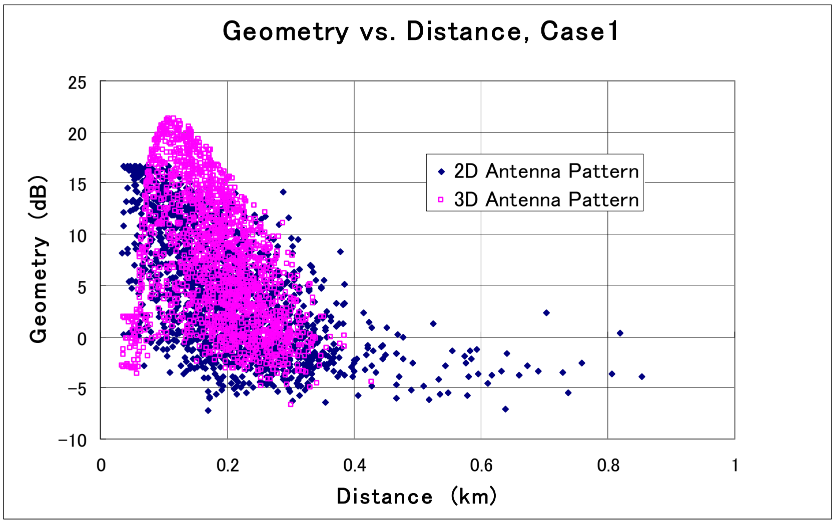

Figure 4: Geometry vs. distance between UE and serving cell in case-1.

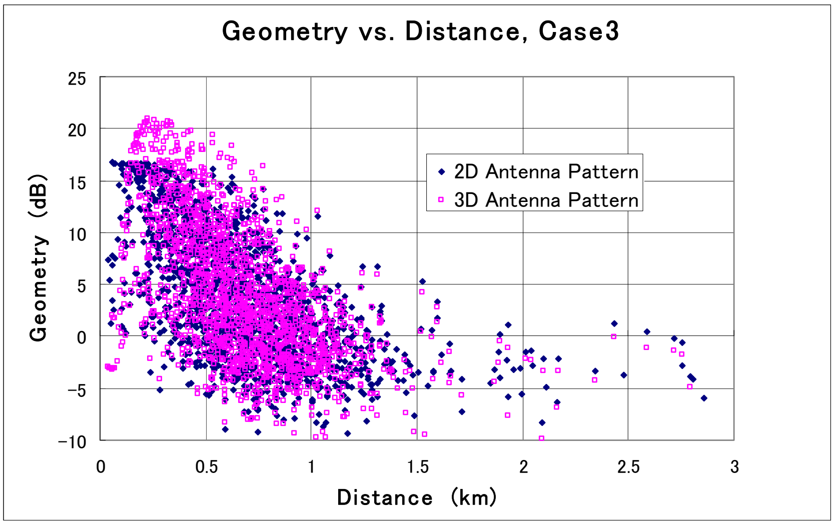

Figure 5: Geometry vs. distance between UE and serving cell in case-3.

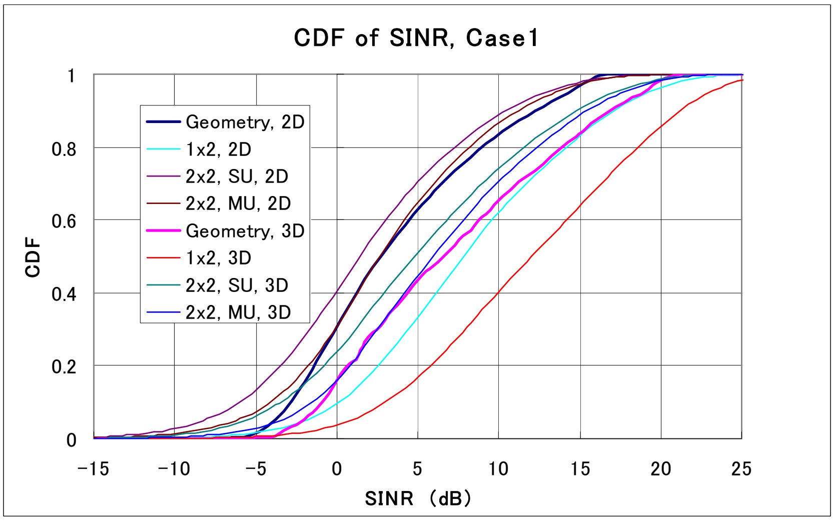

Figure 6: CDF of SINR for case-1.

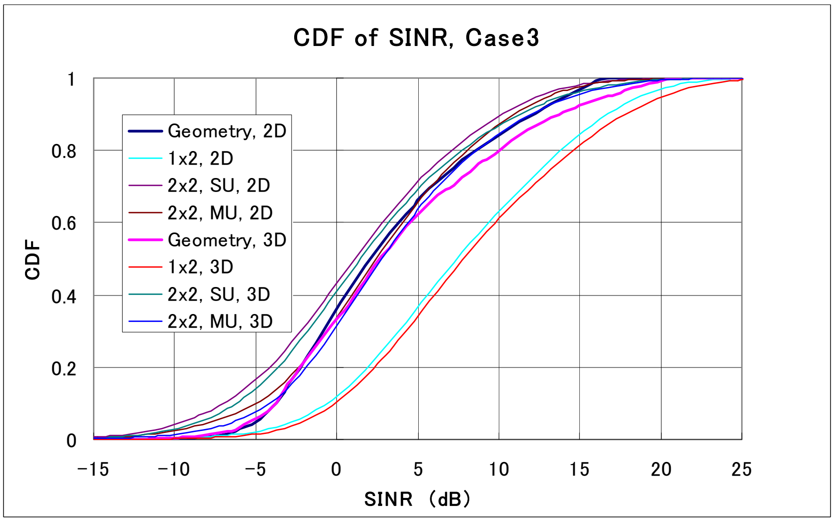

Figure 7: CDF of SINR for case-3.

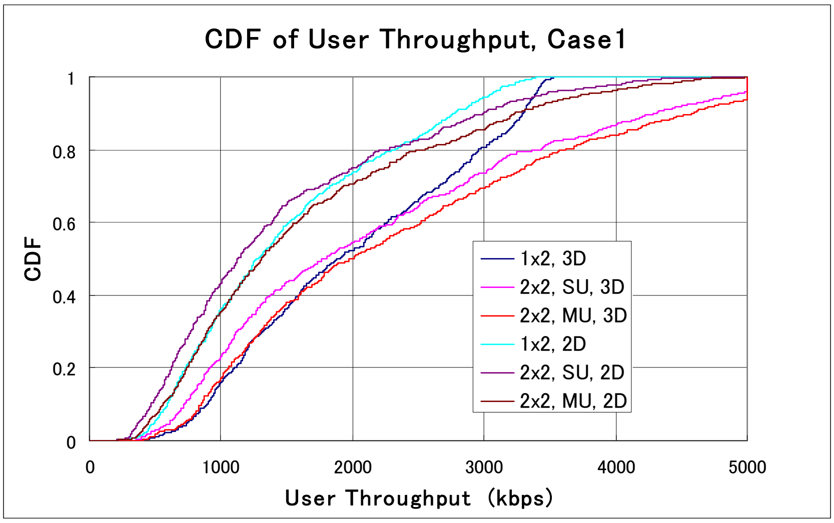

Figure 8: CDF of user throughput for case-1.

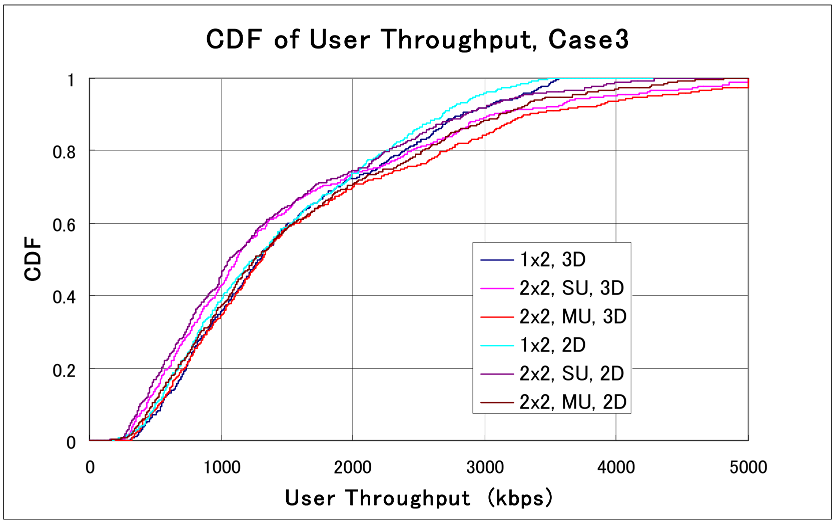

Figure 9: CDF of user throughput for case-3.

Reference

[1] 3GPP TR 36.814 v0.3.1, Further Advancements for E-UTRA Physical Layer Aspects, January 2009.

[2] 3GPP TSG RAN WG1 Meeting #55bis, R1-090473, Antenna Pattern for LTE-Advanced System Evaluations, Ljubljana, Slovenia, January 12-16, 2009.

[3] 3GPP TR 36.913 v8.0.0, Requirement for further advancements for E-UTRA, release-8, June 2008.

[4] IEEE C802.16m-07/080r3, Draft IEEE 802.16m Evaluation Methodology Document, August 28, 2007.