3GPP TSG RAN WG1 #60bis ***R1-103657***
Dresden, Germany, June 28 – July 2, 2010

Agenda item: 6.3.2.2

Source: Samsung

Title: Discussion on the overhead of muting

Document for: Discussion / Decision

1 Introduction

In RAN1#60, the following were agreed with respect to PDSCH RE muting for inter-cell CSI-RS [1]:

- *Study RE muting, i.e., no collision between CSIRS and data, for multi-cell CSI measurement*
  - *Consider the impact of muting on UE interference measurement*
  - *Consider the impact on Rel-8 UE*
  - *Power reallocation of muted REs is FFS*

Currently, there is an ongoing RAN1 evaluation of RE muting to investigate the impacts on Rel.8 UEs and the performance of Rel.10 UEs. However, in the evaluation, muting schemes other than full muting where the PDSCH is turned off on all the CSI-RS locations other than the one used by the serving cell are not considered. While such an approach allows a significant improvement on the channel measurement based on the CSI-RS, it incurs a severe overhead on PDSCH since a large portion of the bandwidth has to be sacrificed. Therefore, if muting is to be adopted for LTE-A, we propose that the means to control the overhead incurred by muting be adopted as well. In this contribution, we investigate the performance impact of PDSCH muting and discuss different alternatives for controlling the overhead of PDSCH muting.

2 PDSCH RE muting

2.1 Full muting

In this contribution, we define full muting as the case where PDSCH muting is performed in the following way:

- Muting is applied with the same periodicity as the CSI-RS
- Muting is applied for all PRB pairs
- Given a CSI-RS reuse factor of *N*, muting is applied for on *N*-1 CSI-RS resources.
- Muting is applied for all PDSCH REs coinciding with neighbouring cell's CSI-RS antenna ports.

Although full muting may be beneficial for the channel measurement process, we need to carefully study its impact on the PDSCH.

2.2 Partial muting

The overhead of PDSCH muting can be controlled by applying muting for a subset of CSI-RS transmissions from neighbouring cells. In this contribution, the term 'partial muting' will be used to differentiate such a muting scheme from full muting. Following are the possible options:

- Partial muting in time domain
  - Muting is applied with larger periodicity compared to the CSI-RS transmission from other eNBs.

- Partial muting in frequency domain
    - Muting is not applied in every PRB in frequency domain.
- Partial muting within different CSI-RS patterns
    - For a CSI-RS reuse factor of *N*, not all *N*-1 CSI-RS resources use by adjacent cells are muted off.
- Partial muting within antenna ports
    - Apply muting for only a subset of antenna ports used by adjacent cells.

Note that partial muting may be implemented by utilizing only one of the above options or by combining two or more options. For example, partial muting in the time domain can be used together with partial muting in the frequency domain and so on.

As a demonstration on how partial muting might be used to control the overhead of PDSCH muting, we provide link evaluation results comparing the link throughput of full muting and partial muting. The evaluation was performed for the partial muting within different CSI-RS patterns. An illustration of the partial muting evaluated in Section 3 is shown in Figure 1. It can be observed that CSI-RS has a reuse factor of 6 but only 2 CSI-RS patterns are muted off.

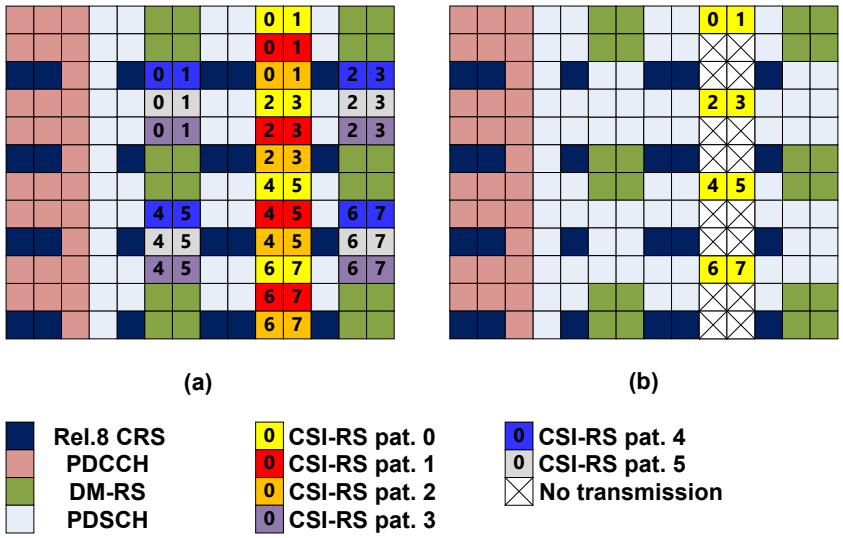


Figure 1. Partial muting within different CSI-RS patterns for reuse factor 6 case.

The left part of Figure 1, shows 6 different CSI-RS patterns that can be used for CSI-RS transmission. The right part of Figure 1 shows partial muting applied such that 2 CSI-RS patterns have been muted off while 3 CSI-RS patterns have not been.

3 Evaluation Results

3.1 Simulation Scenario

In order to accurately assess the impact of muting overhead on the performance of LTE-A, link simulation was performed in a multi-cell environment. The simulation was conducted in a 57-cell environment with an inter-site distance of 500 m. The downlink performance was evaluated for a rank 1 beamforming using 8 transmit antennas. It was assumed that there is no coordination among any of the 57 cells and that all cells other than the serving cell were always generating inter-cell interference. The inter-cell interference was modelled with 6 strongest interferers

generating interference using random precoding subject to time variant Rayleigh fading for a flashlight effect and the remaining 50 interferers generating Gaussian distributed random noise.

Link throughput was evaluated for different UE locations which are determined by the angle and distance from the eNB as shown in Figure 2.

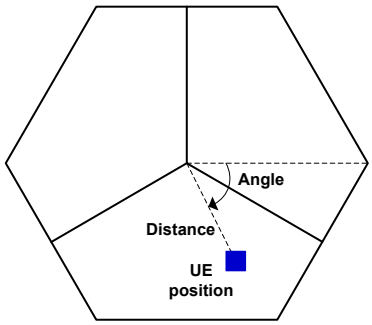


Figure 2. Determination of UE position.

Additional details of the simulation setup and assumptions can be found in the Appendix.

3.2 Simulation Results

Figure 3 shows the link throughput results for different distances from eNB when the angle of UE location is -90 degrees. Such UE locations correspond to the case where the UEs are located at the centre of the eNB antenna pattern.

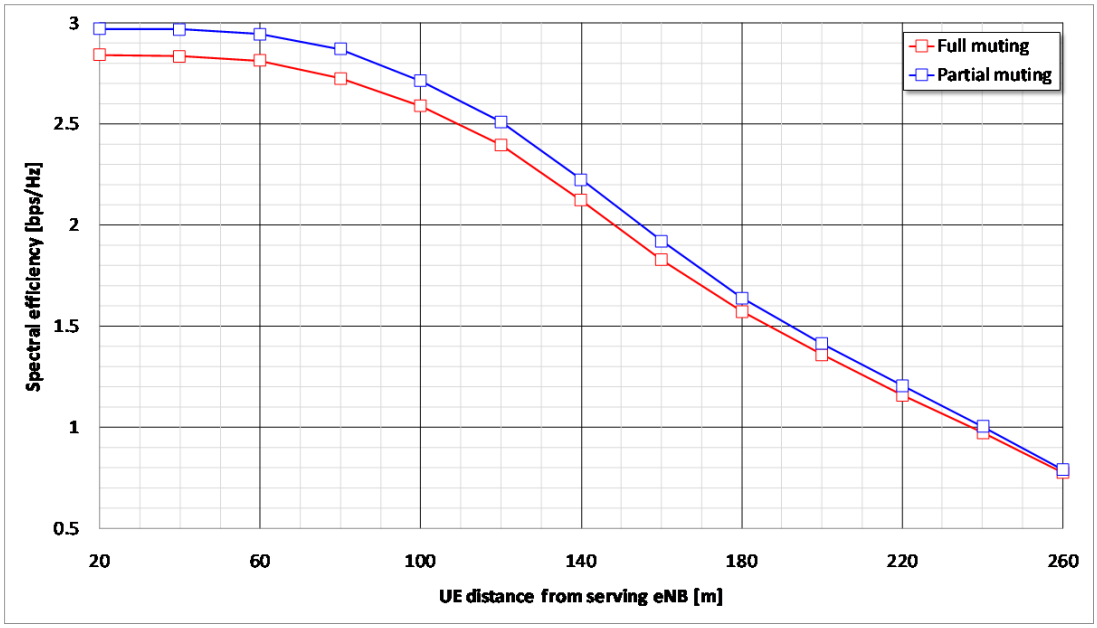


Figure 3. Link throughput of Rel.10 UEs with full and partial muting scheme when the angle of UE location is -90 degrees.

Compared to the full muting case, the channel measurement based on the CSI-RS for the partial muting case is subject to a higher level of inter-cell interference. However, since the overhead due to muting is smaller, the PDSCH transmission for the partial muting case is able to utilize more REs. In Figure 3, for all UE distances from eNB, full muting shows worse link throughput performance compared to that of partial muting. To summarize, the simulation results in Figure 3 show that the PDSCH overhead incurred by full muting might be too much compared to the improved channel measurement accuracy.

Similar observations were made also for other angles for UE location. The figures for simulation results when the angles of UE location are -75, -60, and -45 degrees are provided in the Appendix.

4 Summary

In this contribution, we discussed the overhead of aspect of muting. Although muting may enhance the channel measurement performance, it requires PDSCH REs to be turned off which in effect reduces the bandwidth of PDSCH. In order to control the overhead of PDSCH, four different schemes were identified:

- Partial muting in time domain
- Partial muting in frequency domain
- Partial muting within different CSI-RS patterns
- Partial muting within antenna ports

In addition, link simulation results were obtained for a multi-cell environment to study the performance impact of muting overhead. Simulation results were provided for full and partial muting cases. Based on the simulation results, it was observed that for all UE locations, full muting shows worse link throughput than partial muting.

Currently, it has not been decided yet, whether muting will be adopted for LTE-A or not. However, based on simulation results, it was observed that partial muting can result in better performance compared to full muting. Therefore, if muting is adopted, it is recommended that partial muting be studied as a method to control the overhead of muting while enhancing the channel measurement in LTE-A.

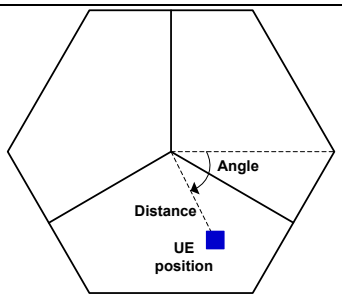
5 References

[1] R1-101711, “Final report of RAN1#60 meeting”, MCC support, San Francisco, USA, February 2010.

[2] R1-102199, “Design and performance evaluation of 8Tx codebook”, Samsung, San Francisco, USA, February 2010.

Appendix

A. Simulation environment

<table>
<tr><th colspan="2">Parameters</th><th colspan="2">Values</th></tr>
<tr><td colspan="2">Channel model</td><td colspan="2">3GPP-TU</td></tr>
<tr><td colspan="2">Velocity [km/h]</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Antenna configuration</td><td colspan="2">8 Tx antennas, 2 Rx antennas</td></tr>
<tr><td colspan="2">Transmission scheme</td><td colspan="2">Rank 1 precoding [2]</td></tr>
<tr><td rowspan="2">UE position</td><td>Angle [degree]</td><td>-90, -75, -60, -45</td><td rowspan="2">
</td></tr>
<tr><td>Distance [m]</td><td>from 20 to 300</td></tr>
<tr><td colspan="2">Interference modelling</td><td colspan="2">19 sites (57 cells)</td></tr>
</table>

	6 major interfering cells are modelled by random precoding and flat fading
	the other 50 cells are modelled by Gaussian distributed uncorrelated random noise
Antenna pattern	2D model
Inter site distance(ISD) [m]	500
Reuse factor	6
Power boosting for CSI-RS	Implicit 9 dB boosting, Explicit 4.77 dB boosting
CSI-RS duty cycle [ms]	5
Number of CSI-RS ports	8

B. Additional simulation results

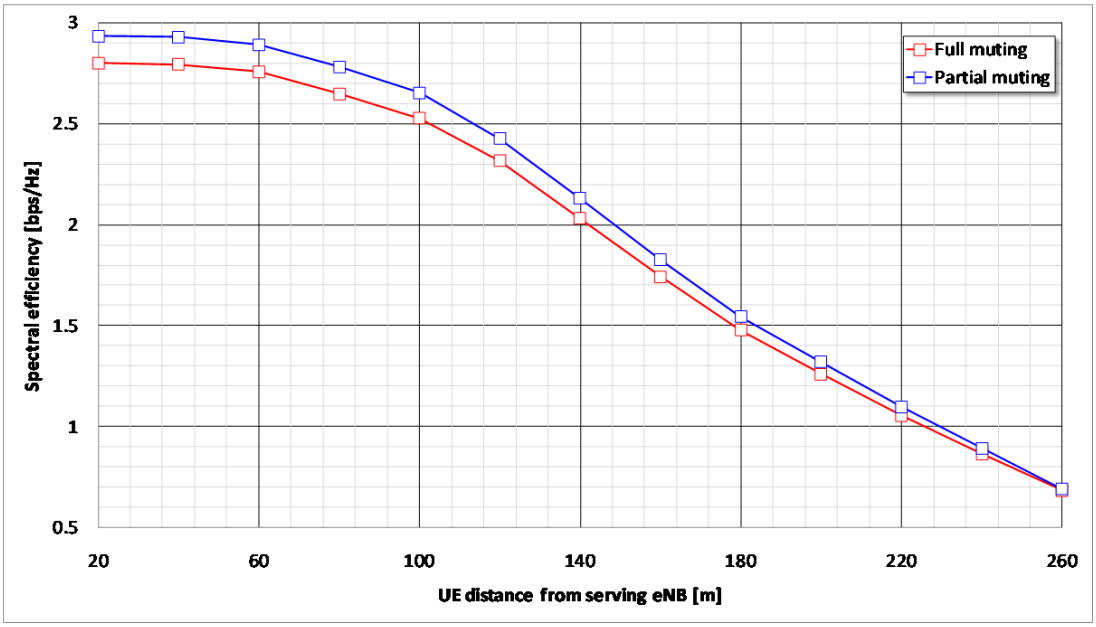


Figure 4. Link throughput of Rel.10 UEs with full and partial muting scheme when the angle of UE location is -75 degrees.

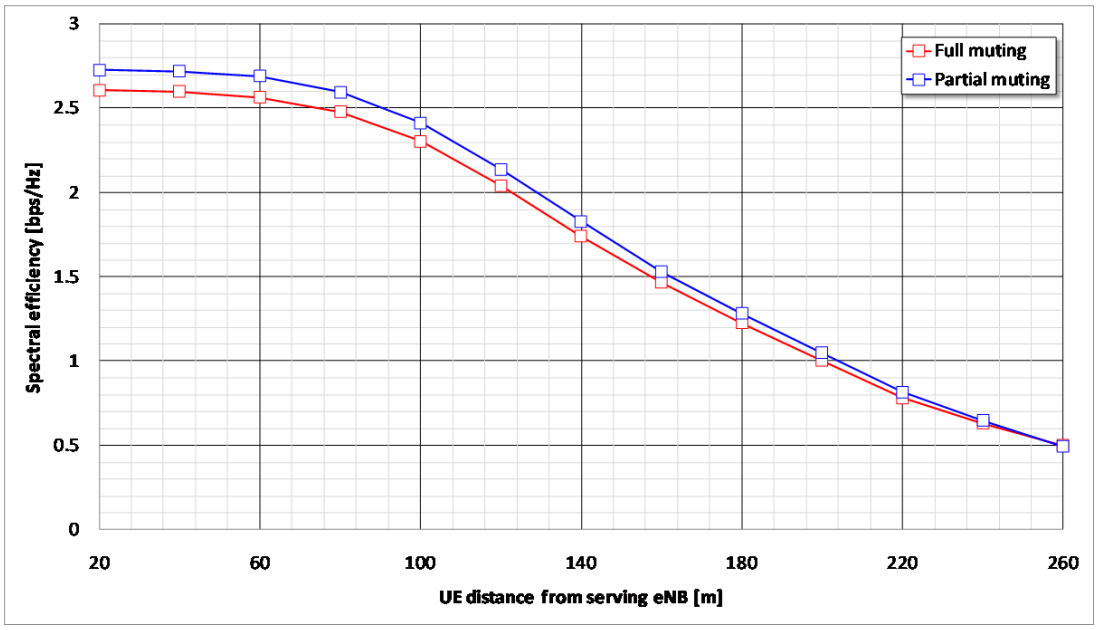


Figure 5. Link throughput of Rel.10 UEs with full and partial muting scheme when the angle of UE location is -60 degrees.

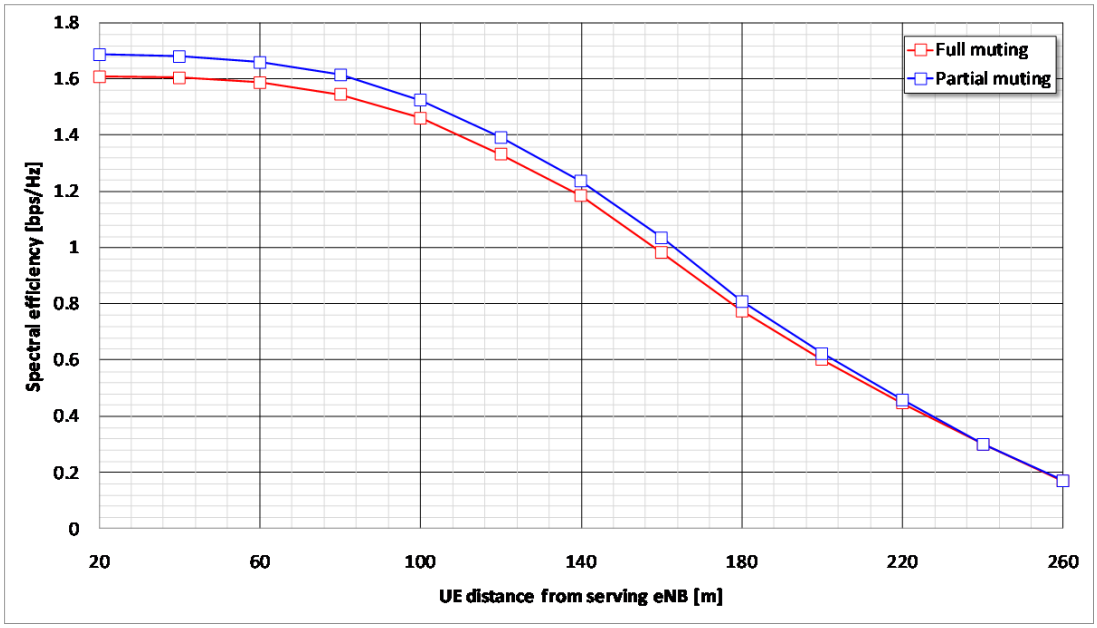


Figure 6. Link throughput of Rel.10 UEs with full and partial muting scheme when the angle of UE location is -45 degrees.