

**Agenda Item: 8**

**Source: Qualcomm Europe**

**Title: Preliminary Cell and User Throughput Comparison for 2x2 MIMO: D-TxAA and PARC**

**Document for: Discussion**

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## **1 Contents and Summary**

### **1.1 Contents**

This document contains an evaluation of the system level throughput obtained with different 2x2 MIMO schemes like D-TxAA proposed in [1] and PARC with and without Successive Interference Cancellation (SIC).

Through a simplified methodology that still uses all the system level assumptions in [2] agreed for MIMO evaluation, the system level cumulative distribution functions (CDF) of the user throughput are obtained for each of the considered MIMO schemes. Assuming a Round Robin scheduling strategy, the average cell throughput is then obtained from the said distributions.

### **1.2 Summary**

The results obtained show that, when using weight matrices derived from the existing CLTD Mode-I weight vectors<sup>1</sup>, the D-TxAA approach has only marginal throughput gain ( $\approx 2\%$ ) over regular PARC with linear receivers.

As shown by the results, the performance gap between such D-TxAA scheme and PARC when SIC capable receivers are used is still (almost) as significant as the difference between PARC with linear receivers and PARC with SIC capable receivers: around 20% in average cell throughput.

## **2 Assumptions and Methodology**

### **2.1 Assumptions**

Both D-TxAA and PARC schemes are evaluated in two modes:

1. A) Dual Stream: Two streams of data are always transmitted
2. B) Dynamic selection Dual/Single Stream: Two streams of data are only transmitted if the addition of the two individual rates is higher than the rate obtained by the corresponding single stream version of the scheme. The single stream transmission schemes in this comparison are
  - CLTD Mode-1 single stream transmission in the case of D-TxAA, and

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<sup>1</sup>As mentioned in [1].

- Selecting a single transmit antenna in the case of S-PARC. See [3] for more details in S-PARC.

The system and receiver assumptions employed in this comparison are:

- Cellular and system level setup in [2] with 75% of the Node-B power dedicated to HSDPA.
- No feedback errors are taken into account for the D-TxAA scheme. The FeedBack Information (FBI) bits are assumed to be perfectly chosen and processed and only the throughput resulting from using the "best" weights is considered.
- The S-PARC scheme would also need some means of indicating which one is the preferred cell station antenna, such selection is also assumed to be without error.
- Perfect channel estimation is assumed in the computation of the receiving filters for all schemes.
- CQI generation, transmission and processing are also assumed to be error free.
- Interference from other cells (non-serving cells) is modelled as to be radiated via static 70 deg 3db beamwidth sector antennas. The "flashlight" effect is hence not taken into account.

## 2.2 Methodology

The procedure to obtain the overall Cumulative Distribution Function (CDF) of the user throughput is based on the same system level simulator used to produce the system level results reported in [4], only that, following the computation by the UE of the achievable data rate(s)<sup>2</sup>, these data rate(s) are logged instead of continuing the process of modeling their transmission to the Node-B and simulating all the scheduling and signaling details.

For each scheme, always the best option is the one finally recorded. For instance, in the case of Dynamic adaptation for the D-TxAA scheme, the recorded data rate will be the maximum between the data rates achieved by any of the possible single stream Mode-I CLTD transmission vectors and the sum of the per stream data rates achieved by each of the D-TxAA transmit matrices.

Enough users are placed in the system to generate a sufficient number of samples resulting in smooth data rate CDF functions. Using this procedure, the CDF of the achievable user data rate for the entire cell coverage area can be obtained.

Once such functions are available for each of the schemes that we want to compare, it is possible to generate cell throughput results if a simple scheduling policy is assumed. For instance a Time Division Multiplex Round Robin (RR) scheduler which will assign all available resources (code, power and number of transmitted streams) to each UE in the cell in a time consecutive manner TTI after TTI.

To illustrate how this is actually done, let us say we have  $U = 10$  users in the system and that the function

$$F_R(r) \tag{1}$$

is the CDF of the user data rate for a given MIMO scheme, which has been experimentally obtained by the procedure previously described. We only need to use (1) to generate 10 independent occurrences of the data rate  $R, R_1 \dots R_{10}$ , and then take their average in order to obtain the cell throughput that the RR scheduler would achieve with such group of 10 users.

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<sup>2</sup>Single and Dual stream transmission is considered in the Dynamic selection mode of each MIMO scheme.

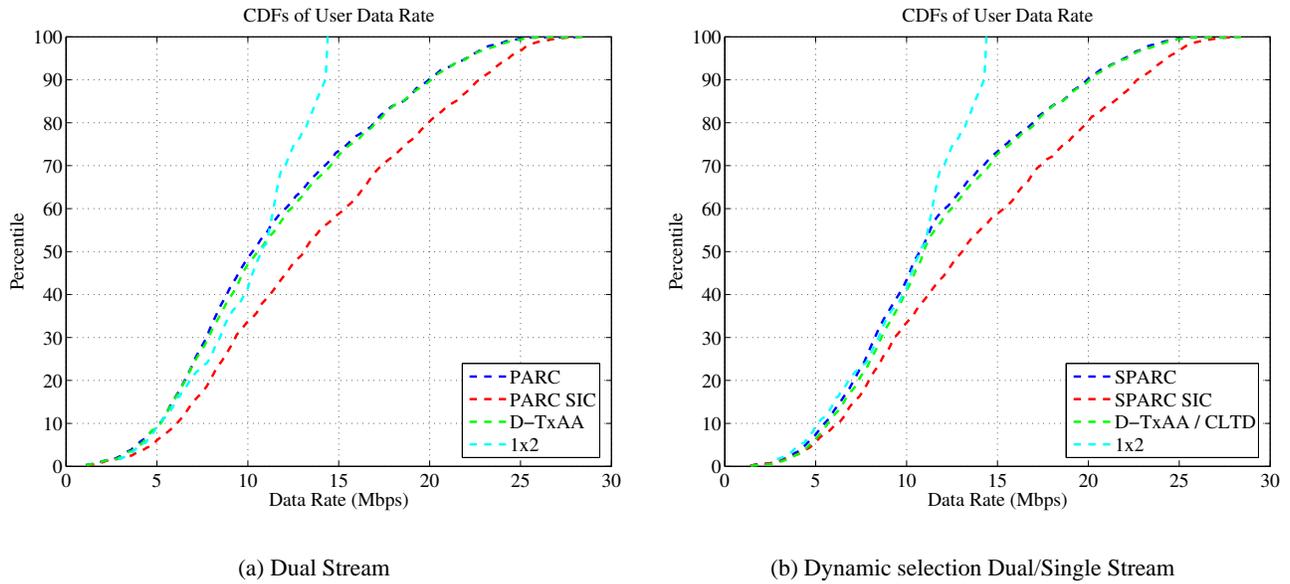


Figure 1: Experimental CDFs of the instantaneous user throughput

The described approach implicitly assumes that the channel conditions do not significantly change between the time when a user computes the CQI(s) and the time that the user is actually scheduled. This is accurate for the considered velocities of 3km/h.

Under the all above constrains, the described throughput calculation procedure results in practically the same outcome than that obtained when the CQI's are fed back to the scheduler and all the detailed HSDPA mechanisms are simulated.

### 3 Results

Figures 1-a and 1-b show the instantaneous user throughput CDFs for both evaluation modes A) and B). In this case "instantaneous" means the data rate achieved in a TTI. Since each user only gets scheduled every  $U$  TTIs, the average user throughput can be obtained by dividing by  $U$  the values in the abscissa. The CDFs for PARC with and without SIC, D-TxAA and a reference 1x2 system with LMMSE receivers are plotted. Tables 1 and 2 contain the cell throughput results for each scheme and its percentual gains versus the 1x2 reference, again for the case of Dual Stream (Table 1) and dynamic selection between Dual and Single stream (Table 2).

Scheme	Cell Throughput (Mbps)	Gain versus 1x2 (%)
1x2	10.13	NA
PARC	11.61	14.6
D-TxAA	11.78	15.3
PARC SIC	13.88	37.0

Table 1: Cell Throughput Results. Dual Stream

<b>Scheme</b>	<b>Cell Throughput (Mbps)</b>	<b>Gain versus 1x2 (%)</b>
1x2	10.13	NA
S-PARC	11.92	17.7
D-TxAA / CLTD	12.17	20.1
S-PARC SIC	13.91	37.3

Table 2: Cell Throughput Results. Dynamic selection Single/Dual Stream

## 4 Conclusions

The simplified comparison presented in the document seems to indicate that the D-TxAA MIMO transmission scheme proposed in [1] will not bring any significant capacity gain over PARC, even with ideal generation and feedback of FBI bits and without consideration of any "flashlight" effects. The performance of the D-TxAA scheme is actually still significantly inferior to what can be achieved by using SIC capable receivers. In light of all this, the extra complexity associated with the generation transmission and processing of FBI bits as well as antenna verification does not seem to be justified for the MIMO application.

## References

- [1] Motorola. *MIMO Evaluation Proposal*. R1-060615, TSG-RAN1 #44, Denver meeting, February 2006.
- [2] Cingular et al. *Reference Scenario for the Selection of the UTRA MIMO Scheme*. R1-051626, TSG-RAN1 Reflector, December 2005.
- [3] Ericsson. *Selective per Antenna Rate Control (S-PARC)*. R1-040307, TSG-RAN1 #36, Malaga meeting, February 2004.
- [4] Qualcomm Europe. *System Level Evaluation for MIMO-WCDMA*. R1-051508, TSG-RAN1 #43, Seoul meeting, November 2005.