

Athens, Greece, 27<sup>th</sup> –31<sup>st</sup> March 2006

**Source:** Nokia  
**Title:** HSDPA system performance with CL transmit diversity  
**Agenda Item:** 8  
**Document for:** Discussion

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## 1. Introduction

In the TSG-RAN WG1 meeting #44 some system level results for HSDPA with and without closed loop transmit diversity were presented [1]. Based on these results concerns were raised that there exists a serious problem inherent in using CLTD for HSDPA due to unpredictable interference behaviour. With the used assumptions the scheduler was not able to function properly.

In this contribution we present some simulation results for a full-dynamic system level simulator [3] with and without the CL transmit diversity in two different propagation conditions and packet scheduling algorithms. In the results presented in [1] the modelling of the interference was based on an orthogonality matrix approximation. In the results presented in this contribution the effect of interference is explicitly modelled. These dynamic system simulations results are presented to provide further insights on the area, where severe concerns were raised.

This same issue related to CLTD performance has also been earlier evaluated in open literature more rigorously and it was concluded that WCDMA/HSDPA system is robust enough to handle the small additional SINR fluctuations which could be caused by partial HSDPA activity and closed loop transmit diversity operation [2].

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## 2. System simulation results

In this section the used simulation assumptions and obtained simulation results are presented.

### 2.1 Simulation scenario

The simulations were performed in a macro cell scenario, which consists of 7 Node B's and 21 hexagonal cells (sectors) of radius of 933 meters. Propagation model was based on [4] and log-normally distributed slow fading with an 8 dB standard deviation and a spatial correlation distance of 50 meters were assumed. The evaluated channel profiles were modified Pedestrian A and Vehicular A. The power delay profiles were modified from the original ITU power delay profiles so that the tap delays are integer chips. Average path powers were [-0.2, -13.5]dB in Pedestrian A channel and [-3.1, -5.0, -10.4, -13.4, -13.9, -20.4]dB in Vehicular A channel.

MAC-hs packet scheduling based on Round Robin and Proportional Fair scheduling algorithms was used without code-multiplexing, i.e. only one UE is scheduled per TTI. The maximum numbers of HS-DSCH codes was 10 with spreading factor 16. HS-DSCH power allocation was 14 W, which is 70% of the total base station transmission power. One code was allocated for HS-SCCH with spreading factor of 128 and HS-SCCH is ideally decoded. Six parallel stop-and-wait (SAW) channels were used for the Hybrid ARQ. A maximum of 4 retransmissions were allowed per transport block. Chase Combining was used for the retransmissions [5].

HS-DSCH link adaptation was based on the UE reported channel quality indicators (CQI's) (inner loop) and UE reported Ack/Nacks from past retransmissions (outer loop). Aimed block error rate (BLER) target for the second transmission was 1% and link adaptation outer loop was used to control the BLER target. The MCS tables used in Node B were throughput optimised with a 30% BLER target. CQI reporting granularity of 1dB was accounted. CQI reporting error, which was modelled as log-normally distributed with standard deviation of 1.5dB, was included in the simulations.

Mobility and traffic models were based on UMTS 30.03 [6]. UE velocity was 3km/h. Modified web browsing traffic model, in which the users do not have a reading time during a download session i.e. they only have one packet call per session, was used.

The total simulation time was 6 minutes. The call arrival rate in the network was 140 calls per second and the average packet call size was 112 kilobytes. Thus, the total average offered load per cell can be calculated as  $A * B / C$ , where  $A$  is the call arrival rate,  $B$  is the average packet call size and  $C$  is the number of cells in the network. In these simulations the average offered load per cell was approximately 6 Mbps. New calls were generated according to homogeneous Poisson process. The offered traffic was high enough to have almost 100% utilization of the HS-DSCH. Admission control allowed up to 16 HSDPA users per cell.

RAKE receiver with single antenna was assumed. The receiver signal-to-interference and noise ratio was evaluated by evaluating the power of specific signal and interference terms by using the principles found in [7]. For the determination of the SINR used in the simulations presented in this document the interference seen from other cells was explicitly accounted by modelling the actual propagation and used transmission antenna weight; e.g. interference variations caused by CLTD was inherently modelled. It also good to note that in the used modelling of CL transmit diversity for interfering cells all power, excluding the common pilot power, is assumed to be weighted accordingly, leading to a larger impact of CLTD induced interference variations. The main simulation parameters are also listed in Annex A.

## 2.2 Results

Figure 1 and 2 present the HS-DSCH  $E_s/N_0$  distributions of scheduled users for Round Robin (RR) and Proportional Fair (PF) in Vehicular A and Pedestrian A, respectively. When comparing the HS-DSCH  $E_s/N_0$  distributions in Vehicular A and Pedestrian A it can be seen that the average  $E_s/N_0$ 's are increased and that the deviations are higher in Pedestrian A. This reflects the lower amount of multipath diversity.

As the RR scheduler allocates each user in turn the HS-DSCH  $E_s/N_0$  distributions shown with blue can be considered to represent the overall  $E_s/N_0$  distribution of active users. Comparing the RR  $E_s/N_0$  distribution to PF  $E_s/N_0$  distribution, the benefit of PF scheduling can be seen in terms of improved average  $E_s/N_0$  and reduced variation. Improvement due to CL transmit diversity can also be seen in  $E_s/N_0$  distribution, with both of the propagation conditions and schedulers. With a proper link adaptation and determination of used modulation and coding set this gain should be observable also in system throughput.

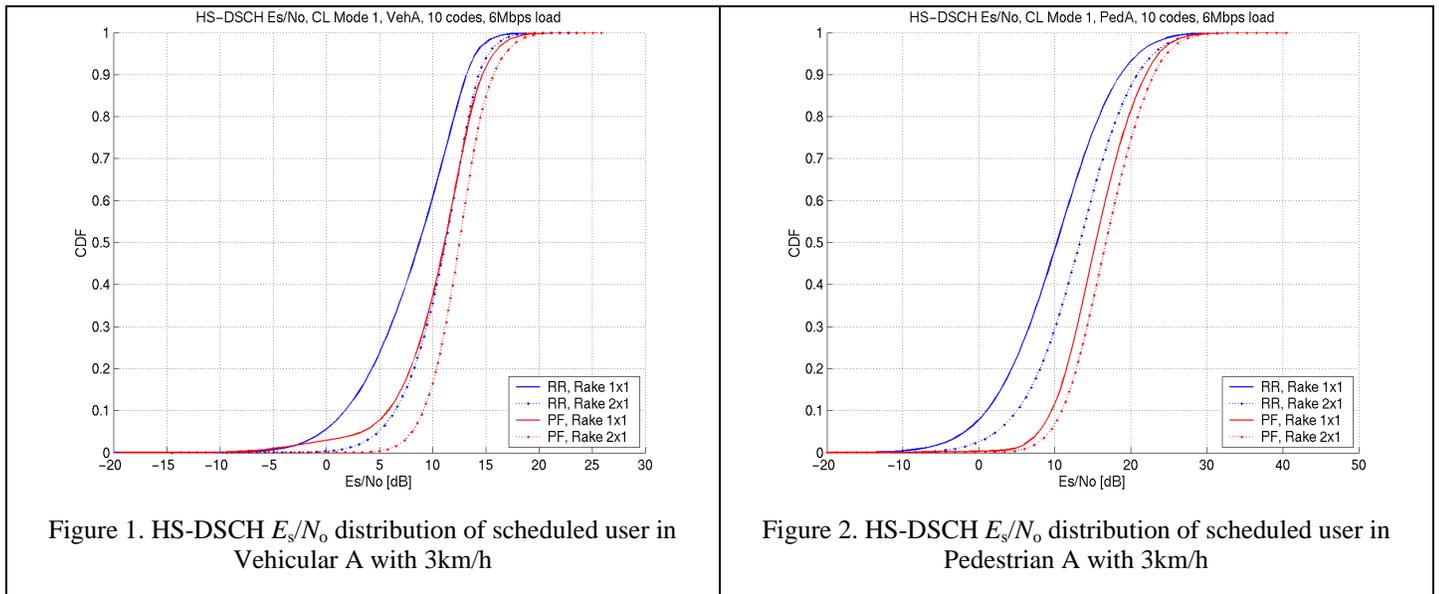


Figure 1. HS-DSCH  $E_s/N_0$  distribution of scheduled user in Vehicular A with 3km/h

Figure 2. HS-DSCH  $E_s/N_0$  distribution of scheduled user in Pedestrian A with 3km/h

Figure 3 and 4 present the distribution of allocated MCS. These results account the 1dB CQI reporting granularity and HS-DSCH link adaptation. The benefit of the CL transmit diversity seen in the HS-DSCH  $E_s/N_0$  distributions above is also visible in the allocated transport formats.

The truncation at low end of the MCS distribution seen with RR scheduler is due to the used RLC PDU size. RLC PDU size of 320 bits excludes the use of lower MCS. At high end the maximum used effective code rate (0.75) limits also the range of available MCS with PF scheduler in Pedestrian A.

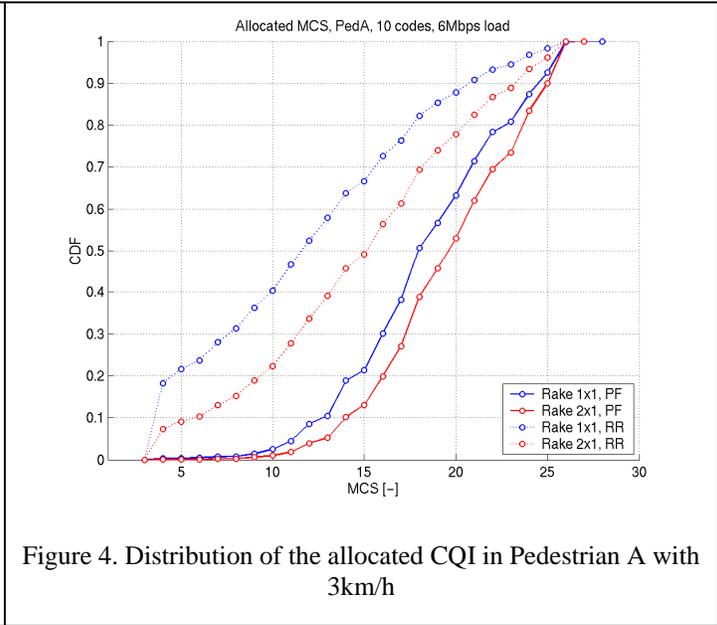
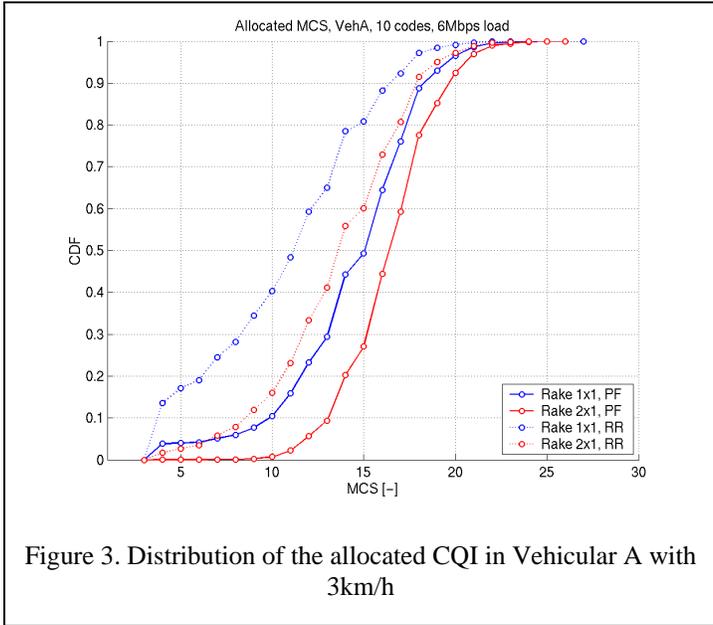
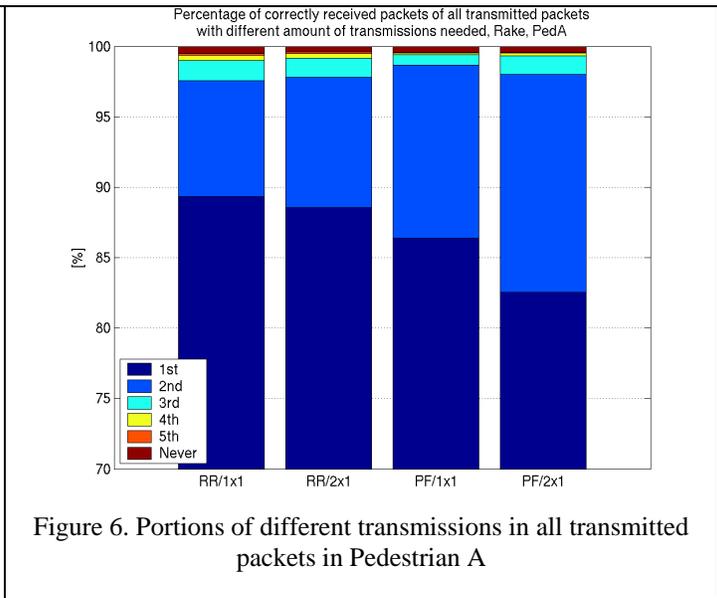
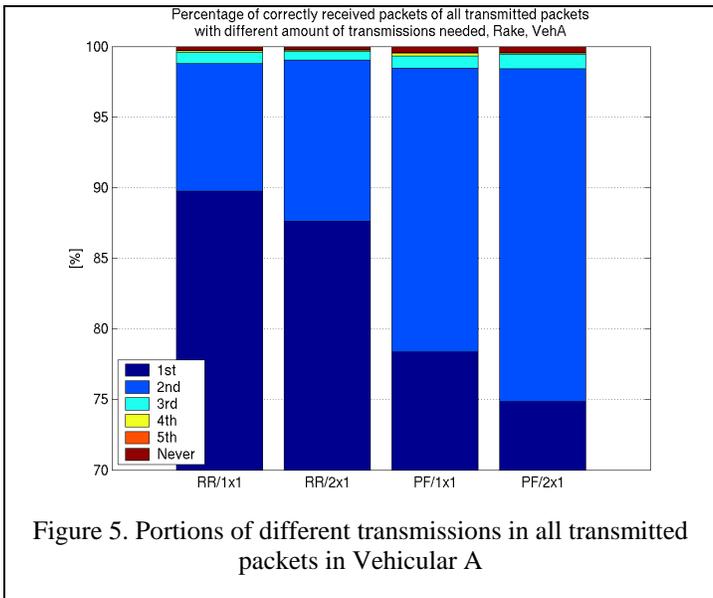


Figure 5 and 6 present the distribution of number transmissions needed for receiving the packets correctly. The portions of different (re-)transmissions are very similar for single transmit antenna scheme and CL transmit diversity. The largest difference between two cases can be seen in Vehicular A with PF scheduler where portion of 2<sup>nd</sup> transmissions has increased 3.5%-units. Larger changes in portions of different transmission required is caused by different scheduling schemes due to the non-ideal link adaptation scheme.



Finally, Table 1 summarises the average cell physical layer throughputs for both of the transmission schemes in Vehicular A and Pedestrian A propagation conditions. Average cell physical layer throughput is defined as sum of correctly delivered bits to all users during the simulation period divided by the simulation period and the number of simulated cells. It can be seen that with RR scheduler the CL transmit diversity is able to provide 46% benefit in Vehicular A and 39% benefit in Pedestrian A. With PF scheduler the benefit from CL transmit diversity is smaller as PF scheduler alone gives a 60% to 100% gain compared to single transmit antenna case. The obtained gain from CL transmit diversity is 23% in Vehicular A and 10% in Pedestrian A.

Table 1. Average cell physical layer throughput

| Scheduler | Average cell throughput [kbps] |      |              |      |
|-----------|--------------------------------|------|--------------|------|
|           | Vehicular A                    |      | Pedestrian A |      |
|           | 1-TX                           | CLTD | 1-TX         | CLTD |
| RR        | 1048                           | 1530 | 1595         | 2213 |
| PF        | 1680                           | 2082 | 3236         | 3545 |

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### 3. Conclusions

In this contribution CL transmit diversity is shown to provide benefit to HSDPA system level performance. The results of this document are supported by the earlier findings presented in open literature [2]. No indication of the problems claimed in [1] were seen even with these fully dynamic system simulations, where interference was explicitly modeled, and which are thereby considered to reflect the reality rather well.

Based on the results of this document we believe that there is no reason why CL transmit should not be considered in as a feasible HSDPA enhancement method.

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### References

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## Annex A: System Simulation parameters

| Parameter                           | Explanation/Assumption                            | Comments  |
|-------------------------------------|---|---|
| Cellular layout                     | Hexagonal cell grid, wrap-around                  | 7 BSs and 21 sectors  |
| Cell radius                         | 933 m   | Corresponds to the BS-to-BS distance of 2800 m.   |
| Propagation Model                   | $L= 128.1 + 37.6\text{Log}_{10}(R_{\text{km}})$   |   |
| Radio propagation condition         | Modified Pedestrian A and Vehicular A with 3 km/h |   |
| Std. deviation of slow fading       | 8 dB  |   |
| Correlation between sectors         | 1.0   | The correlation in the slow fading between the sectors. The UE experiences the same kind of slow fading in the area of the correlating sectors, i.e. the fading is not entirely random. |
| Correlation between BSs             | 0.5   | The correlation in the slow fading between the BSs.   |
| Correlation distance of slow fading | 50 m  | This parameter defines the maximum distance within which the UE experiences correlated slow fading to a sector.   |
| Minimum path loss                   | 70 dB   |   |
| BS antenna gain                     | 18 dB   |   |
| Antenna front to back ratio         | -20 dB  |   |
| BS total Tx power                   | 43 dBm  | Corresponds to 20 W.  |
| Power resource for HS-DSCH          | 14 W  |   |
| HSDPA packet scheduling algorithm   | Round robin and Proportional fair                 |   |
| Used Redundancy Version             | Chase Combining                                   |   |
| Maximum number of retransmissions   | 4   | Maximum number of retransmission before the corresponding HARQ channel is cleared   |
| Traffic model                       | Web browsing without reading time                 | Average packet call size was 112 kbytes   |
| HSDPA RLC PDU size                  | 320 bits  |   |
| Code resource for HS-DSCH           | 10  | SF=16   |
| UE HS-DSCH receiver                 | RAKE  |   |
| Number Of HARQ channels in UE       | 6   |   |