TSG RAN WG4 meeting # 41 **R4-061188**

Riga, Latvia, 6th – 10th November 2006

Source: Nokia

Title: System level simulation results for ideal interference aware LMMSE equalizer

Agenda Item: 7.2

Document for: Discussion

1. Introduction

In this contribution we present system level simulation results for evaluating the performance benefits of ideally interference aware LMMSE chip-level equalizer UE receivers with and without receiver diversity, referred as Type 2i/3i, against the Type 2 and Type 3 reference UE receivers.

The results are obtained from a fully dynamic system simulator [1], where movement of UE's and radio resource management algorithms are modelled. The used system scenario is HSDPA network with a Proportional Fair scheduler.

2. System simulation results

In the following sub-sections we present the simulation assumptions and results.

2.1 Simulation scenario

In this section we present the simulation assumptions and the scenario for the results presented in this document.

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. Thus the site-to-site distance was 2800m, which differs from the 1000m, used in [6]. Propagation model was based on [2] and log-normally distributed slow fading with a 8 dB standard deviation and a spatial correlation distance of 50 meters were assumed. The evaluated channel profiles was modified 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 [-3.1, -5.0, -10.4, -13.4, -13.9, -20.4] dB in Vehicular A channel.

MAC-hs packet scheduling based on 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. HS-SCCH was power controlled so that the power follows the average power over the last TTI of the associated DCH with an offset. Realistic reception of HS-SCCH was considered. Six parallel stop-and-wait (SAW) channels were used for the Hybrid ARQ. At the maximum 4 retransmissions were allowed per transport block. Chase Combining was used for the retransmissions [3].

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 residual block error rate (BLER) after 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. CQI reporting granularity of 1dB was accounted. CQI reporting error, which was modelled as log-normally distributed with standard deviation of 1 dB, was included in the simulations. The CQI's reported by UE's were always based on normal (or non-interference aware) LMMSE chip level equalizer. The link adaptation outer loop was set to account the difference between normal LMMSE and interference aware LMMSE equalizer in SINR calculation.

Mobility and traffic models were based on UMTS 30.03 [4]. 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.

The LMMSE equalizer and interference aware LMMSE equalizer were used for HS-DSCH with and without Rx diversity. For determining the SINR used with the interference aware LMMSE equalizer under study (i.e. either Type 2i or Type 3i) the interference seen from strongest interfering cells was explicitly accounted by modelling the actual channel matrices of the cells [5]. The calculation of noise covariance matrix in SINR calculation was thus done in the assumption that the channel matrices of the strongest interfering cells are ideally known at the receiver. Three strongest interfering other cells were accounted in the calculation as it was noticed that considering fourth strongest interferer or lower did not affect the results significantly. The main simulation parameters are also listed in Annex A.

2.2 Results

In Figure 1 the cell throughput CDFs obtained with different receivers are presented. In Figure 2 the scheduled user E_s/N_0s are depicted.

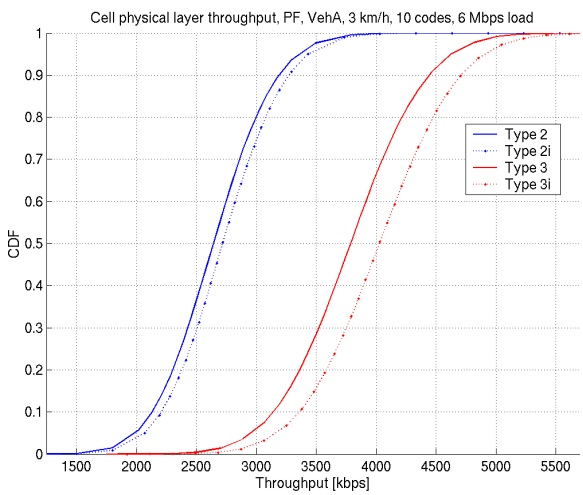

Figure 1: Cell throughput CDFs.

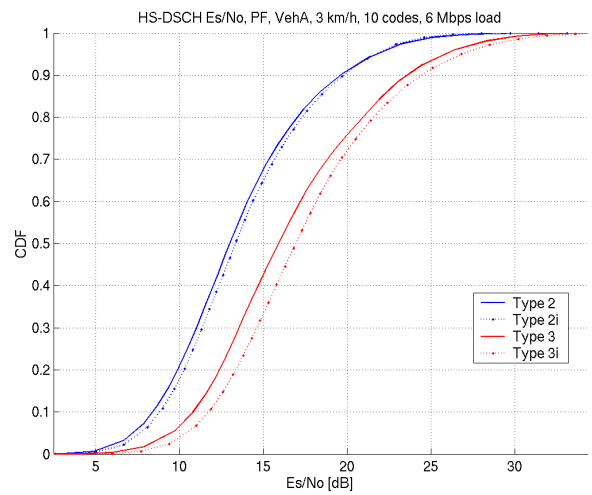

Figure 2: HS-DSCH E_s/N_0 distributions for scheduled users.

In order to more accurately evaluate the receiver gains and the effect of different network situations to them, more specific throughput statistics were gathered. As interference aware LMMSE equalizer is assumed to provide gain specifically when a strong interferer is present, we attempted to capture this effect by collecting statistics from UEs with cells of different strength in their vicinity. As the existence of a cell in UEs active set is a good measure of the strength of the cell, the throughput statistics were gathered from UEs in different DCH soft handover states. Statistics for two different handover states were considered. First, the statistics were collected separately for users in DCH soft handover e.g. UEs that have more than one cell in active set and all the cells do not belong to the same Node B. Second state consisted of users that were in softer handover e.g. UEs that have exactly two cells (sectors) in their active set and both are from the same Node B.

Figure 3 presents the spatial distribution of users in DCH soft handover and in Figure 4 the distribution of users in softer handover is depicted. The terms “soft handover” and “softer handover” refer to DCH handover states and they are only used to refer to the area of interest in the cell.

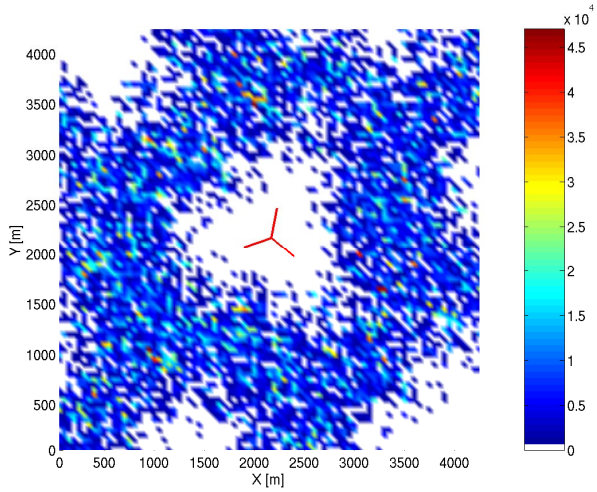

Figure 3: Spatial distribution of users in DCH soft handover in respect to the serving Node B.

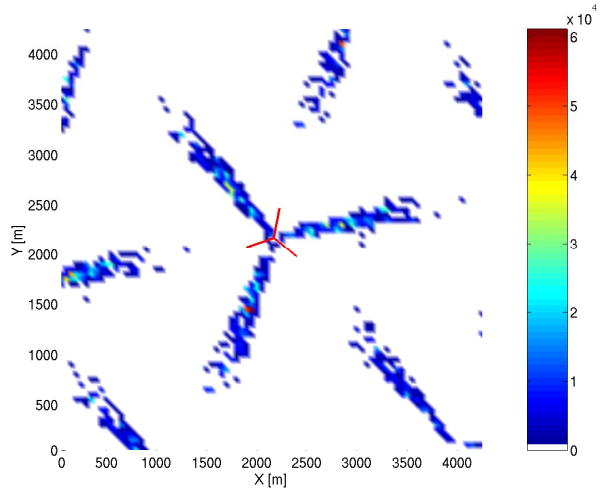

Figure 4: Spatial distribution of users in DCH softer handover in respect to the serving Node B.

In Table 1 the average call throughputs of users in different DCH soft handover states are presented. It can be observed that the benefit of Type 3i receivers is largest at the border regions. The largest gains are observed for the soft and softer handover, ranging from 22% to 21%. Thus the Type 3i interference aware receiver seem to provide some benefits for the cell edge users, roughly increasing the obtained user throughput by 50kbps. For Type 2i receiver some gain can be seen also for the cell border regions, but for all users a slight loss is seen. As the performance of the cell border users is improved, leading to increased scheduling probability, resulting slight decrease in overall user throughput. The DCH soft handover state of the user used in statistics collecting is determined at the end of the call to be the one in which UE has been longest time during a whole call, thus there may be some variance in the observed call throughputs.

In Table 2 the average instantaneous HS-DSCH TTI throughputs of users in the aforementioned states are presented for different receivers evaluated. It can be seen that similarly as in case of the call throughputs, the gains of Type 2i and Type 3i receivers over the Type 2 and Type3 reference receivers are the highest in the border regions between two cells of a three sector Node B. As the overall gain, considering all users, is 3 % with Type 2i and 6 % with Type 3i, the corresponding gains in the border regions between two sectors are 4 % and 19 %.

The small effect of the higher gains to the total average gains is due to low percentage of the users in the given regions. Only 3-4 % of the scheduled users are located between sector borders, as can be seen in Table 3. It should be noted that the percentages shown in Table 3 do not necessarily reflect the actual percentage of scheduled users in the different handover areas. There could be also users being scheduled in the same geographical area with only one cell in the active set. The values given in Table 3 do however give an insight of the actual percentages.

The users in the outer border regions of the cell realize 5 % and 13 % gains using Type 2i and Type 3i receivers, respectively. Their portion of all users is much larger compared to the users in sector borders. Approximately one of four users is at this region. The significance of these users in overall observed gains is therefore much greater than the users between two sectors of the same Node B.

Table 1: Average call throughputs of UEs in different DCH SHO states.

	All UEs		UE DCH is in soft handover		UE DCH in softer handover	
	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]
Type 2	569	0%	99	0%	130	0%
Type 2i	565	-1%	103	4%	136	5%
Type 3	875	0%	196	0%	247	0%
Type 3i	975	11%	240	22%	297	21%

Table 2: Average instantaneous HS-DSCH TTI throughputs of UEs in different DCH SHO states.

	All UEs		UE DCH is in soft handover		UE DCH in softer handover	
	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]
Type 2	2659	0%	1485	0%	1897	0%
Type 2i	2737	3%	1560	5%	1968	4%
Type 3	3795	0%	2223	0%	2705	0%
Type 3i	4037	6%	2513	13%	3209	19%

Table 3: Percentages of user in different SHO states.

	Pct of scheduled users in DCH soft handover [%]	Pct of scheduled users in DCH softer handover [%]
Type 2	24.2 %	3.6 %
Type 2i	23.8 %	3.6 %
Type 3	23.8 %	3.7 %
Type 3i	23.5 %	3.5 %

3. Conclusions

In this contribution we have presented simulation result evaluating the performance benefit of interference aware LMMSE chip level equalizers with and without receiver diversity, obtained with a fully dynamic system simulator [1]. The results indicate as expected that the gains of Type 2i and Type 3i receivers are the highest in the cell border regions. In terms of user throughput the Type 3i would seem to be providing benefits, increasing the cell border throughputs by slightly over 20%. For the instantaneous

HS-DSCH TTI throughput the observed gains were smaller, lying in the range of 15%. Thus it would seem based on the presented system level simulation results that the evaluated receivers would be able to provide benefits for the end user experience by increasing the achievable data rates at the cell edges, but having a minor effect to the average system performance.

References

[1] S. Hämäläinen, “WCDMA radio network performance,” Ph.D. dissertation, University of Jyväskylä, 2003.

[2] Physical layer aspects of UTRA High Speed Downlink Packet Access, 3rd Generation Partnership Project, Technical Specification Group, Radio Access Network, Working Group 4 TS25.848, Rev. v4.0.0, March 2001.

[3] D. Chase, “Code combining - A maximum-likelihood decoding approach for combining an arbitrary number of noisy packets,” IEEE transactions on communications, vol. 33, no. 5, pp. 385–393, May 1985.

[4] Selection procedures for the choice of radio transmission technologies of the UMTS, European Telecommunications Standards Institute (ETSI) TR101.112, Rev. v3.2.0, April 1997

[5] R4-060514 Reference structure for interference mitigation simulations with HSDPA and receiver diversity, Nokia

[6] R4-060364, Minutes of the Ad Hoc on Further Improved Performance Requirements for UMTS/HSDPA UE, Nokia

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	$L = 128.1 + 37.6 Log_{10}(R_{km})$	
Radio propagation condition	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	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	LMMSE equalizer or interference aware LMMSE equalizer with and without receiver diversity.	E.g. Type2/3 and Type2i/3i
Number Of HARQ channels in UE	6	