TSG-RAN Working Group 1 meeting #18 *TSGR1#18(01)0036*

Agenda item: AH 24

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Title: HSDPA System Performance

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1 Introduction

This paper presents results from HSDPA system simulations. In most respects, the simulations are carried out according to the principles specified in [1], i.e. the same principles as were used in [2] and [3].

Table 1 and Table 2 list the main link-level parameters. The most significant difference, compared to [2] and [3], is that this paper assumes an HSDPA TTI equal to T_{slot}.

Note that, although the link-level simulations have been carried out with SF_{HSDPA} = 4 and 3 parallel, the results would not have been different with e.g. SF_{HSDPA} = 32 and 24 codes (or SF_{HSDPA} = 16 and 12 codes). The link-level simulations assume AWGN while fading/time-dispersion is taking into account in the system simulations.

Parameter	Assumption
TTI_{HSDPA}	T_{slot} (?0.67 ms)
SF_{HSDPA}	4
Number of codes	3 (75% of the code tree)
MCS	According to Table 2
Channel estimation	Ideal

Table 1 Link-level parameters

	MCS 1	MCS 2	MCS 3	MCS 4	MCS 5	MCS 6	MCS 7	MCS 8
Modulation	QPSK	QPSK	8PSK	16QAM	16QAM	64QAM	64QAM	64QAM
Coding rate	R=1/4	R=1/2	R=1/2	R=1/2	R=5/8	R=1/2	R=2/3	R=5/6
# info bits per slot[1]	960	1920	2880	3840	4800	5760	7680	9600

Table 2 Modulation/coding schemes

The assumptions for the system simulations are given in Table 3.

[1] Includes tail and possible overhead (CRC etc.)

Parameter	Assumption
Cellular layout	Hexagonal grid, 3-rings with 3-sector sites (3*19 cells) [statistics collected over the two inner rings]
Site-to-Site distance	2.8 km
Antenna pattern	According to [1]
Propagation model	$L = 128.1 + 37.6\ Log_{10}(R)$
Power allocated to HS-DSCH	80 % of total cell power
Std. deviation of slow fading	8.9 dB
Correlation between sectors	1.0
Correlation between sites	0.5
BS antenna gain	14 dB
UE noise figure	9 dB
Max. # of retransmissions	Unlimited
Fast HARQ scheme	Chase combining
BS total Tx power	42.3 dBm
Active set size	3
Fast Fading model	Jakes spectrum
Channel	One-ray Rayleigh (flat fading) unless otherwise mentioned
Doppler frequency	5.3 Hz unless otherwise mentioned
Delay in E_c/N_t estimation	$4*TTI_{HSDPA}$ ($4*T_{slot}$)
Error in E_c/N_t estimation	No error (except due to delay)

Table 3 System-level parameters

The traffic model is according to [1] except that the Reading Time equals 4.4 seconds, compared to 5 seconds in [1].

2 Results

The results are presented as Average Packet Call Throughput (APCT) as a function of Service Throughput. Both these measures are defined in e.g. [2].

Note that absolute performance figures from system simulations very much depend on the exact assumptions and degree of idealization. Thus the presented results should be used for relative comparisons and not as accurate estimates of the absolute performance of HSDPA.

2.1 Benefit of fast scheduling

Figure 1 illustrates the potential performance gain with fast scheduling, i.e. scheduling that takes the instantaneous channel quality into account. The figure shows the performance of three different scheduling algorithms:

- Maximum C/I scheduling (C/I), i.e. the scheduler selects the user with the highest instantaneous C/I (actually HS-DSCH E_c/N_t)
- Round-robin scheduler (RR), i.e. the scheduler selects the user that has not been served for the longest time.
- Proportional-fair (P-F) scheduler as referred to in [4]

As expected, the performance of the C/I and P-F scheduler are similar and both give a significant performance gain over the RR scheduler at high load.

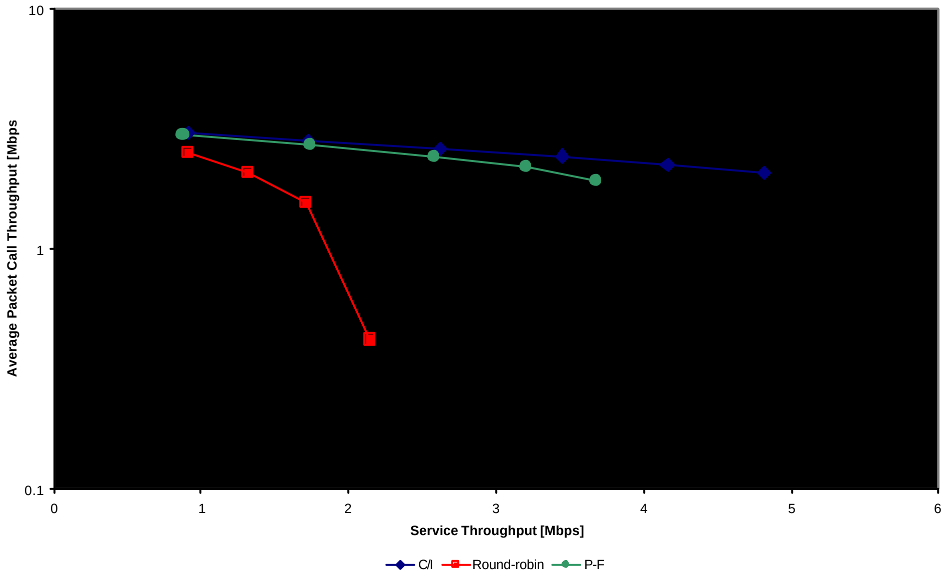

Figure 1 Scheduler performance

Figure 2 illustrates the distribution of the Average Packet Call Throughput (over the users), i.e. in some sense the "fairness" of the system. In this case, there are on average 60 users per cell. As can be seen, although the C/I and P-F scheduler give much larger variations in the APCT (?quality), even the worst case users get better performance with these scheduling algorithms, compared to the RR scheduler. Also as expected, the P-F scheduler gives slightly better performance for the worst-case users, compared to the C/I scheduler.

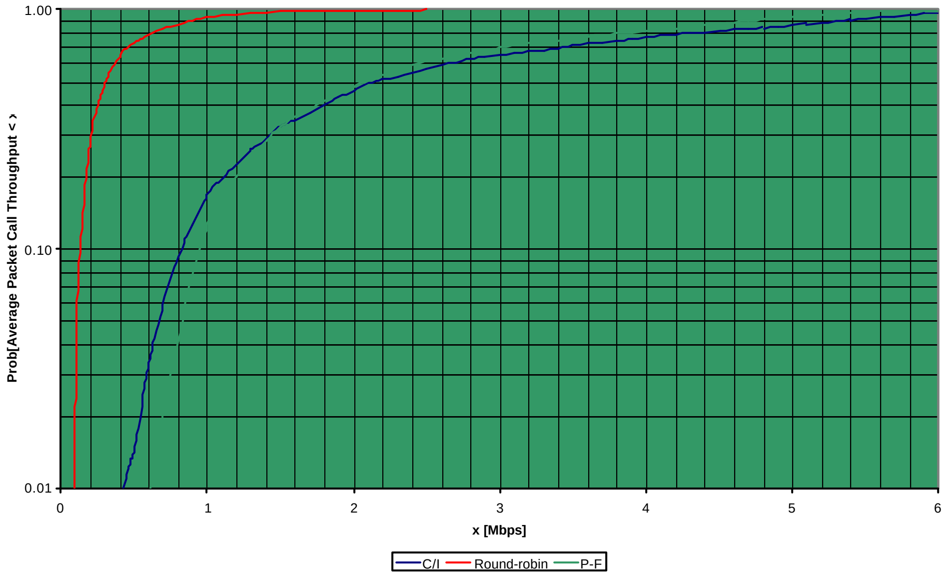

Figure 2 APCT distribution for different scheduling algorithms (an average of 60 UEs per cell)

2.2 Benefit of higher-order modulation (adaptive modulation/coding)

Figure 3 illustrates the performance gain with support of higher-order modulation. The figure compares the performance of HSDPA with the full set of modulation schemes of Table 2, with HSDPA with QPSK only. As can be seen, the gain is significant for both the RR and C/I scheduler.

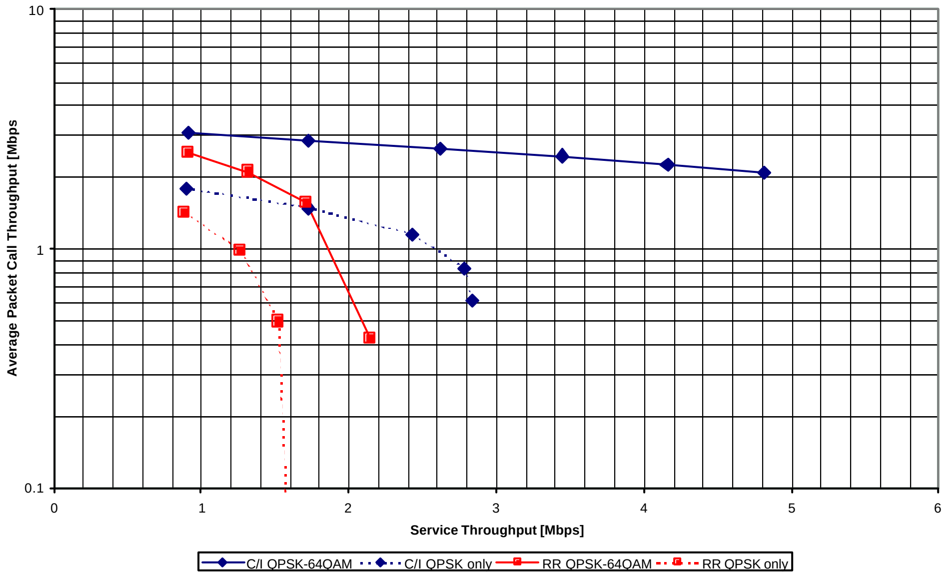

Figure 3 Performance gain with higher-order modulation

2.3 Benefit of Fast Cell Selection

Figure 4 illustrates the potential gain with Fast Cell Selection (FCS) for HSDPA. In case of FCS, cell selection is based on the instantaneous CPICH E_c/N_t while, with no FCS, cell selection is based on average (path-loss + shadowing) received CPICH power.

As can be seen, FCS gives a significant gain for the RR scheduler while the gain for a C/I and P-F scheduler is smaller. The reason is that a significant amount of diversity is already achieved by the scheduling in case of C/I and P-F scheduling, i.e. the additional diversity of FCS is less important. Note that the simulations assume perfect FCS, i.e. no measurements error or errors in the uplink FCS signaling.

Figure 4 Performance fast cell selection vs no fast cell selection

Figure 5 illustrates the “fairness” in case of no FCS. Comparing with Figure 2, we see that without FCS the performance of the worst-case users is somewhat reduced. This is according to the expectations as the worst case users on the cell edge are the users for which FCS may apply.

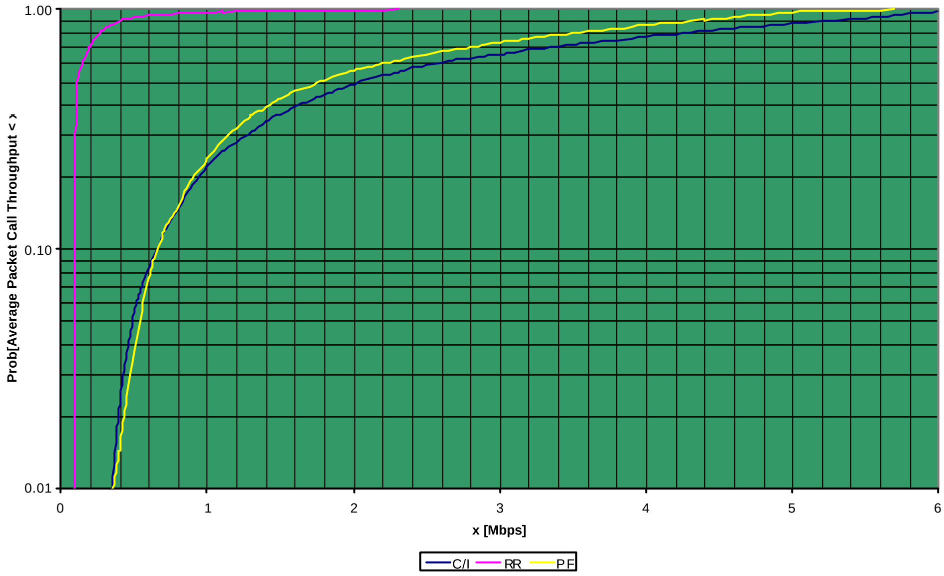

Figure 5 APCT distribution in case of no FCS (an average of 60 Ues per cell)

2.4 Performance at high speed

Figure 6 compares the performance difference for HSDPA for low and medium/high speed (5.3 Hz and 53 Hz Doppler spread respectively). As can be seen, the performance is considerably degraded at the high Doppler spread. The reason is degraded E_c/N_t estimates. This will effect:

- MCS selection
- FCS
- Scheduling (C/I only, i.e. not for RR)

Note that this loss could probably partly be compensated for by e.g. predictive estimation.

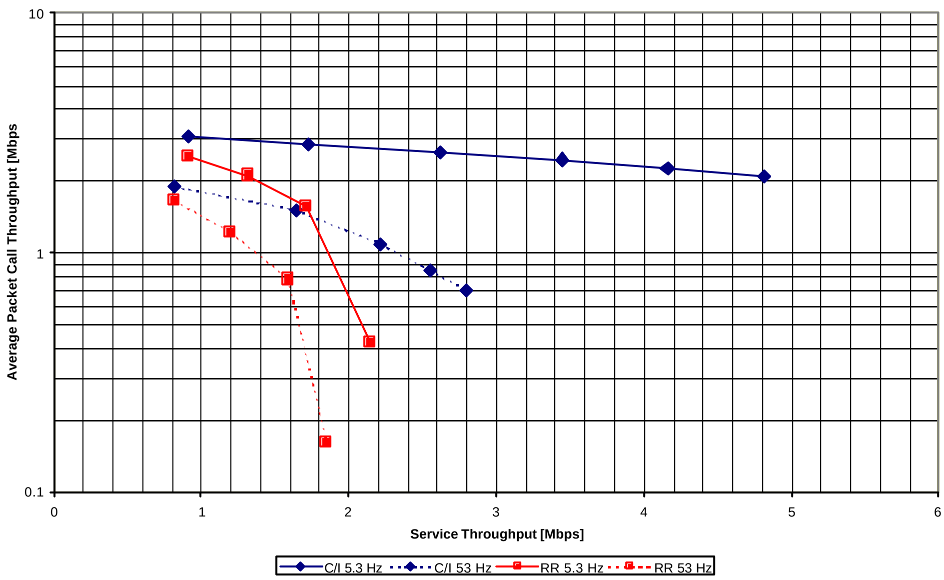

Figure 6 Performance low-speed (5.3 Hz) vs. high speed (53 Hz)

2.5 Performance at time dispersion

Figure 7 illustrates the performance loss in case of multi-path channel. The figure compares the performance in case of one-ray and 2-ray (equal power) channels. The loss of performance with time dispersion is due to a reduction in E_c/N_t, especially close to the cell site. Note that also this loss could partly be compensated for by means of more advanced receiver structures including interference-cancellation/equalization functionality.

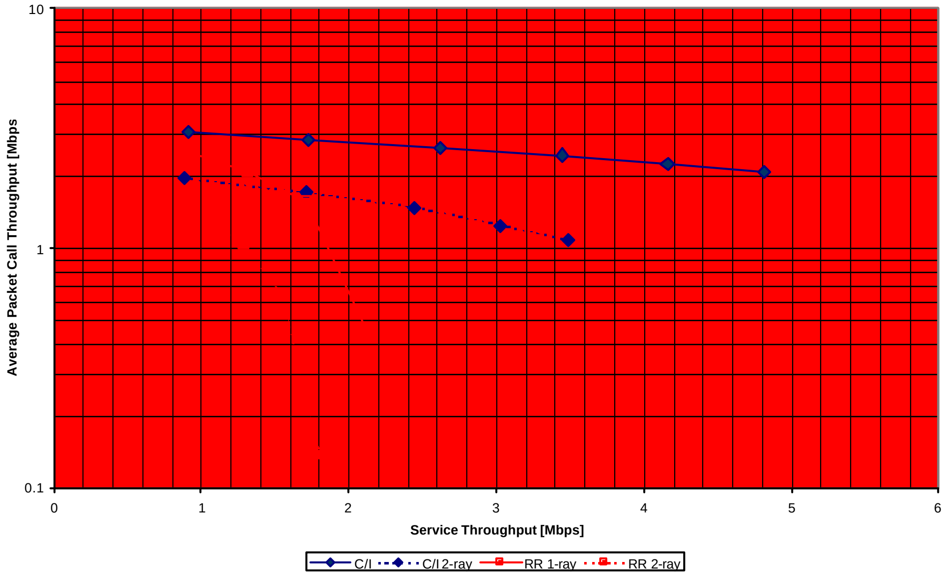

Figure 7 Performance 1-ray channel vs. 2-ray channel

3 Conclusions

- There is a significant gain with fast scheduling and fast adaptive modulation/coding.
- The gain with fast cell selection is most notable for Round-Robin scheduling while, with a scheduler that already takes the channel conditions into account in the scheduling, the gain with fast cell selection is smaller.
- Both fast fading and time dispersion has significant negative impact on the HSDPA performance. However, in both cases, the performance can most likely be improved by means of more advanced UE signal processing.

References

[1] "Common HSDPA system simulation assumptions “, TSGR1#17(00) 1094

[2] " HSDPA system performance based on simulation“, TSGR1#16(00) 1240

[3] “HSDPA system performance based on simulation (II)”, TSGR1#17(00) 1397

[4] “Issues for consideration in the HSDPA report”, TSGR1#15(00) 1120