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Agenda item: AH24, HSDPA

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Title: Throughput Results for Asynchronous and Adaptive Incremental Redundancy (A^2IR) for HSDPA

Document for: Discussion

1 Introduction

An asynchronous and adaptive IR (A^2IR) scheme for HSDPA was proposed in [1]. More details on the scheme are provided in [2]. This contribution provides link-level simulation results for the A^2IR scheme.

2 Modulation and coding schemes

Table 1 summarises different modulation and coding schemes supported in A^2IR. Note that different code block size (number of transport blocks) can be selected for the same data rate depending upon the data backlog in the user's buffer. The data rates below 60 Kb/s are achieved by repeating the 60 Kb/s code sub-blocks using the A^2IR scheme. Implicit in the A^2IR approach is the use of a variable length TTI whose advantages have been outlined in [3]. As an example, consider a code block of 640 bits first transmitted at 960 Kbps. If the receiver sends a negative acknowledgement, then the code block can be retransmitted at any rate from MCS1-MCS5 with the suitable rate and corresponding TTI being picked based on the UE link quality feedback.

Table 1. Data Rates [assumes 20channelization codes of SF=32 and transport block size=320 bits]

MCS	Data Rate [Kb/s]	Modulation	Effective coding rate [actual coding + repetition]	Transmission Time Interval (TTI) [number of slots]			
				16 Transport blocks per TTI [code block = 5120 bits]	8 Transport blocks per TTI [code block = 2560 bits]	4 Transport blocks per TTI [code block = 1280 bits]	2 Transport blocks per TTI [code block = 640 bits]
1	60	QPSK	0.0125				16
2	120	QPSK	0.0250			16	8
3	240	QPSK	0.0500		16	8	4

4	480	QPSK	0.1000	16	8	4	2
5	960	QPSK	0.2000	8	4	2	1
6	1920	QPSK	0.4000	4	2	1	
7	3840	QPSK	0.8000	2	1		
8	7680	16-QAM	0.8000	1			

The sub-block rate is selected based on the link quality feedback from the receiver. In order to benefit from HARQ operation, the sub-block rate is always selected to be greater than or equal to the supportable rate determined by the mapping from link quality feedback. The larger the difference between the sub-block rate and the supportable rate better the throughput due to improved IR/combining granularity. However, the delays are directly proportional to the rate difference because the average number of transmission attempts needed to recover a code block increases, as the sub-block rates become more and more aggressive relative to the supportable rate. The sub-block rates corresponding to different supportable rates are given in Table 2. The supportable rate would be determined based on mapping of link quality feedback to rate.

Table 2. A^2IR sub-block rates.

Supportable rate [Kb/s]	Sub-block rate [Kb/s]
15	60
30	120
60	240
120	480
240	960
480	1920
960	3840
1920	3840
3840	7680
7680	7680

3 Simulations

The simulation parameters are summarised in Table 3. We provide AWGN link level performance results for a single user. The throughput results are obtained by simulating multiple users (eight users). The simulations are performed for different values of average $\hat{I}_{or}/I_{oc}$. However, in a given simulation run, the average $\hat{I}_{or}/I_{oc}$ is set to the same value for all users. Different users see different SNR due to independent Raleigh fading. The scheduler selects the user with the highest supportable rate and start sending data to that user at the sub-block rate (see Table 2). The sub-block rate is kept unchanged during the transmission time of the sub-block. However, the subsequent sub-blocks will use the sub-block rate based on the prevailing supportable data rate.

Table 3. Simulation Parameters

Parameter	Value

Carrier Frequency	2GHz
Channel Model	AWGN, 3.0 Km/h Raleigh
Overhead Power Allocation (CPICH+P-CCPCH+S-CCPCH+SCH+PICH…)	20% (-7dB)
Max Traffic Channel Power Allocation	-1dB
$\hat{I}_{or}/I_{oc}$	Variable
Channel Estimation	Ideal
Fading Model	Jakes
No of iterations for Turbo Codes	8
Metric for Turbo Code	Max
Turbo Code Rates	0.2-0.8
Input to Turbo Decoder	Soft
Turbo Interleaver	As per 3GPP (modified to handle higher data rates)
Hybrid ARQ	IR/Chase Combining
ACK Feedback Error	0 %
Max number of frame transmissions for H-ARQ	15
ACK/NACK delay	3 slots (2 ms)
Link quality feedback delay	6 slots (4 ms)
Number of parallel “Stop and Wait” channels per user	Up to 4
Multipath	1-path
Information Bit Rates Simulated (Kbps)	As defined in Table 1
Number of users	8
Number of channelization codes	20 at SF=32
Scheduling	Best link quality user first (Max C/I)

3.1 Performance in an AWGN channel

Figure 1 through Figure 4 depict FER as a function of $\hat{I}_{or}/I_{oc}$ in an AWGN channel for code block sizes of 5120, 2560, 1280, and 640 bits respectively.

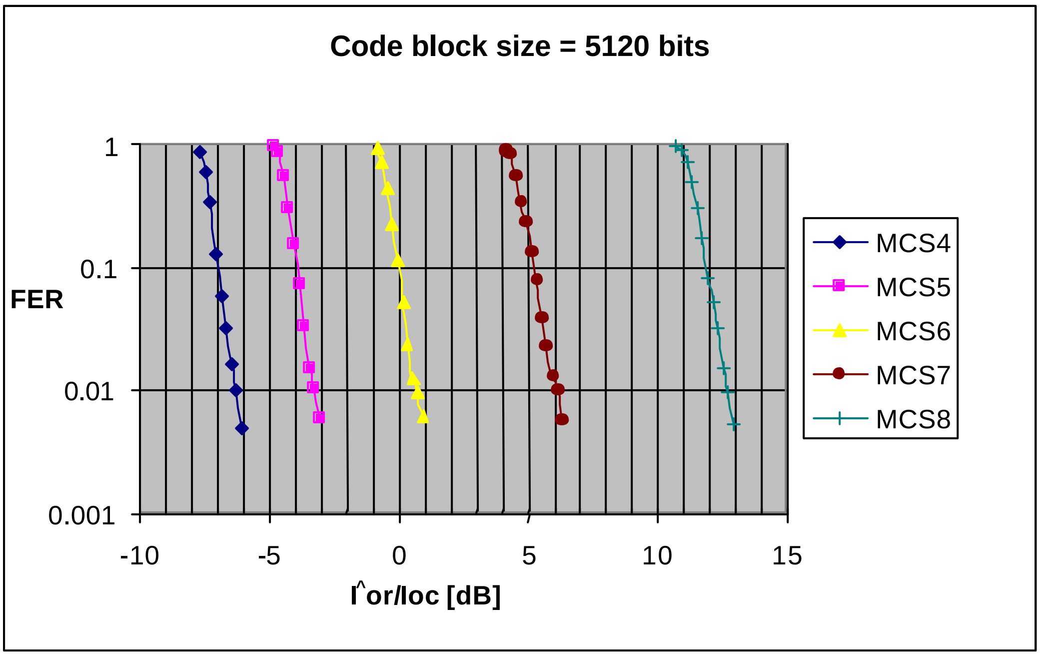

Figure 1

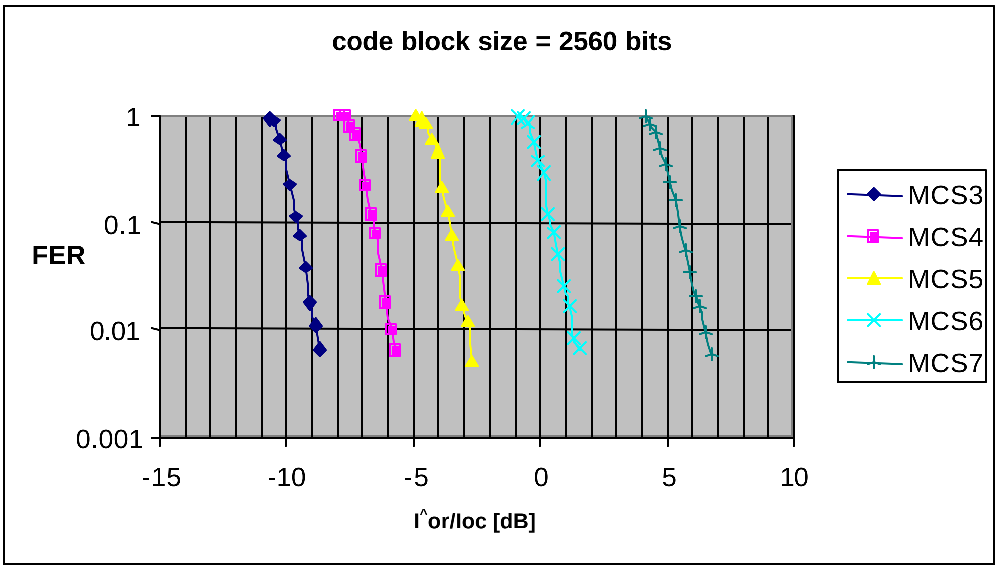

Figure 2

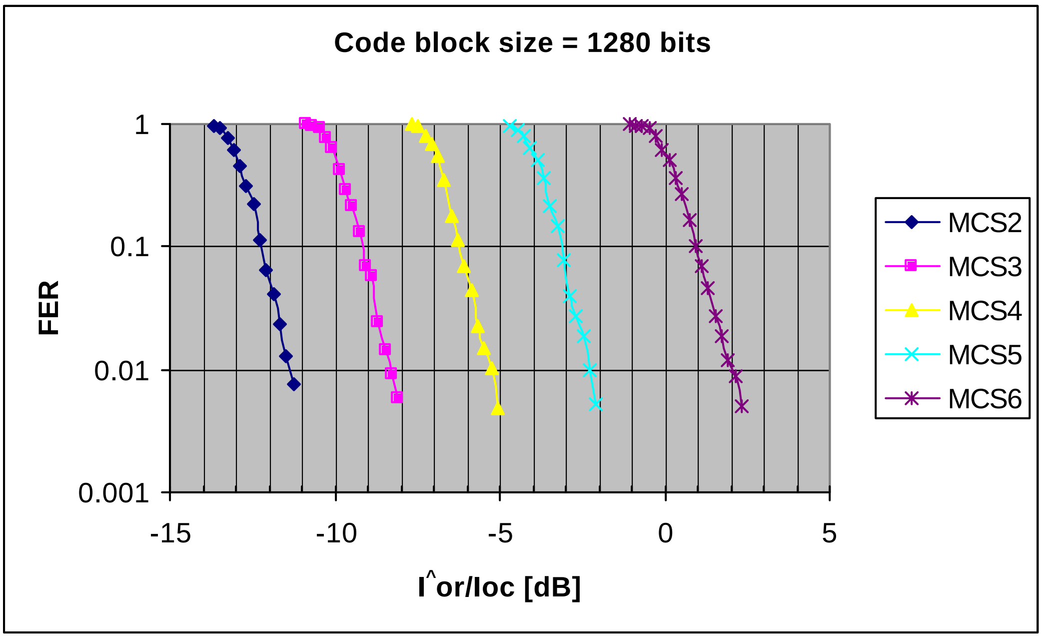

Figure 3

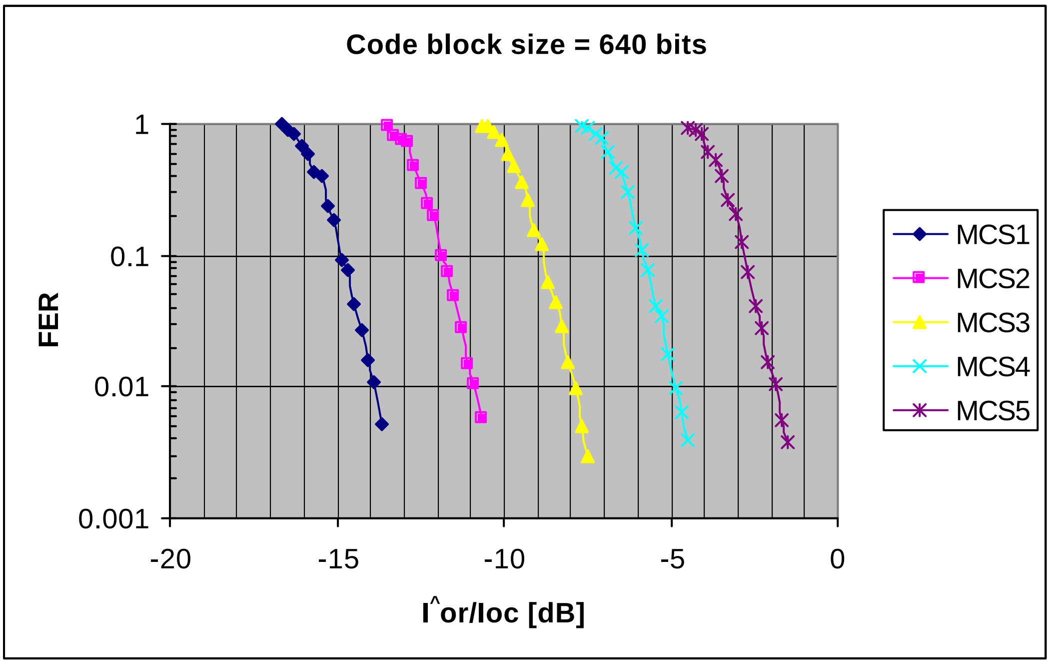

Figure 4

3.2 Throughput in a fading channel

The multi-user throughput results are depicted in Figure 5 and Table 4 for a code block size of 5120 bits. We simulated two different levels of aggressiveness for A^2IR sub-block starting rates. In the first case, sub-block rate is selected by mapping the received SNR to a rate that guarantees 1% or better FER from the AWGN curves (supportable rate). In the second case, the sub-block rate is 1-4 times higher than the supportable rate as depicted in Table 2. It can be seen that he aggressive approach provides up to 45% better throughput compared to the non-aggressive case.

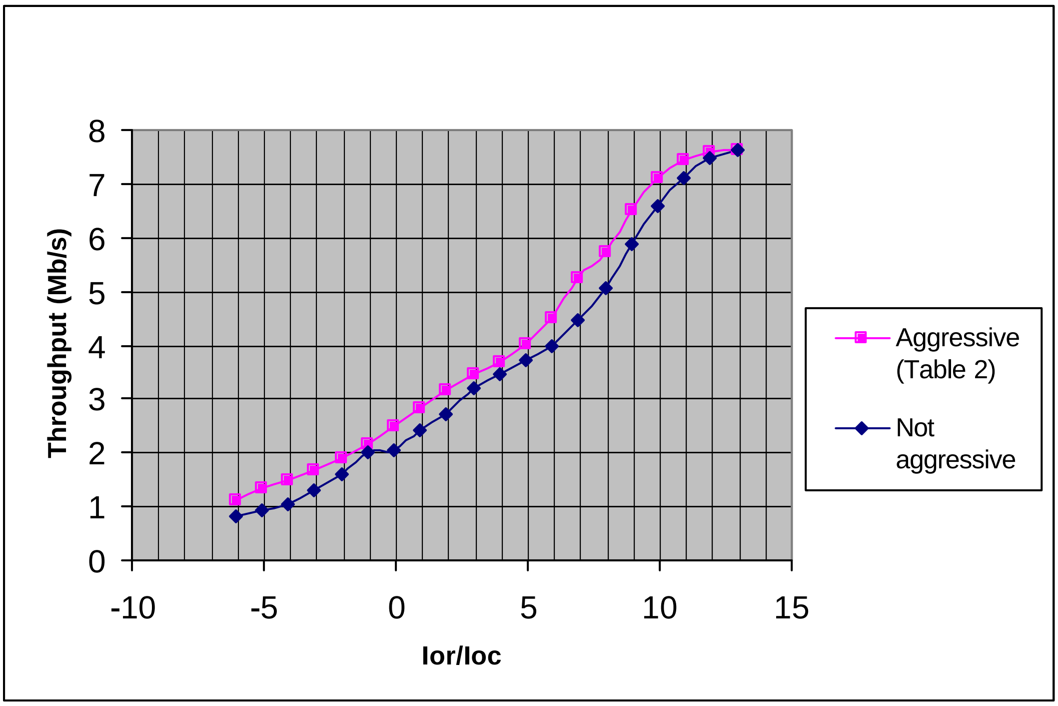

Figure 5: Throughput vs Ior/Ioc for aggressive and non-aggressive sub-block rates. For the aggressive scheme, the sub-block rates are as in Table 2. For both cases, the maximum number of retransmissions is 15.

Table 4: Performance of A^2IR with and without aggressive sub-block rate.

Ior/Ioc in dB	Throughput (aggressive) [Mb/s]	Throughput (non-aggressive) [Mb/s]	% gain with aggressive
-6	1.12	0.81	38.08
-5	1.35	0.93	45.65
-4	1.49	1.04	43.23
-3	1.68	1.29	30.08
-2	1.88	1.59	18.41
-1	2.16	2.02	6.93
0	2.48	2.04	21.51
1	2.83	2.41	17.67
2	3.17	2.72	16.55
3	3.45	3.21	7.42
4	3.67	3.45	6.59
5	4.00	3.71	7.86
6	4.50	3.99	12.71
7	5.26	4.46	18.10
8	5.73	5.06	13.22
9	6.50	5.87	10.71
10	7.12	6.60	7.89
11	7.43	7.12	4.39
12	7.58	7.47	1.52

4 Conclusions

We provided the link-level simulation results for Asynchronous and Adaptive IR (A^2IR) scheme. The Throughput is improved when the sub-block rate (HARQ starting rate) is aggressive compared to the supportable rate. The difference between the supportable rate and the sub-block rate can be made larger at low to medium data rates (using QPSK modulation). The larger the difference between the sub-block rate and the supportable rate better the throughput due to improved IR/combining granularity. However, the delays are directly proportional to the rate difference because the average number of transmission attempts needed to recover a code block increases, as the sub-block rates become more and more aggressive relative to the supportable rate.

5 References

[1] "Asynchronous and Adaptive IR (A^2IR) for HSDPA", Lucent Technologies, TSG-RAN #17(00) 1382, Stockholm, Sweden, November 2000.

[2] "A^2IR – An asynchronous and adaptive HARQ scheme for HSDPA", Lucent Technologies, TSGR1#18(01) 0080, Boston, USA, January 2001.

[3] "Variable Transmission Time Interval (TTI) for HSDPA," Lucent Technologies, TSG-RAN1 #18(01) 0079, Boston, USA, January 2001.