3GPP TSG RAN WG1 ***TSGR1#17(00)1357***
Stockholm, Sweden, 21st-24th November, 2000

Agenda item:

Source: **Philips**

Title: **Throughput of HSDPA in different channel conditions**

Document for: **Discussion**

1. Introduction

This document presents some further system level results on the performance of HSDPA.

Here we consider the impact on total throughput of some different assumptions on the channel model.

The basic approach is the same as in the previously presented contribution R1-00-1202.

2. Simulation Parameters

The simulation assumptions are the same as in R1-001202 unless otherwise stated. For clarity, some details are repeated here.

2.1 Link-level assumptions

The following are taken as a baseline for the results presented in this document

Parameter	**Value**	**Comments**
Propagation conditions	AWGN	Assumes stationary channel over duration of packet transmission, including any re-transmissions. Interference modelled as noise
Terminal speed	Zero	Stationary or slow moving terminals
Closed Loop power control	Off	
HSDPA Frame Length	Variable	Frame length is determined by number of user bits in the packet, the coding and spreading, assuming 1 packet per frame.
Channel coding	Idealised block code with soft decoding rates 1/3, 1/2, ¾	Performance assumed to be determined by minimum distance (R1-00-1202).

		Overheads (CRC, tail bits etc) not included
Packet size	8000	Number of user bits per packet
ARQ	Soft combining	Retransmission of contents of the first packet
Maximum number of transmissions	10	
Control channel overheads	Not included	
Chip rate	3.84 Mcps	
Spreading factor	32	Other SF could be used if needed
Maximum number of spreading codes of SF=32 available	20	

2.2 System level assumptions

Parameter	Assumption	Comments
Cellular layout	Hexagonal Grid	Two rings of cell sites around the serving cell are considered
Sectors	1 or 3 per site	Results can be scaled for different numbers of sectors
Site to Site distance	2	Interference limited (no noise), so arbitrary distance scaling can be used
Antenna pattern	Unity gain inside sector Zero gain outside sector	Ideal assumption
Propagation model	$L = 37.6Log_{10}[R]$	Interference limited, so absolute path loss not required
CPICH power	-10dB	10% of maximum total cell power
Other downlink channels Power allocated to HSDPA in the serving cell	-10dB Up to 80% of total cell power	10% of maximum total cell power
Average power allocated to HSDPA in each interfering cell	80% of total cell power	Together with CPICH and other downlink channels this gives 100% of maximum total cell power from each interfering cell. If power utilisation for HSDPA is lower than 80%, then interference would be reduced accordingly
Slow fading model	Log normal	Normal distribution in dBs
Standard deviation of slow fading	5.6dB	Equivalent to 8dB standard deviation with 0.5 correlation between sites
Correlation between sectors	1.0	
Correlation between sites	0.0	
Active set size	No limit	Any one cell may be selected
Fast fading	Ricean with 12dB K factor	2Hz fading rate has been suggested for stationary terminals. Here it is assumed that this only affects the distribution of SIR over the terminals, not the SIR during a packet transmission
Error in SIR estimation	Stan Dev =1dB	Normal distribution in dB's. This will affect site selection and selection of transmission scheme. The size of the error will depend on the averaging time. 1dB seems a reasonable value for a practical implementation.
Number of carriers	1	

2.3 ARQ Scheme

The following ARQ schemes are considered

?? **A**: Re-transmission of failed packets, discarding of erroneous packets
?? **B**: Re-transmission of failed packets, soft combining of all received packets. The effective SIR is then N?SIR$_1$, where N is the number of transmissions and SIR$_1$ is the SIR of the first transmission.
?? **C**: For each failure, transmission of an amount of additional redundancy equivalent to the first transmission. When the transmissions are combined, the effective code rate is then R_1/N where R_1 is the code rate of the first transmission.
?? **D**: For each failure, transmission of an amount of additional redundancy such that when the transmissions are combined the effective code rate is $R_1/(1.4^{N-1})$ This means that the code rate is reduced in more uniform steps than with option C. However, the re-transmitted packet size is not constant.

A maximum of 10 re-transmissions is allowed.

Scheme B is used as the reference condition.

Note that after a few retransmissions the code rates resulting from the use of schemes C and D may become too low to be practical, but the intention is to study the potential performance benefits of the technique, rather than consider the detailed feasibility of implementation.

2.4 Throughput and Capacity

The capacity of the system is defined here as the throughput in bits per second per carrier per cell. For one carrier and one cell:-

Throughput = Number_of_bits_received / Sum_of_packet_transmission_times

In the case of uniform packet size:

Number_of_bits_received = Packet_size x Number_of_packets

2.5 Packet Scheduling

It is assumed that the packet transmission duration (including re-transmissions) is determined by the selected transmission scheme (i.e. modulation, channel coding rate, number of spreading codes and possibly spreading factor) together with the local SIR. Each packet is sent using the whole of the available HSDPA resource, bearing in mind that the system may be code or power limited for that particular packet.

In our estimation of system throughput, the delays due to packet scheduling are not considered. Therefore the transmission order of packets (and any re-transmissions) is not important, except for the assumption that any re-transmissions experience the same channel conditions as the first transmission.

This model of scheduling also assumes that there are no constraints due to downlink frame structure when mapping the transport blocks to the channel. The transport block size is assumed to be the same as the packet size. The TTI is assumed to be determined by the selected transmission scheme. As examples, for the currently considered transmission schemes for an 8000 bit packet the TTI would be from 100ms (QPSK, 1/3 rate coding and SF=32) to 0.741ms (64-QAM, ¾ rate coding and 20 codes with SF=32). In practice there is likely to be some loss in throughput due to the use of a fixed frame structure.

The fairness of the scheduler should be discussed. Two types can be considered.

?? **Fair Scheduling**: All packets are transmitted. The disadvantage is that significant radio resources may be required to deliver packets over channels where the SIR is poor.

?? **Unfair Scheduling**: Packets to be transmitted over channels with poor SIR can be delayed, but to improve throughput, some packets must be rejected (i.e. discarded and never transmitted). The degree of unfairness could be defined in terms of the fraction of packets which are rejected.

Although in practice the scheduling should be based on the estimated SIR, we can obtain an indication of the possible benefit from using unfair scheduling by rejecting those packets with the longest transmission times from the calculation of throughput. Note that such a procedure does not consider any effect on delay.

The use of an unfair scheduler can be considered as a form of admission control, in that mobiles with poor radio links will not be sent any data packets.

In the analysis presented here it is assumed that the service is offered in such a way that the required QoS is maintained across a coverage area which covers a substantial part of the cell. If it were acceptable to offer a service in only part of a cell, then further improvements in throughput might be achieved. However, it is not clear that this would be satisfactory to users.

3 Simulation Results

The results presented here were obtained under the basic assumptions in section 2, with modulation schemes up to 64QAM, ARQ option B (soft combining), fair scheduler etc. One simulation run was carried out with 300 UE locations and 1 packet sent to each location. Unless otherwise stated the same set of pseudo-random values for shadowing, fast fading and SIR estimation error are used throughout. However, different values may be used in different simulation runs (e.g. for the results in R1-00-1202). This means that although variations due to statistical fluctuations within a run can be removed, there may be run-to-run variations. Therefore, although the absolute values of throughput may have a noticeable error margin. the differences required for sensitivity analysis are reliable,

3.1 Summary of Throughput Results

In Figure 1 we show the changes in total throughput for the Ricean channel model with various K factors. It can be seen that there is very little impact over the whole range from very large K factor (equivalent to no fast fading) to very small K factor (equivalent to single path Rayleigh fading). One reason for this is that the distribution of SIR values results from a sum of the effects of both fast fading and shadowing, and the shadowing term is significant.

It should be noted that these results assume that the fast fading rate is always “slow” with respect to the ARQ process. That is, any re-transmissions experience the same SIR as the first transmission.

The results for an unfair scheduler are similar, except that the throughput is generally greater.

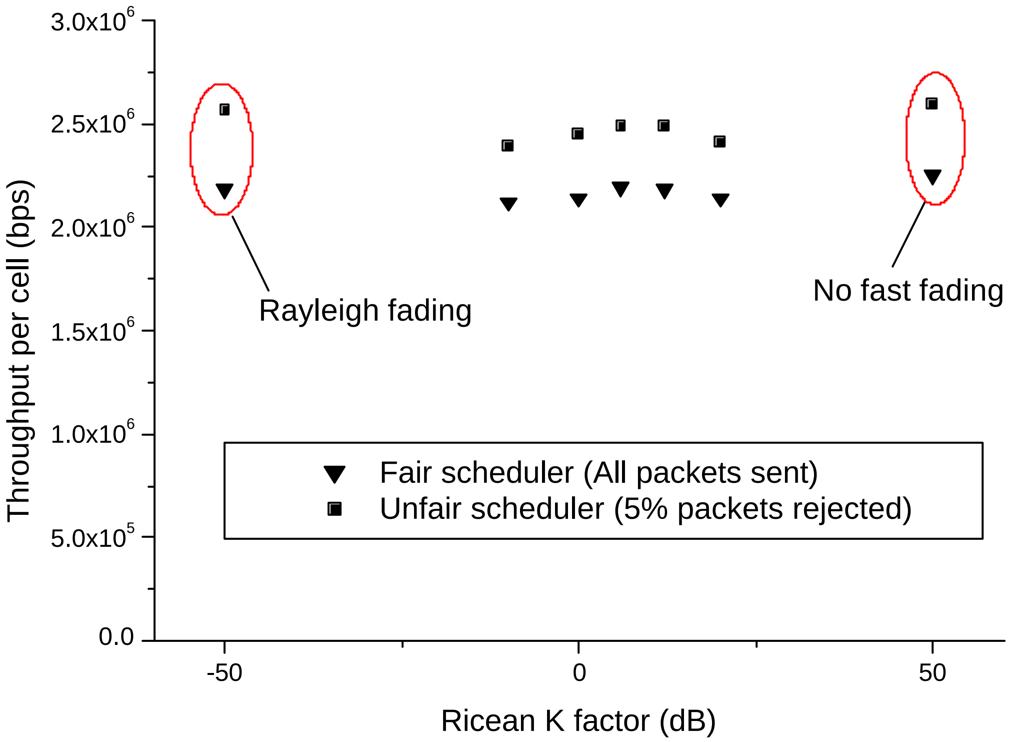

Figure 1 Effect of fast fading model on throughput

In Figure 2 we show the effect of propagation exponent (rate of increase of path loss with distance) on throughput and it can be seen that the two are strongly correlated. This emphasises the fact that good isolation between cells is needed to achieve high throughputs.

A similar relationship is obtained for an unfair scheduler.

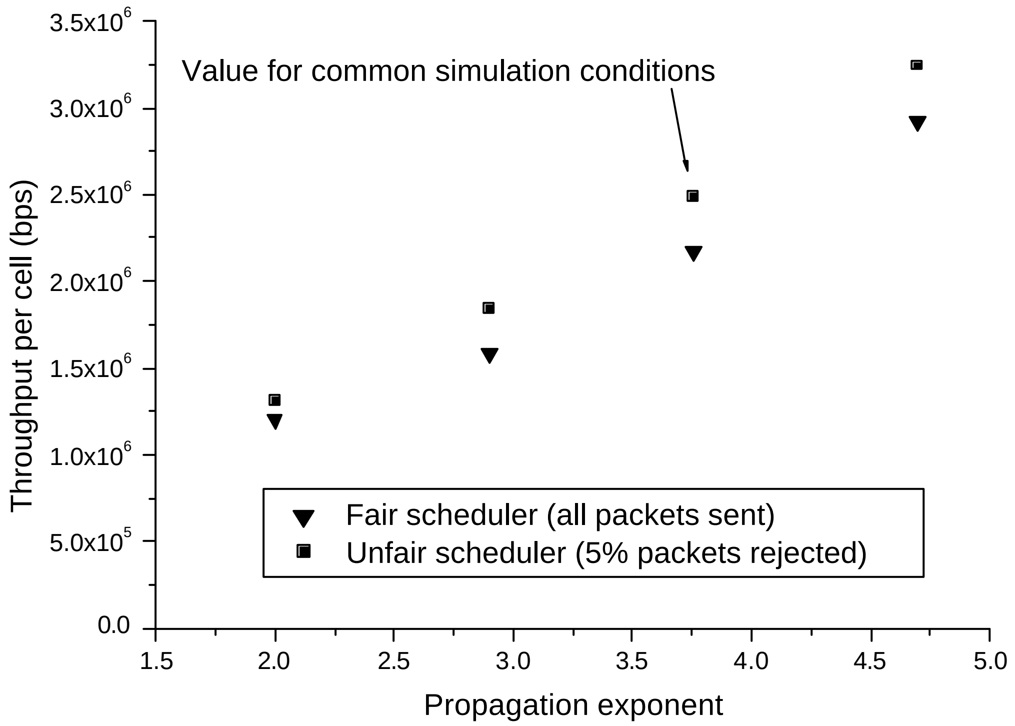

Figure 2 Effect of propagation exponent on throughput

4. Conclusions

The following conclusions can be drawn:-

(1) Under the simulation conditions considered, the fast fading model has little impact on the total throughput.

(2) The total throughput is very sensitive to the propagation exponent (path loss model), since this determines the inter-cell interference level.