3GPP TSG RAN WG1 ***TSGR1#15(00)1045***
Berlin, Germany, 22nd – 25th August, 2000

Agenda item:

Source: **Philips**

Title: **Performance of HSDPA**

Document for: **Discussion**

Introduction

This document presents some system level results on the performance of HSDPA. The intention is to highlight the possible capacity gains which might be achieved and draw some initial conclusions on the features which might be part of a final UMTS specification for this feature.

In order to make the simulation and analysis more tractable a number of simplifying assumptions have been made compared with simulation conditions proposed elsewhere (e.g. “Link Evaluation Methods for High Speed Downlink Packet Access (HSDPA) “, Ericsson, Motorola and Nokia). However, where such simplifications are used, it is generally intended that they should lead to a more optimistic estimate of potential performance, rather than a reduced one.

Simulation Parameters

Link-level assumptions

Parameter	**Value**	**Comments**
Propagation conditions	AWGN	
Terminal speed	Zero	Stationary or slow moving terminals
Closed Loop power control	Off	
HSDPA Frame Length	Variable	Frame length is determined by number of bits in the packet
Channel coding	Ideal block code with soft decoding rates 1/4, 1/3, 1/2, 2/3, 3/4	Similar performance to turbo coding (approaching Shannon limit)
Packet size	Variable	Number of user bits per packet is defined
ARQ	Discard erroneous packets	Other schemes could be considered
Control channel overheads	Not included	
Spreading factor	32	Other SF could be used if needed
Maximum number of spreading codes of SF=32 available	20	

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	$L = 37.6\mathrm{Log}_{10}[R]$	Interference limited, so absolute path loss not required
CPICH power	-10dB	Relative to maximum total cell power
Other downlink channels	-10dB	Relative to maximum total cell power
Power allocated to HSDPA in the serving cell	Up to 80% of total cell power	
Average power allocated to HSDPA in each interfering cell	50% of total cell power	
Slow fading	Log normal	
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 cell may be selected
Fast fading	None	AWGN

Cell Layout and UE Placement

The cell layout is shown in Figure 1.

The central cell site is assumed to contain the serving cell. However, a UE may receive downlink transmissions from any cell site.

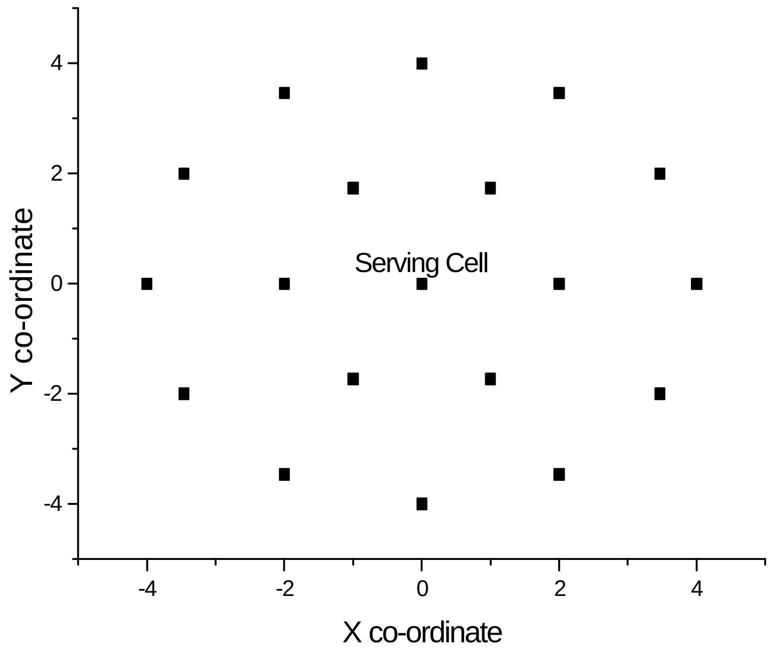

Figure 1 Cell site locations

The UE locations are selected with a uniform pseudo-random distribution. Since any sector in the region around the serving cell should be statistically equivalent, for convenience, the UE's are placed only in a region bounded by a triangle of width unity and height Tan(pi/6). A typical set of 100 UE locations are shown in Figure 2. In practice more UE positions than this would be needed for reliable results.

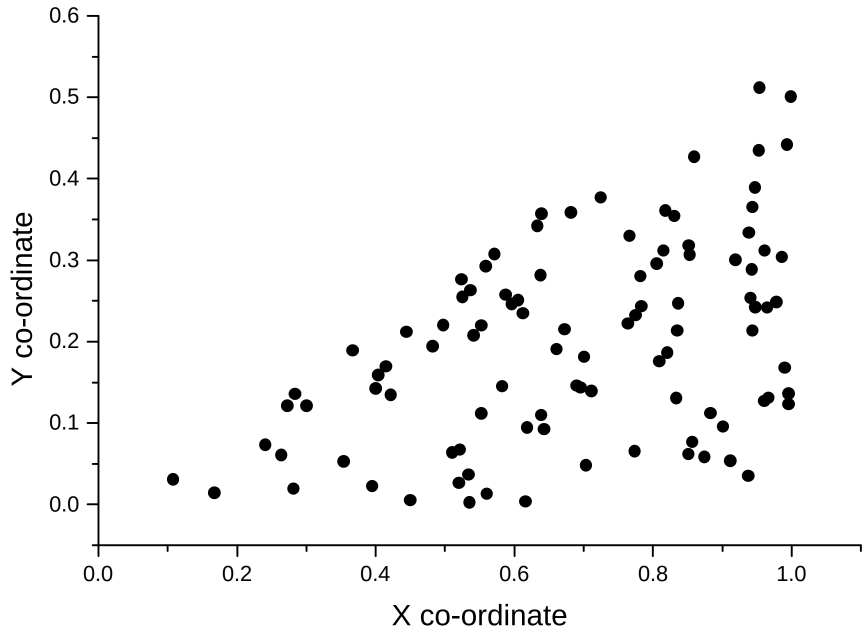

Figure 2 Example of random UE locations

Data Traffic Model and Packet Scheduling

In each simulation all packets are assumed to contain the same number of bits. Only transmission individual packets considered. One packet is sent to each UE location, and information such as the required transmission duration calculated, (based on the SIR at that location).

It is assumed that the packet transmission duration is determined by the selected modulation, channel coding rate, number of spreading codes and possibly spreading factor, together with the local SIR. Delays due to packet scheduling, ARQ protocols etc are not considered.

UE mobility model

The UE is assumed to be stationary at each location to which a packet is transmitted, so that the SIR does not change during packet transmission.

Site Selection and SIR model

The path loss to each cell site is calculated, based on the path loss model and a pseudo random value due to slow fading. The site with the lowest path loss is selected for the packet transmission. The wanted signal is calculated from the selected site, assuming that all the power available for HSDPA is used. The interference is calculated as the sum of the power received from all the other sites, assuming that they all transmit the CPICH, the defined power level on the other channels and a power equal to the assumed value of the average power assigned to HSPDA.

This model thus assumes Ideal Fast Site Selection.

The AWGN channel model with no fast fading is justified on the basis that
(1) Path diversity (i.e. RAKE receiver), transmit diversity and receive diversity would all tend to reduce fast fading amplitude and the channel would thus approach AWGN.
(2) There is no fast fading (or very little) for a stationary terminal
(3) A terminal can be considered stationary if the fading is not significant over the duration of the packet.

If considered desirable, some of the effects of fast fading could be included by increasing the value of the parameter for standard deviation of slow fading.

The use of an ideal sector antenna model means that the SIR value is not affected by the use of cell sectorisation. However, the total capacity per cell-site would be multiplied by the number of sectors.

Modulation and Coding Schemes

The following modulations are considered: QPSK, 16-QAM, 64-QAM. 8-PSK is not currently considered since it is not different enough from 16-QAM in terms of bandwidth efficiency and Eb/No. However, it could be added later. Analytical expressions are available for the symbol error rates of each modulation.

The channel coding is modelled as follows: Given the code rate, the packet is assumed to coded into a single code word. The minimum distance of the code word is assumed to be

$$d_{\min} = n - k + 1$$

where:

n = total number of bits in the code word
k = number of information bits.

Note that this is an optimistic expression for binary codes.

The probability of a code word error using soft decision decoding can be estimated from:

$$P_M \approx (M-1)Q\left(\sqrt{2g_b R_c d_{\min}}\right)$$

where:

$M = 2^k$

$Q(x) = \frac{1}{2} erf\left(\frac{x}{\sqrt{2}}\right)$

$g_b =$ SNR per bit

$R_c =$ Code rate

This expression can be used directly for QPSK, and also be adapted for 16-QAM and 64-QAM.

The following code rates are considered for the moment: 1/3, ½, 2/3, ¾. It would be possible to add ¼ rate coding, but this adds very little improvement in E_b/N_o compared with1/3 rate coding and anyway is not currently present in R'99.

We also assume that different numbers of spreading codes (SF=32) can be allocated, up to a maximum of 20.

The different combinations of modulation/code rate/spreading code considered are as follows:

Scheme	**Modulation**	**Code rate**	**No of spreading codes (SF=32)**
1	QPSK	1/3	1
2	QPSK	1/3	2
3	QPSK	1/3	3
4	QPSK	1/3	4
5	QPSK	1/3	5
6	QPSK	1/3	6
7	QPSK	1/3	8
8	QPSK	1/3	10
9	QPSK	1/3	12
10	QPSK	1/3	16
11	QPSK	1/3	20
12	QPSK	½	20
13	QPSK	2/3	20
14	QPSK	¾	20
15	16-QAM	1/3	20
16	16-QAM	½	20
17	16-QAM	2/3	20
18	16-QAM	¾	20
19	64-QAM	1/3	20
20	64-QAM	½	20
21	64-QAM	2/3	20
22	64-QAM	¾	20

The aim in choosing these schemes was to provide the widest possible dynamic range, and with sufficient granularity that the selected scheme can be assumed to be close to the optimum one.

Simulation Results

Figure 3 shows the relationship between SIR and distance from the serving cell. Deviations from a smooth curve are largely due to shadowing.

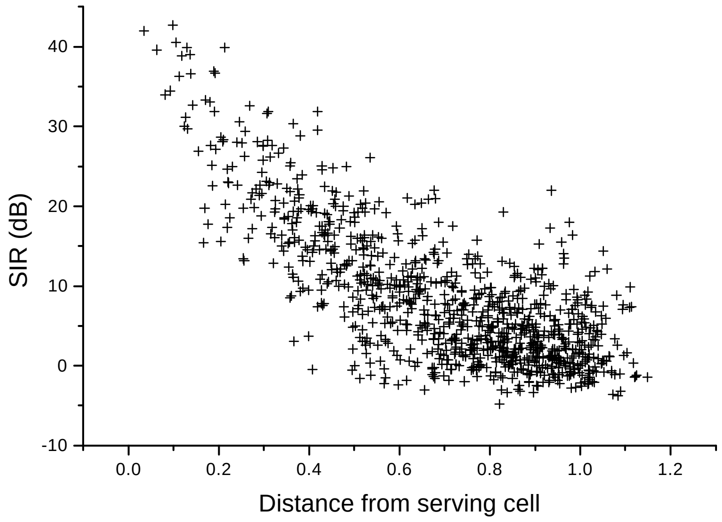

Figure 3 Scatter diagram of SIR vs distance (1000 packets)

Figure 4 shows a histogram of SIR values, with typical values between 0 and 10dB.

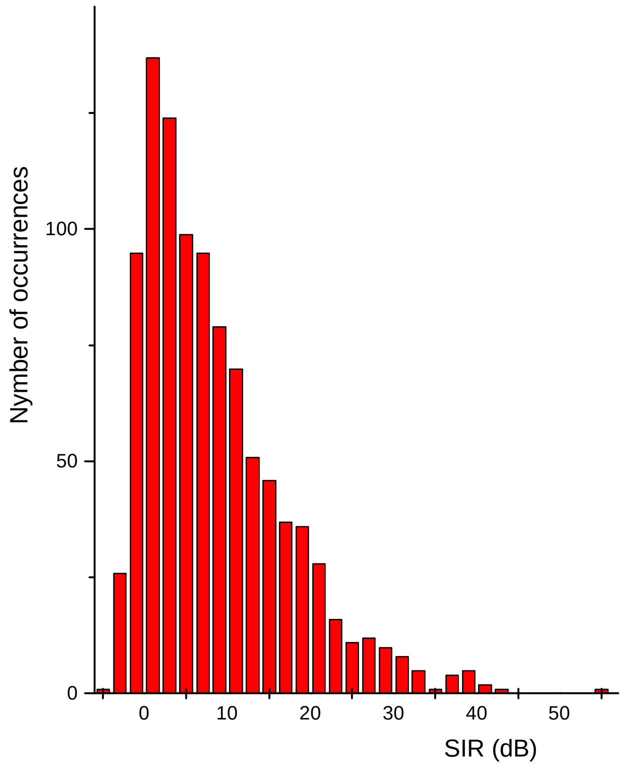

Figure 4 Histogram of SIR per packet (1000 packets)

The selection of transmission scheme according to minimum transmission duration for packets of 8000 user bits (including re-transmissions) and is shown as a function of SIR in Figure 5. It is significant that schemes 19 and 20 (64-QAM with 1/3 and 1/2 rate coding) are never selected. Neither is scheme 15 (16-QAM with 1/3 rate coding). Schemes below about 8 are not used. These correspond to 10 or fewer spreading codes, and the SIR is unlikely to be low enough to require this amount of processing gain.

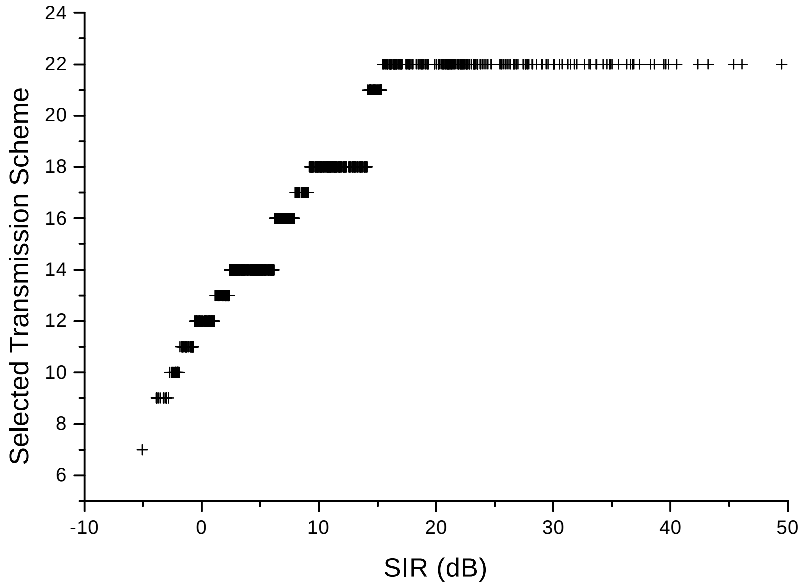

Figure 5 Selected transmission scheme vs SIR (1000 packets)

Figure 6 shows a histogram of the use of each modulation scheme (per packet). It can be seen that 64=QAM is chosen frequently. However, the system capacity will be dominated by the lower order modulations, since the packet transmission time will be much longer for these schemes.

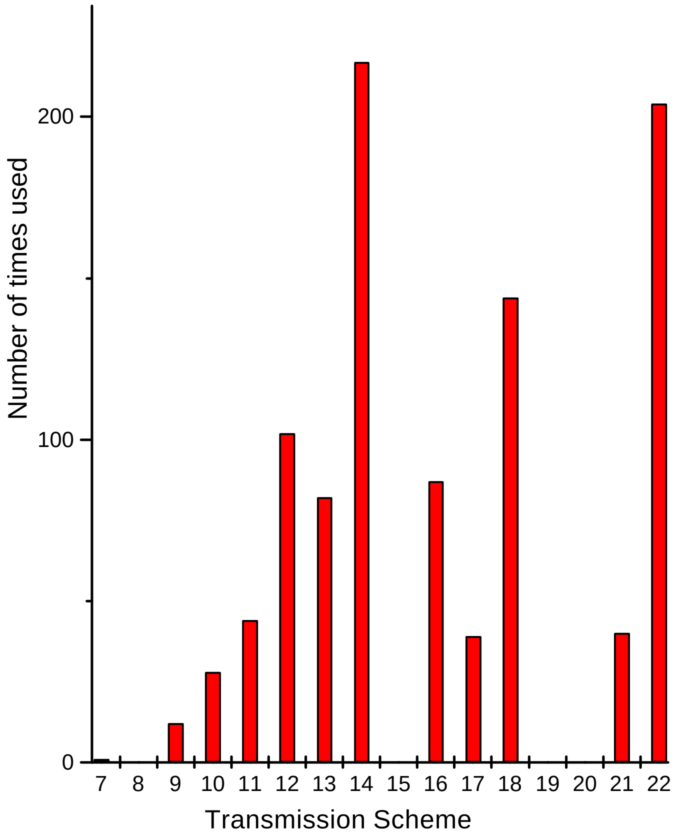

Figure 6 Histogram of use of transmission schemes (1000 packets)

Conclusions

It is possible to estimate the percentage of use likely for different modulation and coding schemes. Although high order modulations may be used for a significant fraction of UE's, the capacity is likely to be dominated by the packets with longer transmission times (i.e. lower order modulation).

Further results will be produced in the near future.