Agenda item:	AH24 : High Speed Downlink Packet Data Access
Source:	Lucent Technologies
Title:	Text contribution on MIMO performance
Document for:	Text contribution for TR

1. INTRODUCTION

We propose the following text for the HSDPA TR [1] for Section 7.4.1 regarding UE MIMO performance. The new proposed text is highlighted below.

2. PROPOSED TEXT

Link level simulations were performed and the frame error rate (FER) versus ~~Eb/N0~~Ior/Ioc were measured for a variety of system architectures. We first compare the systems for a fixed data rate and show that, compared to the conventional transmitter, MIMO architectures can achieve the same frame error rate at much lower ~~Eb/N0~~Ior/Ioc. Next, we show how for a similar ~~Eb/N0~~Ior/Ioc, the MIMO architectures can achieve higher data rates. Using the notation (*M*,*P*) to denote a system with *M* transmit and *P* receive antennas, we study a conventional (1,1) system, a (2,2) MIMO system, and a (4,4) MIMO system.

The data rate was fixed at 10.8 Mbps, achieved assuming a chipping rate of 3.84 Mchips/sec, a spreading factor of 32 chips per coded symbol, *N* = 20 spreading codes, and appropriate coding rates and data constellation sizes. A ~~serially~~ parallel concatenated convolutional coding and turbo decoding with 8 decoding iterations ~~**[Editors note: as per the assumptions parallel concatenated Turbo codes should be used]**~~ was used**.** The system architectures for *M* transmit antennas and *P* receive antennas are given in Table 1~~Table 1Table 23~~.

Puncturing for the (4,4) system is used to achieve 10.8 Mbps. A flat fading channel with 3km/hr fading, perfect channel estimation, and uncorrelated fading between antenna pairs for the MIMO systems is assumed. Figure 1~~Figure 1Figure 27~~ below shows the FER versus ~~Eb/N0~~Ior/Ioc. Compared to the conventional transmitter, there are gains of about 9dB and 16dB for the (2,2) and (4,4) systems, respectively, at 10% FER. The enormous performance gains are due to a combination of diversity, receiver combining gain, and increased spectral efficiency due to MIMO processing. We emphasize that these gains are achieved using the same code resources (20 codes) as the conventional transmitter.

Table 1~~123~~. System Architecture for achieving 10.8 Mbps

(*M*, *P*)	Tx technique	Code rate	Modu-lation	Rate per substream	Number of substreams	Total data rate
(1,1)	Conven-tional (2x1)	¾	64QAM	540 Kbps	20	10.8Mbps

(2,2)	MIMO	¾	8PSK	270 Kbps	40	10.8Mbps
(4,4)	MIMO	~½	QPSK	135 Kbps	80	10.8Mbps

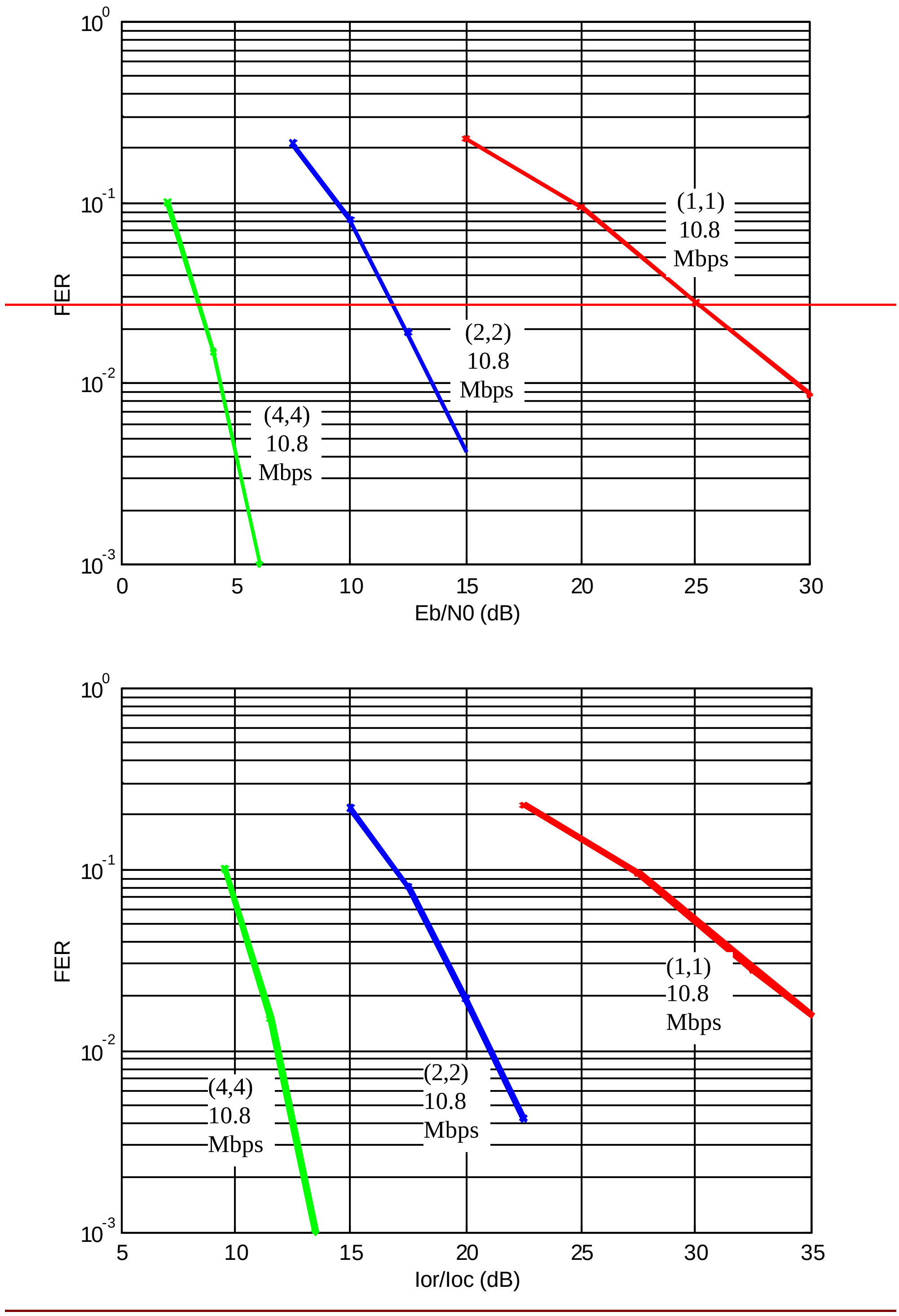

Figure 11~~27~~. Flat fading channel performance for 10.8 Mbps

Using MIMO techniques, the maximum data rate can increase to 14.4 for the (2,2) system and up to 21.6 Mbps for the (4,4) system. As shown in the Table 2~~Table 2Table 24~~, the constellation sizes are still smaller than those of the conventional transmitter. As seen in

Figure 2~~Figure 2Figure 28~~, the required ~~Eb/N0~~Ior/Ioc's for these rates are less than that for the conventional system operating at 10.8Mbps.

Table 2~~224~~. System Architecture for achieving 21.8 Mbps

(*M*, *P*)	Tx technique	Code rate	Modu-lation	Rate per substream	Number of substreams	Total data rate
(1,1)	Conven-tional (2x1)	¾	64QAM	540 Kbps	20	10.8Mbps
(2,2)	MIMO	¾	16QAM	360 Kbps	40	14.4Mbps
(4,4)	MIMO	¾	QPSK	180 Kbps	80	14.4Mbps
(4,4)	MIMO	¾	8PSK	540 Kbps	80	21.6Mbps

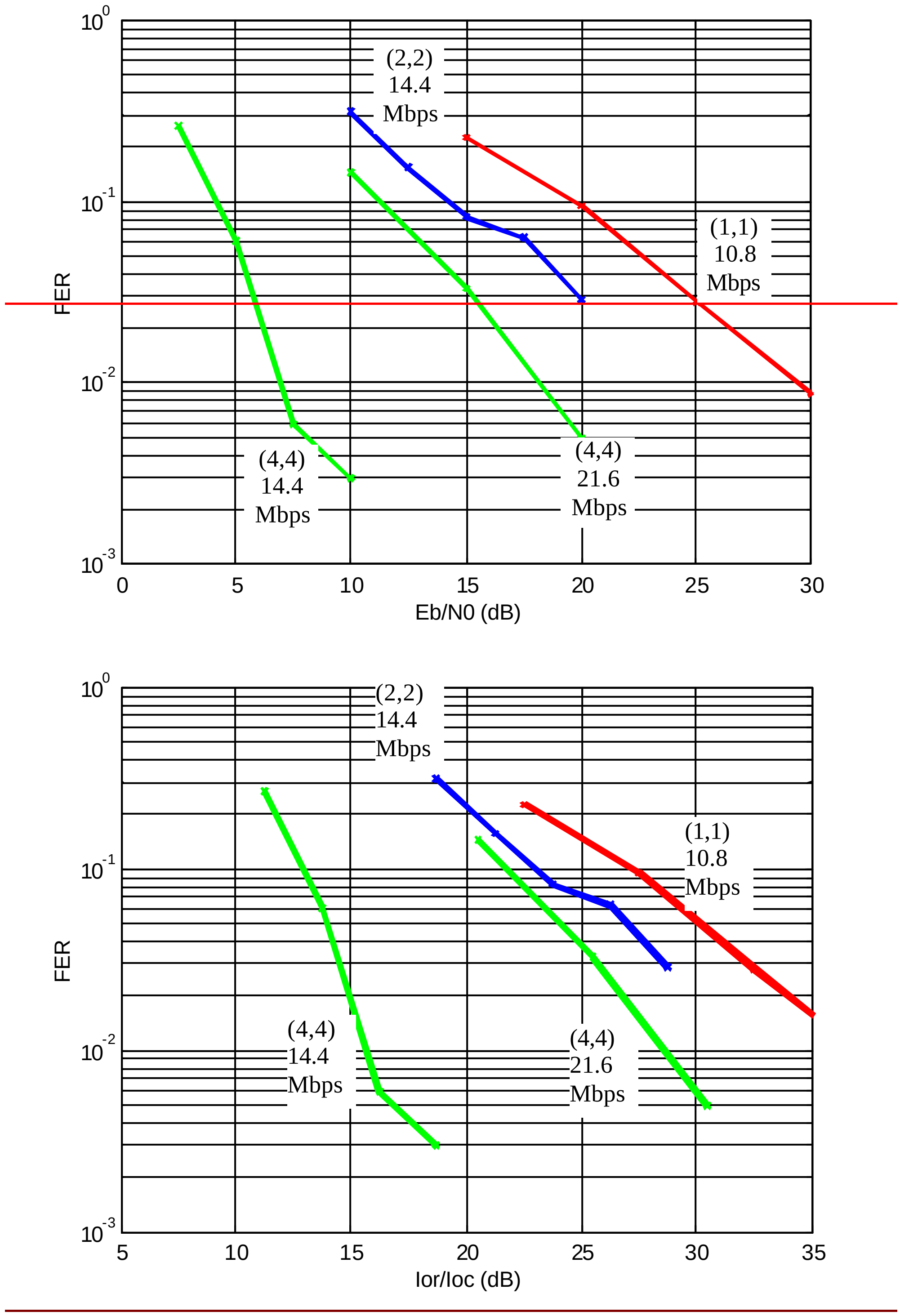

Figure 22~~28~~. Flat fading channel performance for higher data rates

One way to interpret the ~~Eb/N0~~Ior/Ioc gains for MIMO is that the high data rates can be achieved with less transmit power. Alternatively, if the DSCH is transmitted at a fixed power, then the MIMO gains translate into the higher data rates being used over a larger fraction of the cell area. Under this assumption of a rate-controlled DSCH, a system level study employing a base station scheduler showed that the average sector throughput using a (4,4)

MIMO system increases by a factor of 1.8 and 2.8 for proportional fair and maximum C/I scheduling, respectively, compared to a conventional (1,1) system [1]. (As an aside, a surprising result in [1] is that under a proportional fair scheduler, the conventional (1,1) system actually outperforms both the (2,1) and (4,1) diversity systems when there are multiple users vying for the DSCH.). It may be noted that the system level simulation did not use all the assumptions as outlined in Annex A.

Additional link level studies investigated the effect of higher doppler frequencies and channel estimation [2]. These studies indicate that a worst case loss in required Ior/Ioc of only about 2dB. In non-ideal channel conditions, there may be spatial channel correlations which could potentially degrade MIMO performance. Reference [3] gives a parametric model for modeling spatial correaltions in multiple antenna channels based on antenna separations and anglular spreads at both the UE and Node B. In reference [4], parameters are chosen to model a microcellular environment, and link level results shown below indicate insignificant performance degradation for the (2,2) system. The (4,4) systems are less robust, but losses can be mitigated by transmitting with two of the four antennas and using larger constellations. In fact, as shown by the figure below, performance gains can be achieved by transmitting from the *worst* two antennas (worst in the sense of highest correlation). The resulting performance is within 2dB of the ideal uncorrelated (4,4) performance. For comparison, spatial correaltions modeled by actual MIMO channel measurements have also been derived. Preliminary results indicate similar performance trends derived from the theoretical model given above [4].

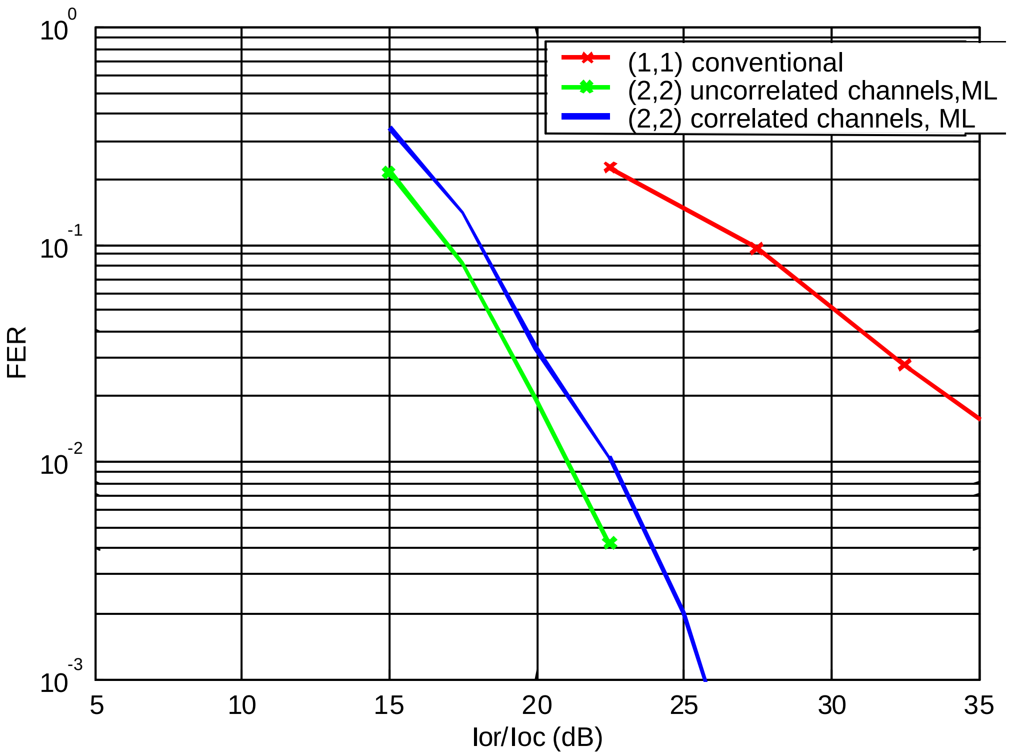

Figure 3. FER for (2,2) system, 10.8 Mbps, flat channel, 3km/hr

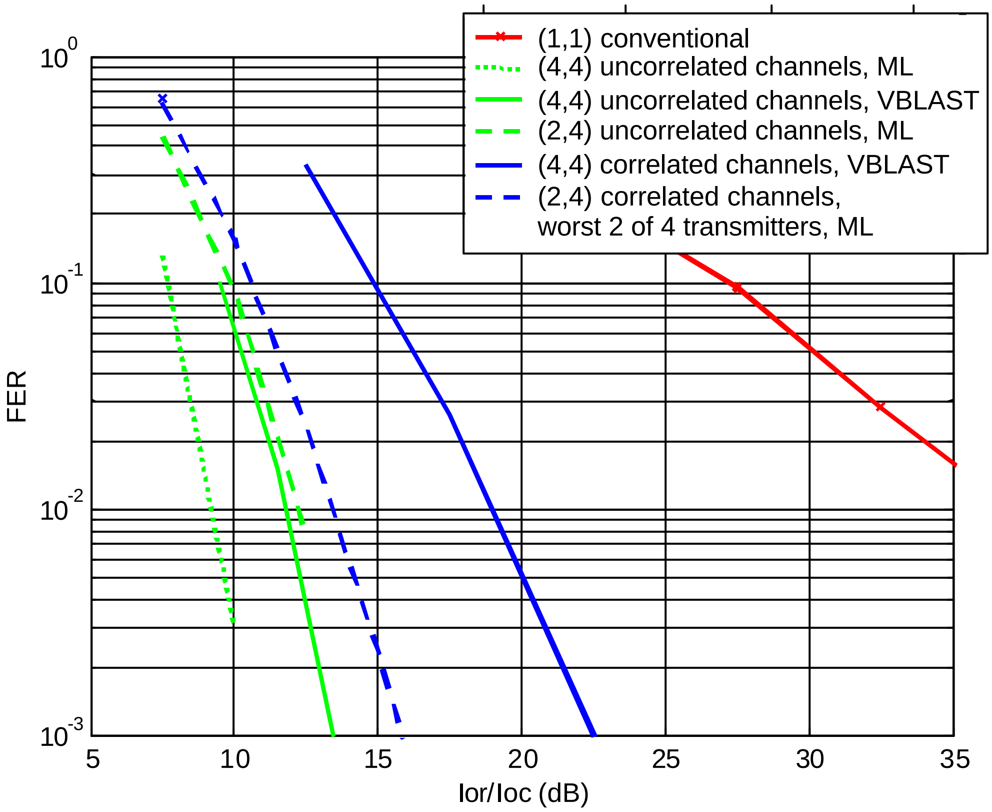

Figure 4. FER for 4 receive antenna system, 10.8 Mbps, flat channel, 3km/hr

[1] Lucent. Throughput simulations for MIMO and transmit diversity enhancements to HSDPA. TSG_R WG1 document TSGR1#17(00)1388, 21-24th, November 2000, Stockholm, Sweden.

[2] Lucent. Further link level results for HSDPA using multiple antennas. TSG_R WG1 document TSGR1#17(00)1386, 21-24th, November 2000, Stockholm, Sweden.

[3] Siemens. Channel model for TX diversity simulations using correlated antennas. TSG_R WG1 document TSG1#15(00)1067, 22-25th, August 2000, Berlin, Germany.

[4] Link level results for HSDPA using multiple antennas in correlated and measured channels. TSG_R WG1 document TSGR1#19(01)0302; 27th February –2nd March, 2001, Las Vegas, USA.