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Agenda item: **AH24: HSDPA**

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Title: **Link Level Simulation Results for HSDPA: Comparison between MIMO and Tx Diversity**

Document for: **Discussion**

1. Introduction

The multi-input/multi-output (MIMO) transmission was proposed by Lucent for high speed downlink packet access (HSDPA) and link level simulation results were presented showing significant performance gains over the conventional single antenna architecture and the space-time transmit diversity (STTD) technique [1-3]. However, the conventional techniques with only one receive antenna were compared to the MIMO architecture with two transmit two receive, or four transmit four receive antennas. In last Boston meeting, it was pointed out that the closed-loop transmit diversity with more than two antenna elements is under study in WG1 and this mode should be incorporated as a reference point for MIMO performance comparisons [4,5].

In this contribution, we present link level simulation results using the multiple reception antennas diversity with STTD and closed-loop transmit diversity schemes to compare to the MIMO performance. The frame error rate (FER) performance for the same total data rate of 10.8 Mbps is compared in a flat fading channel. Although MIMO architecture with code-reuse can support the data rate of more than 10.8 Mbps, nearly the same performance can be achieved for both schemes with the same number of transmit and receive antennas.

2. Simulation Parameters

We consider the following data rates and antenna architectures shown in Table 1. The number of antennas for the conventional, STTD and closed-loop Tx diversity schemes are chosen between 1 and 4. The STTD with only two transmit antennas is considered, since the optimum STTD coding scheme for four antennas does not exist. The Mode 1 operation or simple extension of Mode 1 specified in Release 99 is assumed for the closed-loop Tx diversity. Additional simulation parameters are shown in Table 2.

Table 1. Transmission architectures

(*M*,*N*)	Tx technique	Code rate	Modu-lation	Data rate per substream	# sub-streams	Total data rate
(1,N)	Conventional	¾	64QAM	540Kbps	20	10.8Mbps
(2,N)	STTD	¾	64QAM	540Kbps	20	10.8Mbps
(M,N)	CL Tx Diversity	¾	64QAM	540Kbps	20	10.8Mbps

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

Table 2. Simulation parameters

Carrier frequency	2 GHz
Chip rate	3.84 Mcps
Spreading factor	32
Number of multi-codes	20
Frame length	0.667 ms (1 slot length)
CPICH Channel coding / decoding	-10 dB total Turbo coding (R=3/4, k=4) Max-Log-Map decoding (8 iterations)
Channel estimation	Ideal / CPICH channel estimation
Channel model	1 path Rayleigh (v=3km/h, 30km/h)
TPC	off

3. Simulation Results

We measure the FER versus Eb/N0 per receive antenna, assuming a flat Rayleigh fading channel. Figure 1 gives the performance for the conventional single antenna transmission. We assume perfect channel estimation and an uncorrelated channel at 3 km/h. The maximal ratio combining (MRC) is done when multiple antennas are used at the receiver. As references, the simulation results presented by Lucent [1-3] are shown in this figure. Results show that the (4,4) MIMO code-reuse has about 4 dB gain from the (1,4) reception diversity.

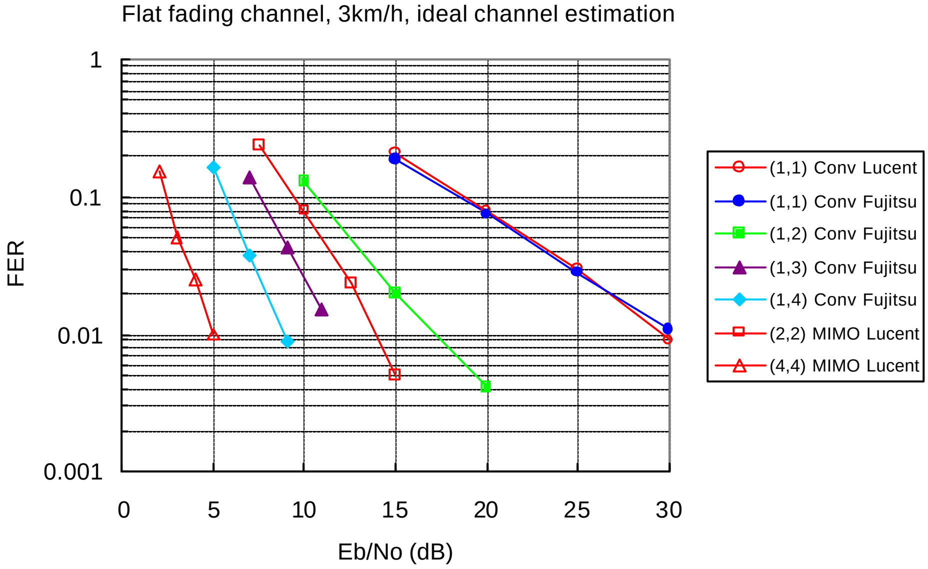

Figure 1. FER performance for the conventional antenna diversity

Figure 2 gives the performance for the STTD coding schemes. Result shows that the (2,2) STTD system outperforms the (2,2) MIMO code-reuse. The result for the (2,1) STTD system agrees well with that from Lucent, which gives the verification of our simulation result.

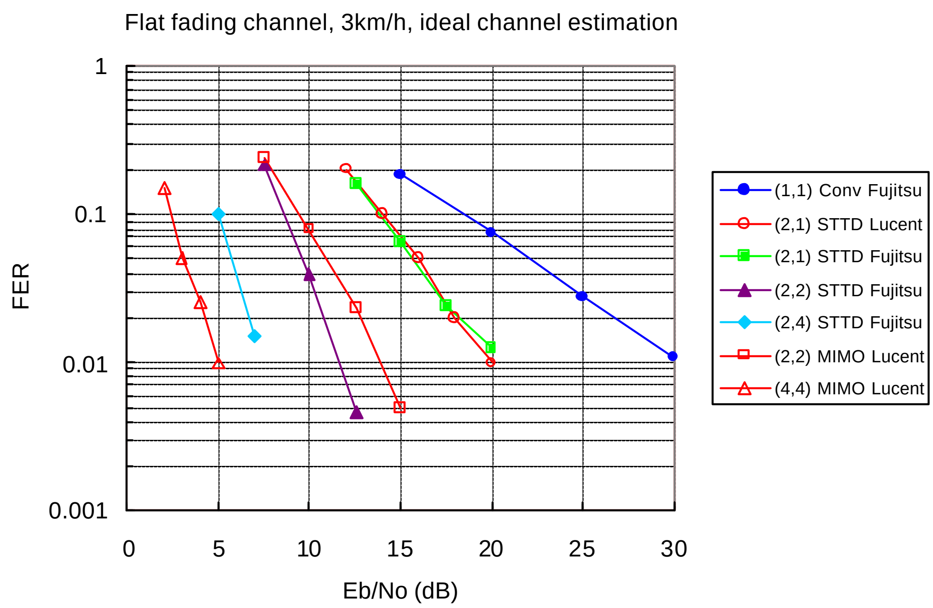

Figure 2. FER performance for the STTD system

Figure 3 shows the results for the closed-loop Tx diversity. We assume the 1 slot feedback loop delay and 4% feedback bit error rate in accordance with [6]. The (2,2) closed-loop Tx diversity outperforms the (2,2) MIMO code-reuse, and the (4,4) closed-loop Tx diversity has slightly better performance than that from (4,4) MIMO code-reuse. However, it should be noted that the closed-loop Tx diversity needs the uplink DPCH to transmit the feedback information.

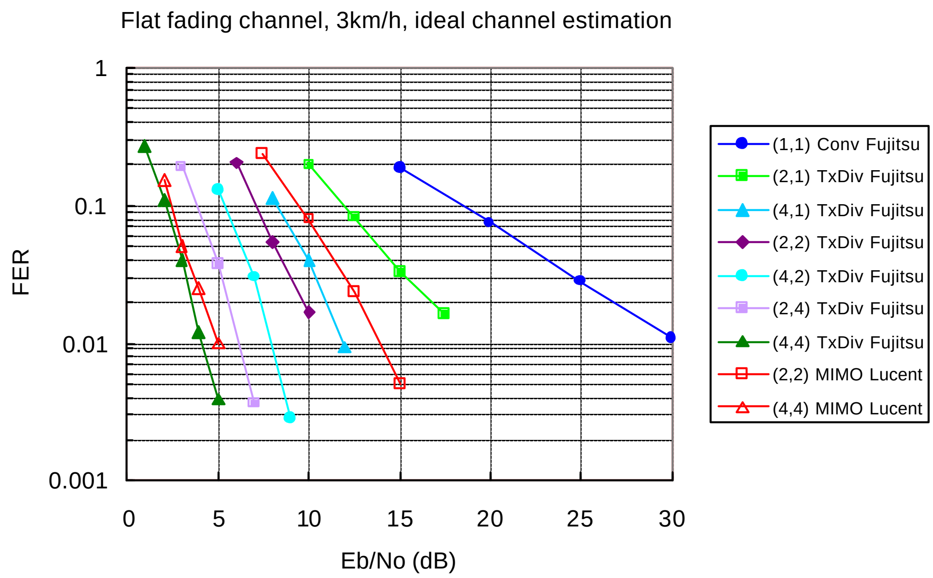

Figure 3. FER performance for the closed-loop Tx diversity

In Figure 4, we measure the effect of UE velocity comparing the performance at 3 km/h and 30 km/h. We perform the channel estimation with 1 slot averaging of CPICH, where the CPICH has –10 dB of total transmit power. While the performance of diversity schemes at 30 km/h is degraded compared to that at 3 km/h, the performance of MIMO code-reuse improves. Result shows that the performance of MIMO code-reuse has slightly better performance than that from transmit diversity at 30 km/h.

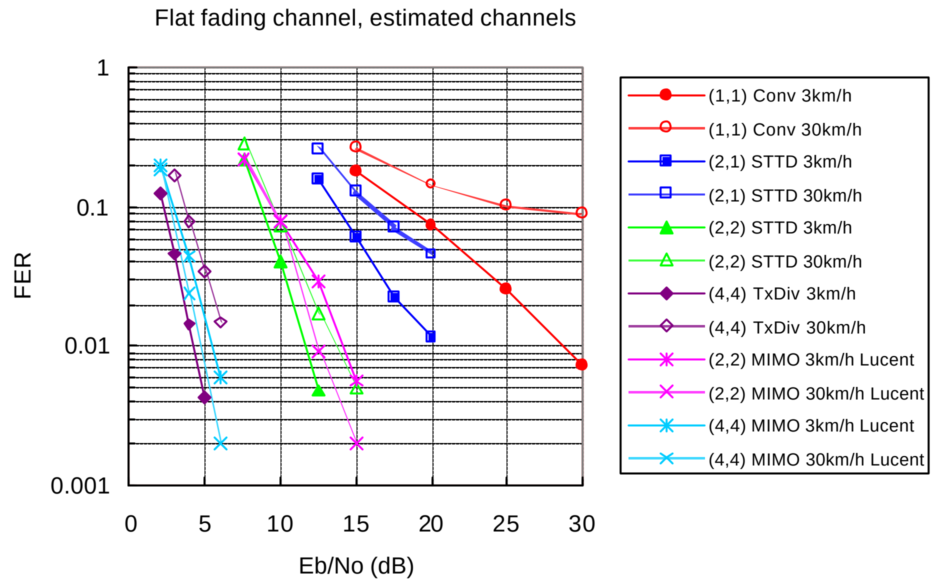

Figure 4. FER comparison in the fading channel

In Figure 5, we present the simulation results which consider the channel correlation with estimated channels at 3km/h. The channel models of urban, channel A and channel B, which were introduced in [2,3] are used in this simulation. The channel A and channel B are highly correlated than urban channel model. Results show that the closed-loop Tx diversity is more robust than MIMO code-reuse for (4,4) antenna configuration.

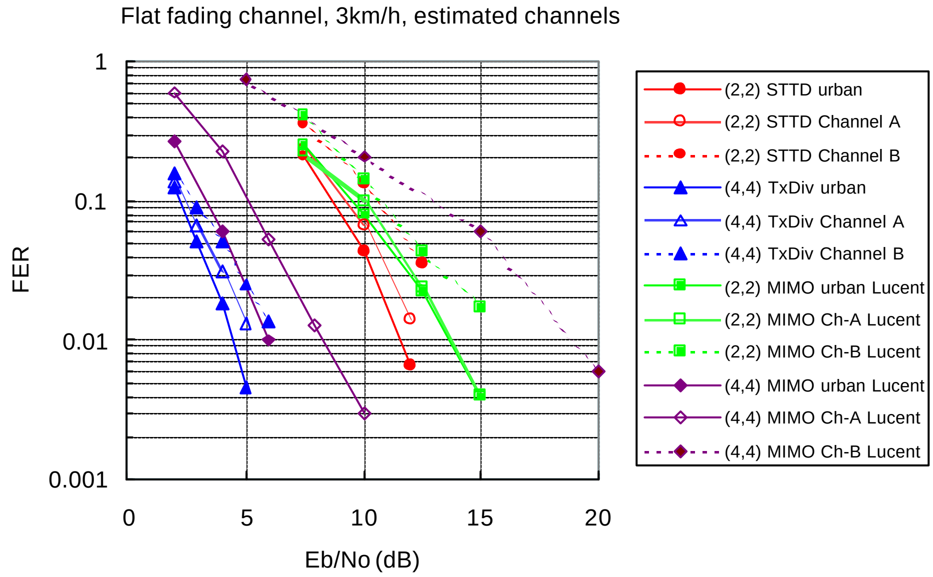

Figure 5. FER comparison in the correlated channel
(Results of MIMO for channel A and channel B assume ideal channel estimation [3].)

4. Conclusion

We presented link level simulation results for the schemes based on transmit diversity and MRC reception diversity and compared with MIMO code-reuse at the total data rate of 10.8 Mbps. When the same number of antennas are assumed at both transmitter and receiver, the similar performance was obtained for both schemes, and significant performance gains could not be observed for MIMO architecture compared to multiple antennas diversity.

However, these simulations were done assuming a flat Rayleigh fading channel where all transport channel streams maintain their orthogonality. We think that a flat fading channel is not appropriate to represent the actual propagation environment and should not be used for the feasibility study. In the last meeting, NTT DoCoMo presented link level simulation results for (1,2) diversity in a 2-path Rayleigh fading channel at 10.8 Mbps [7]. As shown in this contribution, the performance in a frequency selective fading channel is extremely degraded due to the multipath interference.

Finally, we should note that the MIMO with code-reuse has an advantage that can support higher data rate more than 10.8 Mbps. If there are enough possibility in which the higher data rate such as 14.4 / 21.6 Mbps are used in the practical propagation environment, the throughput gain for MIMO system will be possibly significant.

References

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[7] NTT DoCoMo, Multipath Interference canceller (MPIC) for HSDPA and effect of 64QAM data modulation. TSG-R WG1 document, TSGR1#18(01)0102, 15-18, January, 2001, Boston, USA.