Agenda item:	**AdHoc #24 HSDPA**
Source:	**Motorola**
Title:	**Alternatives in MIMO Link Design**
Document for:	**Discussion**

Introduction: MIMO is under study under HSDPA TR 25.848. At this point, alternate schemes have yet to be studied and a number of open issues remain. In this contribution, various alternatives to V-BLAST proposed by Lucent[1] are outlined. These alternatives should be evaluated in detail in WG#1.

Alternative 1: Punctured Schemes

This was proposed by Nokia in [2]. In this scheme the user data throughput can be increased using punctured Turbo codes (although the example illustrated in [2] used a convolutional code). The transmitter utilizes a STTD and the receiver uses a simple dual-antenna Rake. It was shown in [2], that the performance of this scheme is superior to a 2X2 MIMO scheme using a two-stage LMMSE detector with post-decoding symbol feedback. With [2] one could also use a 2x2 scheme proposed by Alamouti in [3].

Alternative 2: Channel State Information Available at the Transmitter

As shown by Telatar in [4], channel capacity is related to the "eigen modes" of the channel. This relation can be exploited in number of ways distinct from the V-BLAST scheme. Foschini and Gans [5] show results for a number of MIMO schemes applicable to an FDD based TDMA environment and Raleigh and Cioffi [6] show techniques applicable to a TDD based OFDM like system. While these schemes may more closely approach Shannon channel capacity than a pure V-BLAST method, they are not directly applicable in a cellular CDMA system and environment. Issues include the required knowledge of the channel matrix to the transmitter, with associated open issues in optimal channel coding, bit allocation per subchannel, channel state source coding, and power amplifier power management. Further, the performance advantage of all MIMO schemes is dependent on the underlying channel model, and a validated MIMO model has not yet been identified by RAN1. The channel model is particularly important, as the performance of these schemes varies with multipath conditions. Additionally, the impact of inter cell interference on the various MIMO approaches is not well known, and requires significant study.

Alternative 3: No Channel State Information

The data rate in this class of scheme is also increased by OVSF code re-use at each transmit antenna. However, open loop schemes are by definition incapable of adapting to the channel state, with associated loss of link capacity regardless of the receiver signal processing. Further, receiver complexity often rises to accommodate the nonlinear signal processing required at the receiver. In the V-Blast approach, for example, an subtractive interference canceller is used (SIC) to mitigate the effect of self-interference before log-likelihood ratio generation.

Conclusion and Recommendation:

The goal of HS-DSCH is to increase the average throughput as well as the peak data rate. This should be achieved using low terminal complexity and power consumption. MIMO represents a promising approach but there are a wide variety of applicable techniques and a large number of open issues. At present, therefore, an informed comparison of different MIMO methods cited above cannot be made.

Further, the performance advantage of MIMO schemes is heavily dependent on the underlying channel model. We like to see a agreed upon MIMO channel model in WG#1 to assess the performance of various schemes.

As such, it is recommended to study the above alternatives for MIMO based on a agreed channel model before settling on a given implementation.

References:

[1] Lucent, "Enhancement for HSDPA using Multiple Antennas," TSGR1#15(00)1096.

[2] Nokia, "Double data rate for FDD downlink through channel code puncturing in MIMO channels," TSGR1#19(01)xxxx.

[3] S. Alamouti, "A Simple Transmit Diversity Schemes for Wireless Communications," JSAC, October 1998.

[4] E. Telatar, "Capacity of Multi-antenna Gaussian Channels," European Transactions on Communications, Nov./Dec. 1999.

[5] G. Foschini, M. Gans, "On Limits of Wireless Communications in a Fading Environment when Using Multiple Antennas", Wireless Personal Communications, pp. 311-335, Kluwer Academic Publishers, 1998

[6] G. Raleigh, J. Cioffi, "Spatio-Temporal Coding for Wireless Communication", IEEE Trans. Comm. Vol. 46 No. 3, March 1998.