TSG-RAN Working Group 1 meeting #12 ***TSGR1#12(00)506***
Seoul, Korea
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Agenda item:
Source: Samsung and Seoul National University
Title: Proposal for the use of closed loop Tx diversity with more than 2 Tx Antennas
Document for: Review and Discussion

Summary

The use of two transmit antennas has been so far considered in 3GPP specifications for transmit (Tx) diversity. An increase in the number of Tx antennas for closed loop transmit diversity systems has been found to improve performance significantly [1]. We propose in this contribution the optional use of more than 2 antennas for Tx diversity. Simulations show that the use of 4 antennas with the considered scheme offers about 3.9dB performance gain at 5 km/hr, compared to 2 transmit antenna systems with mode 2 (without progressive refinement). We have also started to investigate efficient representation schemes for feedback information.

- Significant performance improvement using more than 2 Tx antennas
- Efficient way to represent the feedback information
- Minimal changes in the specifications

The intention of this document is to initiate the discussion on the closed loop transmit diversity antenna with more than 2 antennas in WG1 for Release 2000. So, we only summarize the required number of feedback information for new scheme, the preliminary simulation results. Note that the detail structure is not described in this document. We can start extensive discussion via e-mail reflector if WG1 members are interested in the suggestion.

I. Introduction

In 3GPP meetings, there have been a lot of contributions to closed loop Tx diversity with 2 Tx antennas. We present in this contribution the potential benefits of closed loop Tx diversity with more than 2 antennas, and propose the optional use of more than 2 antennas. Our simulations show significant performance improvements from using more than 2 antennas.

II. Potential of more than 2 Tx antennas

Open-loop Tx diversity systems are known to offer diversity gain. As the number of antennas for these systems increases, the average power of a received signal does not change, whereas the variation of a received signal decreases. This variation decrease results in performance improvements. In contrast to the open-loop systems, as the number of antennas in the closed-loop Tx diversity systems increases in closed-loop systems, the average power of a received signal increases and the variation of a signal decreases. The average received signal power increases 3 dB, as the number of antennas doubles. Because of both signal power increase and variation, the closed-loop systems with more than 2 antennas offer more potential benefits than the open-loop systems.

Figure 1 shows simulation results of uncoded BER performance of a closed loop Tx diversity system with 1, 2, 3, and 4 Tx antennas. In these simulations, it is assumed that the number of paths is 1 and the channel response is known and does not change over one symbol duration. Furthermore, the optimal weight vector for Tx antennas are assumed to be exactly calculated and fed back to the base station without any error and delay. This figure shows that the system with 4 antennas requires 7 dB less power than a system with 2 antennas for 10^{-3} uncoded BER. Note that the performance is not plotted in terms of fading rates, although the performance varies with fading rates in practical systems. It is due to the simulation assumptions such as no fading delay and no channel variation over one symbol duration. For more information, please refer to [1].

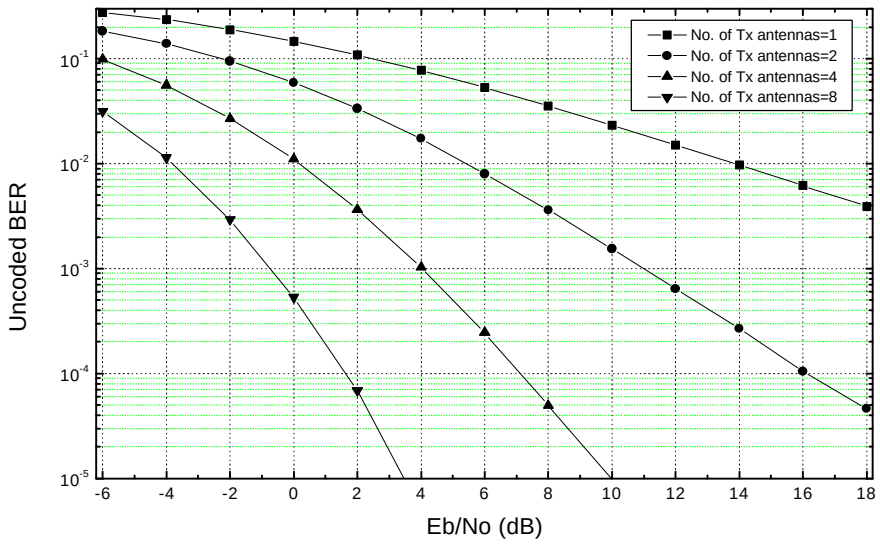

Figure 1. Performance of an ideal closed loop Tx diversity system (1 path).

III. Efficient way to represent feedback information

Although the closed loop Tx diversity with more than 2 antennas provides potentially significant gain over that with 2 antennas, the implementation of more than 2 antenna systems may not be practical because of the large amount of feedback information. For closed loop Tx diversity in 3GPP, the weights of transmit antennas for maximum SNR are calculated at a mobile station and fed back to the base station. The collection of calculated Tx antenna weights may be viewed as a vector $\underline{w}=[w_1\ w_2\ \ldots w_i \ldots\ w_M]^T$, where M refers to the total number of Tx antennas and w_i is a complex weight associated with the ith Tx

antenna. This weight vector information is periodically fed back to the base station. Note that the amount of feedback information increases with the number of Tx antennas. An efficient representation of weight information is desired to reduce the amount of feedback data.

The representation of the optimal weight vector may require $(M\text{-}1)*N_c$ bits, where N_c bits are required to represent each element of the vector. This representation, referred to as the direct representation, indicates that the transmission of $(M\text{-}1)*N_c$ bits at 1500bps is required to support Tx diversity with M Tx antennas. The reason for $(M\text{-}1)*N_c$ not $M*N_c$ is that one of M Tx antennas may be viewed as reference and the relative weights for other antennas are required.

We have started to look into an efficient way to represent a weight vector for the reduction of feedback data. In Table 1, the required numbers of bits for the new scheme (but not disclosed in this document) and direct representations are compared for M=4 and N_c =4. Note that the use of the new scheme offers ***58%*** reduction in the required number of bits for feedback information, compared to the direct representation.

Table 1. Comparison of required number of bits for weight representation (N_c =4).

Scheme No. of Antennas(M)	New scheme	Direct representation
4	5 bits	12 bits

IV. Simulation Parameters and Results

Although the required number of bits per feedback weight is compared in Table 1, it is hard to compare the performance of new scheme and direct representation for M=4 and N_c =4. It is because the required computational load for direct representation is enormous. Instead, we obtain and compare the simulation results for new scheme, Tx diversity in Release 99 (without progressive refinement), and no diversity case. The simulation parameters are summarized in the Table 2.

Table 2. Simulation parameters

Name	Value
Target coded BER	0.1%
Comparing output	Required SNR(dB) for satisfying target coded BER
Chip rate	3.84Mcps
Information bit rate	8kbps (Speech)
Modulation	QPSK
Physical channel rate	30ksps
Interleaving	10ms
Coding	1/3 Convolutional coding
CPICH power	10% of total BTS power
Ior/Ioc	0dB
Feedback data rate	1500bps
Number of antennas	3GPP: 2 New scheme: 4
Required number of bits per feedback weight	3GPP: 4 bits New scheme: 5 bits
Number of feedback bits per slot	1
Feedback delay	3GPP: 4 slots New scheme: 5 slots
Progressive Refinement	No
Feedback bit error rate	4%
Power control step	1dB
Power control bit error	4%
Carrier frequency	2GHz
Bit allocation/slot (data1,TPC,TFCI,data2,pilot)	(6,2,0,28,4)
Speed	5, 10, 20 km/hr
Rake channel estimation(WMSA)	4slot(1,4,4,1)
The number of paths per antenna	1

V. Simulation Results

Figure 2 shows the required Ec/Ior for 0.1% coded BER at various speeds. The 4-antenna Tx diversity system with the new scheme is found to require 3.9 dB less power than the 2-antenna Tx diversity [2] at 5 km/hr. It is worth noting that the simulation results for the transmit diversity antenna for Release 99 coincide with the previous results without progressive refinement [2].

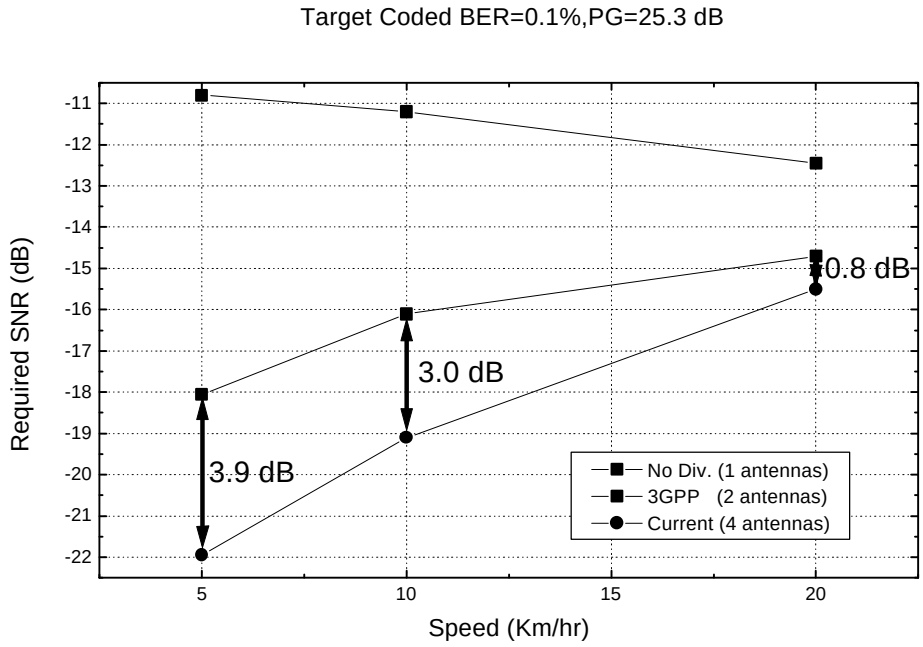

Figure 2. Required Ec/Ior of 2-antenna and 4-antenna system

VI. Conclusion

In this contribution, the use of more than 2 transmit antennas has been suggested for closed loop Tx diversity system. Although the detail proposal was not presented, we briefly introduced that the required number of bits for feedback weight can be reduced. Without an increase in feedback data rate, the use of 4 transmit antennas has been found to improve the performance by 3.9dB at 5 km/hr, compare to 2 transmit antennas. As a consequence, it is recommended that WG1 should start the discussion on the initiation of closed loop transmit diversity for more than 2 antenna.

Reference

[1] T. K. Y. Lo, "Maximum ratio transmission," *IEEE Trans. on Commun.*, vol. 47, pp. 1458-1461, Oct. 1999.

[2] 3GPP TSG-R WG1 document, TSGR1#(99)c11, Aug. 30-Sep. 3, 1999, Hannover, Germany.