**Title:** Performance Metric for MIMO PARC System

**File:** SCM-076 LUC mmse metric.doc

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**Date:** November 20, 2002

# 1 INTRODUCTION

This document presents further system-level simulation results for a MIMO system based on per-antenna rate control (PARC)[1]. The goal is to illustrate the mapping from system level FER simulation to the link level AWGN FER results. This is a continuation of the system simulation methodology presented in [2].

# 2 REVIEW OF PARC TRANSMISSION AND DETECTION

A block diagram of PARC transmission is shown in Figure 1. The high-speed data stream is first demultiplexed among *T* transmit antennas. The number of bits assigned to each antenna may be different depending on the rate assignment. Following demultiplexing, the individual substreams for each antenna are coded, interleaved, and mapped to symbols. These symbols are further demultiplexed among *C* orthogonal spreading codes with spreading factor *F*. Note that in PARC transmission, code reuse occurs since a given code modulates data for all of the antennas.

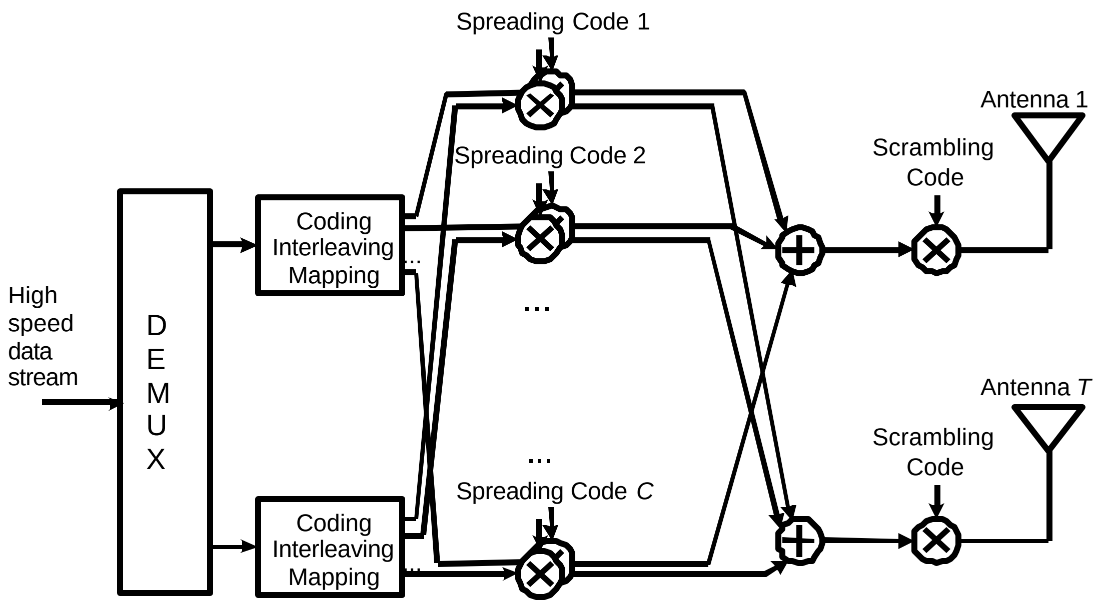


Figure 1. Block diagram of PARC transmitter

Here we present the result for minimum mean-squared error (MMSE) detection [3] without interference cancellation. Figure 2 shows the MMSE detector. The received signal is a complex *R*-dimensional vector where *R* is the number of receive antennas. The vector is multiplied by a *T*-by-*R* matrix representing the linear transformation, which minimizes the mean-squared error between the transmitted chip-level data symbols and the output of the transformation. Because the spreading codes are orthogonal and we assume a flat fading channel, the transformation is applied on each chip period, and its matrix is not dependent on the spreading codes. For each chip period, the output of the linear transformation is a *T*-dimensional vector. *F* consecutive output vectors corresponding to a given symbol period are collected, and the *t*th collection ($t$ = 1 … *T*) of *F* samples are correlated with the *C* spreading codes. For the *t*th antenna, the *N* despread signals are multiplexed, symbols are detected, demapped, deinterleaved, and decoded. Recall that the coding rates and modulation constellations could be different for each of the $t$ antennas.

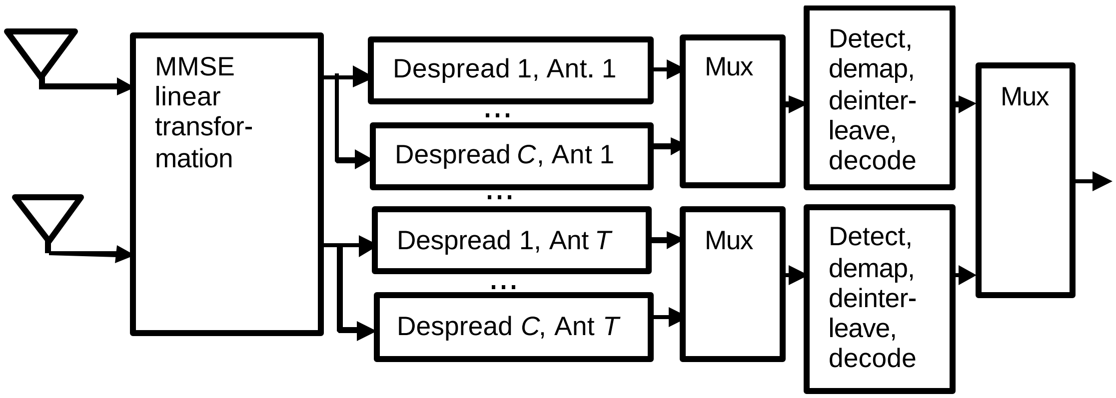


Figure 2. Block diagram of MMSE receiver

## 3 MAPPING BETWEEN LINK-LEVEL AND SYSTEM-LEVEL SIMULATIONS

For PARC transmission, the received signal is

$$\mathbf{r} = \sqrt{\frac{G}{T}}\mathbf{H}\mathbf{b} + \mathbf{n}$$

where $\mathbf{H}$ is the $R$-by-$T$ channel realization matrix, and $\mathbf{b}$ is the $T$-dimensional coded symbol vector. The elements of $\mathbf{b}$ are assumed to have unit variance. The MMSE receiver is given by the $R$-by-$T$ matrix

$$\mathbf{W} = \sqrt{\frac{T}{G}}\mathbf{H}\left[\mathbf{H}^H\mathbf{H} + \frac{T}{G}\mathbf{I}_T\right]^{-1}, \tag{1}$$

hence a sufficient statistic vector for the data vector is $\mathbf{W}^H\mathbf{r}$. Let us write the matrices $\mathbf{W}$ and $\mathbf{H}$ in terms of their column vectors: $\mathbf{W} = [\mathbf{w}_1 \ldots \mathbf{w}_T]$ and $\mathbf{H} = [\mathbf{h}_1 \ldots \mathbf{h}_T]$. We also express $\mathbf{b}$ in terms of its components: $\mathbf{b} = [b_1 \ldots b_T]^T$ (where $T$ denotes a vector transpose). For the $t$th transmit antenna, a sufficient statistic for $b_t$ is

$$\mathbf{w}_t^H\mathbf{r} = \sqrt{\frac{G}{T}}\mathbf{w}_t^H\mathbf{h}_t b_t + \sqrt{\frac{G}{T}}\sum_{\substack{j=1 \\ j\neq t}}^{T}\mathbf{w}_t^H\mathbf{h}_j b_j + \mathbf{w}_t^H\mathbf{n}\,.$$

If we consider the power received from the other antennas ($j = 1 \ldots T$, $j \neq t$) as interference, it follows that the SINR for the $t$th antenna is

$$SINR_t = \frac{\frac{G}{T}\left|\mathbf{w}_t^H\mathbf{h}_t\right|^2}{\frac{G}{T}\sum_{\substack{j=1 \\ j\neq t}}^{T}\left|\mathbf{w}_t^H\mathbf{h}_j\right|^2 + \mathbf{w}_t^H\mathbf{w}_t}\,. \tag{2}$$

## 4 NUMERICAL RESULTS

We run system simulations for a single user with T = R = 4 antennas. We consider spatially uncorrelated frequency-flat channels.

Figure 1 shows the FER curve for the AWGN channel for four selected MCSs. Figure 2 shows the system simulation results to verify the mapping described in Section 2. The propagation channel is assumed fixed within a simulation drop, and rates for different antennas are selected based on the AWGN FER curve to maintain FER<$10^{-1}$. System simulation is performed for PARC without using the mapping. In other words, for a given channel realization, MCSs are chosen, and link level simulations are performed to determine the FER. These results are shown as red squares in Figure 2. As expected, the FER from the system simulation lie on the AWGN curve with corresponding EsNt. These results can be accurately predicted based on the mapping from EsNt for each of the rate from the AWGN curves as described in Section 2.

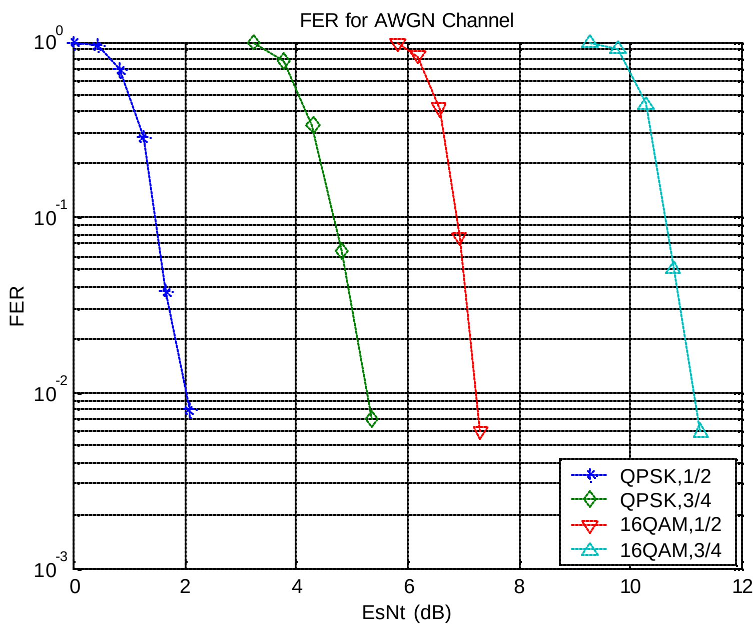


Figure 1. FER for AWGN Channel

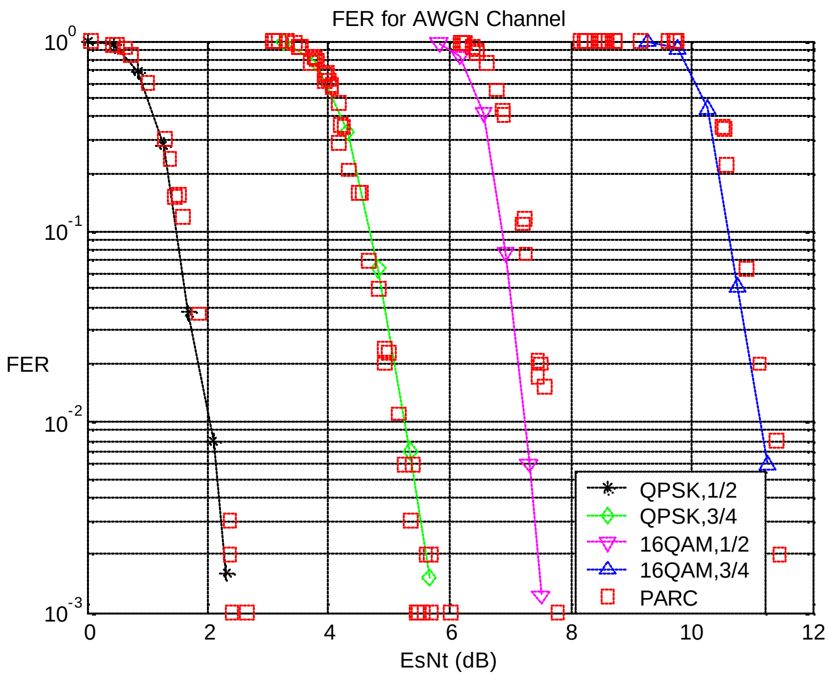


Figure 2. FER for PARC MMSE

## 5 CONCLUSIONS

We present further simulation results to show the evaluation of MIMO performance based on a simple SINR metric for each antenna under MIMO/PARC transmission. Frequency flat Rayleigh iid channels are used, and metrics are computed for each user during each transmission interval. The maximum supportable data rate for each PARC data stream is determined based on the SINR metric. The simulations show that the FER from the AWGN channel can be used to predict the performance of PARC system through the mapping of the SINR metric.

## 6 REFERENCES

[1] Lucent. Increasing MIMO throughput with per-antenna rate control. TSG_R WG1 document TSGR1(01)0879; 27th-31st August, Turino, Italy.

[2] SCM-058 Lucent, “Preliminary system-level simulation results.”

[3] S. Verdu, *Multiuser Detection*, Cambridge University Press, 1998.