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| Title | **Analog Feedback per Band – A proposal** |
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| Source(s) | Ron Porat , Yi Jiang, Keith Holt<br>Nextwave Wireless<br>Voice:<br>E-mail: rporat@nextwave.com;<br>*<http://standards.ieee.org/faqs/affiliationFAQ.html> |
| Re: | Contribution to support a Comment on the DL-MIMO Rapporteur group final draft: C802.16m-08/657r2. |
| Abstract | This document describes a proposal for 802.16m DL or UL CL-MIMO feedback |
| Purpose | To be discussed and adopted by 802.16m SDD. |
| Notice |  |
| Release |  |
| Patent Policy |  |

**Analog Feedback per Band – A proposal**

Ron Porat, Yi Jiang

Nextwave Wireless

## 1. Introduction

Typical CL-MIMO operation is characterized by feeding back one value per band. A typical band is 400-800KHz and spans 36-72 subcarriers.

One possible option is to calculate the feedback based on the central subcarrier of a band. This option is suboptimal as it doesn't represent very well the 'average' channel of the band.

While actual averaging of the channel across the subcarriers in a band doesn't work well it is possible to average the channel covariance as was shown in simulations in C80216m-08_372r3. This approach is reasonable for small antenna configurations (2 or 4) but not for larger because the amount of feedback becomes prohibitive.

In addition, for small antenna configurations it is also possible to reduce the amount of feedback by sending the first or first and second singular vectors especially for SU-MIMO.

Here we derive a method that feeds back the average of the singular vectors across the band of interest. The exact same idea can be used for precoder smoothing or interpolation at the transmitter which is key for making sure that the effective channel seen by the subscriber is continuous.

## 2. Average Singular Vector Calculation

The underlying idea is to solve the following minimization problem $\begin{matrix} \min\limits_{v,\phi} & \sum \left\| v_i e^{j\phi_i} - v \right\|^2 \\ s.t. & \|v\| = 1 \end{matrix}$ where $v_i$ is the first or second singular vector of the channel in subcarrier $i$.

The algorithm works separately on each singular vector. The singular vectors are not limited in length.

The optimal solution given known phase $\phi_i$ can be shown to be $v = \sum_{i \in B} v_i e^{j\phi_i}$

A solution can be found using the alternate minimization (AM) method as follows:

- Pick any subcarrier j and align the phases of all singular vectors in the band relative to that subcarrier. In other words - $v_i \leftarrow v_i \frac{v_i^* v_j}{\left| v_i^* v_j \right|}$
- Calculate the average beamforming vector by normalizing the vector $\sum_{i \in B} v_i$
- Repeat step 1 by using the vector calculated in step 2.

In principle performing more iterations lead to better performance but we observed that one iteration is good enough.

Another option for rank-2 feedback involves operating on the unitary Nx2 precoder matrices.

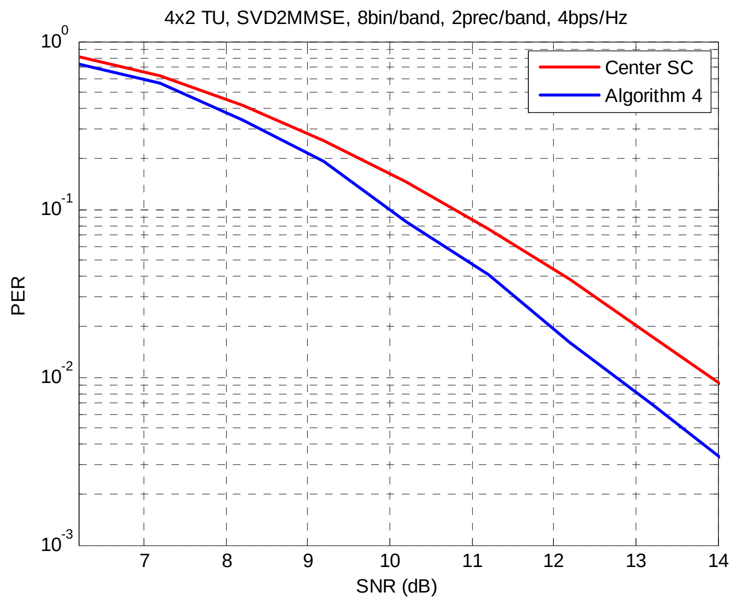
In this case we use a unitary matrix to 'phase align' the Nx2 per subcarrier precoder matrices. In other words we need to solve $\min_G \| V_i - V_j G \|$ where G is a 2x2 unitary matrix.

The solution requires a simple SVD operation on the 2x2 matrix $V_i^* V_j = Q \sum P^*$ to get $G = PQ^*$

## 3. Simulation Results

The following plots show a comparison of the column by column algorithm (denoted algorithm 4 in the plot) with a precoder based on just the central subcarrier.

Shown is a 4 antenna configuration using rank-2 transmission and a MMSE receiver. One precoder was used per 36 subcarriers.
It was observed that the performance advantage increases to 2dB for a 2 antenna system and also with increasing the band size.




## 4. Recommendation

We therefore recommend adding analog feedback to the DL MIMO SDD as specified in C80216m-DL_MIMO-08_008r2_Analog_Feedback