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| Title | **An enhanced closed-loop MIMO design for stream power distribution** |
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| Re: | Response to Sponsor Ballot on IEEE802.16e/D6 document |
| Abstract | The document proposes an enhanced closed-loop MIMO design for stream power distribution in different stream. |
| Purpose | To incorporate the text changes proposed in this contribution into the 802.16e/D6 draft. |
| Notice |  |
| Release |  |
| Patent Policy and Procedures |  |

# An enhanced closed-loop MIMO design for stream power distribution

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## 1 Introduction

In this contribution, a per-stream adaptive power distribution scheme in MIMO is presented. Usually, the SNR in each stream has great difference. References pointed out that the gap between the strongest and the weakest SNR is more than 9dB. What's more, with the number of streams increase, the gap becomes more obvious. In order to reduce the interference between streams, a closed-loop that involves pre-coding has been presented in IEEE 802.16eD6. Although the pre-coding method can improve the decoding performance, it is still based on the even power distribution in all streams. So the capacity of the pre-coding system does not improve. To remedy this problem, the per-stream adaptive power distribution in MIMO is required that streams with different SNR have different power. We will present one criteria to choose different power in different steams. Since the criteria is only depended on the streams' scaled SNR and the current 802.16eD6 supports to feedback these value through CQICH channels, it is not necessary to add new uplink channel to feedback, but only to change the power distribution in each stream so it has compatibility with current protocol completely.

## 2 Adaptive Power Distribution in Different Streams

We have known that in MIMO system the channel capacity can be written as

$$C = \sum_{i=1}^{S} W \log_2 \left(1 + P_i \rho_i\right) \qquad (1)$$

where the stream power and the scaled SNR in the ith stream are denoted by $P_i$ and $\rho_i$ respectively, and the total number of streams is denoted by $S$ .

In reality, when the total number of streams is fixed then the total power in all streams is also fixed, denoted by $P$ . So the following constraint should be satisfied

$$\sum_{i=1}^{S} P_i = P \qquad (2)$$

In order to maximize the equation (1) with the condition of equation (2), we can use the Lagrange multiplier $\lambda$ to resolve the problem, namely maximize the following equation without constraint conditions

$$M = \max_{P_i,\lambda} \sum_{i=1}^{S} W \log_2 \left(1 + P_i \rho_i\right) + \lambda \left(P - \sum_{i=1}^{S} P_i\right) \qquad (3)$$

Problem (3) can be easily resolved as

$$\frac{\partial M}{\partial P_i} = 0 \qquad (4)$$

and

$$\frac{\partial M}{\partial \lambda} = 0 \qquad (5)$$

So we can obtain that

$$\frac{1}{\rho_1} + P_1 = \frac{1}{\rho_2} + P_2 = \cdots = \frac{1}{\rho_S} + P_S = Q \qquad (6)$$

here $Q$ is a constant, then

$$\sum_{i=1}^{S} P_i = \sum_{i=1}^{S}\left(Q - \frac{1}{\rho_i}\right) = SQ - \sum_{i=1}^{S}\frac{1}{\rho_i} = P \qquad (7)$$

$$Q = \frac{P + \sum_{i=1}^{S}\frac{1}{\rho_i}}{S} \qquad (8)$$

The final result is

$$P_n = Q - \frac{1}{\rho_n} = \frac{P + \sum_{i=1}^{S}\frac{1}{\rho_i}}{S} - \frac{1}{\rho_n}, n = 1, 2, \cdots, S \qquad (9)$$

So if each scaled SNR in different streams is obtained, we can easily determine the power distribution in each stream.

# 3 Enhanced Closed-loop MIMO design

In close-loop MIMO design, if we denote the pre-code matrix as $V$ , then we have

$$\mathbf{R} = \mathbf{HVs} \qquad (10)$$

If the pre-code matrix is ideal (namely pre-code the transmitted symbols with the eigenvectors $\mathbf{V}$ of the matrix $\mathbf{H}^H\mathbf{H}$ ) and after decoding, we can get

$$\tilde{\mathbf{s}} \approx \mathbf{V}^H\mathbf{H}^H\mathbf{R} = \mathbf{V}^H\mathbf{H}^H\mathbf{HVs} = diag(d_1, d_2, \cdots, d_S)\mathbf{s} \qquad (11)$$

If we define $\mathbf{E} = diag(\sqrt{P_1}, \sqrt{P_2}, \cdots \sqrt{P_S})$ , then the enhanced closed-loop MIMO design can be

$$\mathbf{W} = \mathbf{VE} \qquad (12)$$

So after enhanced pre-coding, we find that every stream has the optimal power.

# 4 Advantages of the Enhanced Scheme

1. This new power distribution in each stream is optimal, compared with scheme of the same power distribution and the same bit load in each stream;
2. Since individual SNR in each layer can be feedback through CQICH channel, it is not necessary to add new uplink feedback channel in this new enhanced scheme;
3. In the new scheme, we only change the power distribution in each stream, so it has compatibility with current protocol (IEEE 802.16eD6) completely. Everything we need to do is multiply a power contribution matrix $\mathbf{E}$ on the left of pre-code matrix $\mathbf{V}$ ;
4. The power in every stream changes adaptively and not need to be quantized;
5. Different modulation and coding schemes can also be changed according the power distribution in each stream.

# 5 Specific Text Changes

*[Insert new sub-clause 8.4.8.3.7 on page 425:]*

**8.4.8.3.7 Power distribution in different streams for MIMO precoding**

If MSS feedback each layers SNR to BS through CQICH channels, BS shall use this information to distribute different power in each stream. The power in nth stream is

$$P_n = \frac{P + \sum_{i=1}^{S} \frac{1}{\rho_i}}{S} - \frac{1}{\rho_i}$$

$\rho_i$ represents the ith scaled SNR, $S$ represents the total number of streams and $P$ represents the total power in all streams.