Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Improved MIMO Feedback and Per-Stream ABL for OFDMA/OFDM Systems**
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Re:	
Abstract	Per-Stream ABL for MIMO Precoding Systems
Purpose	Adoption of proposed changes into P802.16e ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
Notice	
Release	
Patent Policy and Procedures	

Per-Stream ABL for MIMO Precoding Systems

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Abstract

In this contribution, a per-stream adaptive bit loading (ABL) scheme is proposed. The SNR in the strongest and the weakest beamformed spatial channel is usually greater than 9 dB. This gap is hard to be compensated by FEC codes. Simulation results demonstrate that closed-loop MIMO (i.e. MIMO precoding) provides only 0.5-1 dB gain over open loop MIMO for 2x2 and 4x4 MIMO when uniform bit load is employed. To remedy this problem, adaptive bit loading is required, which employs different constellations on different spatial channels. Since the exact ABL require large overhead to send the bit load table, per-stream ABL is proposed. The per-stream ABL employs one constellation per spatial channel, where the *i*-th spatial channel is formed by the *i*-th eigenmodes of all subcarriers. To further reduce the feedback overhead, we define a set of modulation coding schemes (MCSs), where each MCS specifies the modulations on each stream and the FEC code rate. Since the set for up to 4 streams has less than 64 entries, the MCS feedback only needs 6 bits.

1 Compact Feedback Scheme

The eigenvalue distributions of 4x1, 4x2, 4x3, and 4x4 are shown in Figure 1, and the means of the eigenvalues are listed in Table 1. The difference between the greatest and the smallest eigenvalues increases with the number of spatial streams, and it is greater than 17 dB for 4x4. This large difference is hard to be compensated by FEC coding and adaptive bit/power loading is required.

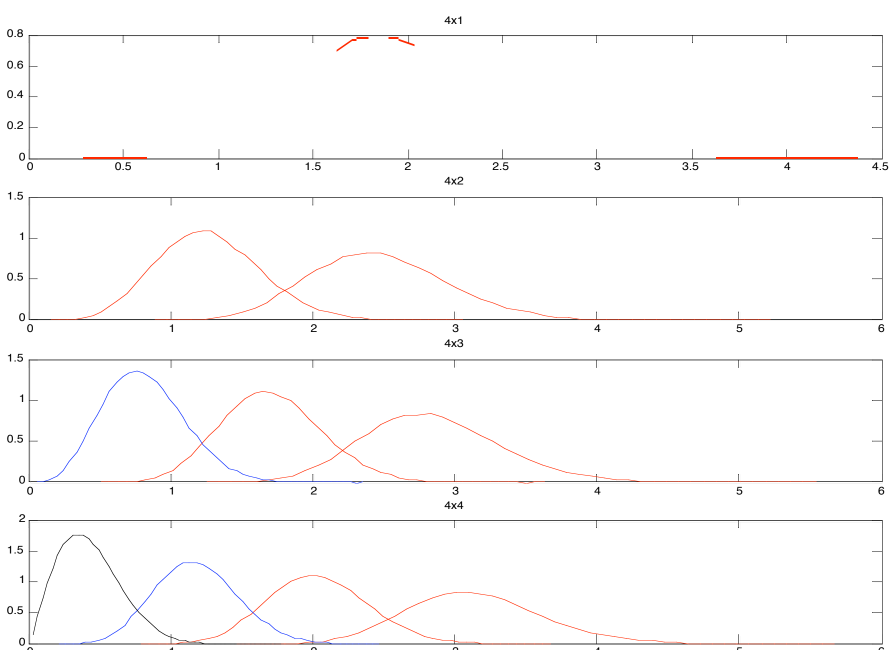

Figure 1. Eigenvalue distributions of spatial modes.

Table 1. Means of channel gain (i.e. sorted eigenvalues) of each spatial channel. The different between the greatest and smallest eigenvalues increases as number of spatial streams.

Mt	Mr	$\bar{\lambda}_1$	$\bar{\lambda}_2$	$\bar{\lambda}_3$	$\bar{\lambda}_3$
2	2	1.81	0.61		
3	3	2.53	1.39	0.49	
4	4	3.14	2.03	1.17	0.43

The exact adaptive bit (or power) loading has the flexibility to put a different number of bits (or amount of power) on each OFDM subcarrier and each spatial channel. Since the loading table requires significant amount of overhead to feed back, the exact adaptive bit (or power) loading is not practical for 802.16e. In order to reduce the overhead, we propose per-stream adaptive bit loading as shown in Figure 2. It assigns the same number of bits on each spatial channel, where the *i*-th spatial channel is formed by the *i*-th eigenmodes of each subcarrier. To further reduce the feedback overhead, we define a set of modulation coding schemes (MCSs), where each MCS specifies the modulations on each stream and the FEC code rate (and suggested power ratio across streams). An MCS set for 2x2 MIMO is illustrated by **Error! Reference source not found.**. Since the whole set for up to 4 streams will have less than 64 entries, the MCS feedback only needs 6 bits.

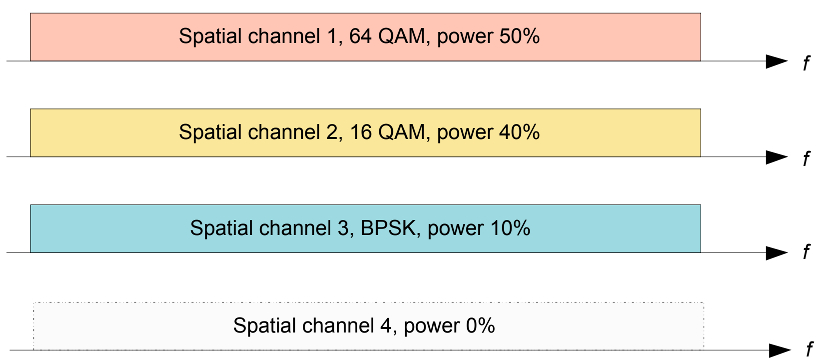

Figure 2. Illustration of per-stream adaptive bit loading. The horizontal axis is for subcarrier index while the vertical is for spatial channel index.

In addition to uniform bit loading scheme defined from 8.4.8.3.3 to 8.4.8.3.5, transmitter should be allowed to load different numbers of bits specified in Table 3to different precoded spatial streams according to the status of the spatial channels.

Table 2 MCS set of 10 entries for 802.1e per-stream adaptive bit loading.

MCS index	1	2	3	4	5	6	7	8	9	10
Code rate	1/2	3/4	3/4	1/2	3/4	1/2	1/2	3/4	3/4	3/4
Constellation 1	16	64	64	16	64	16	16	64	64	64
Constellation 2	Q	Q	16	16	64	16	16	16	64	64
Constellation 3				Q	16	Q	16	Q	Q	16

Constellation 4						Q	Q	Q	Q	Q

One transmitter architecture for per-stream ABL are shown in Figure 3 for discussion. Both architectures try to minimize the addition to the existing 16e transmitter chain. The only new component is a codebit distributor, which assigns bits to different streams with the amounts specified by the selected MCS.

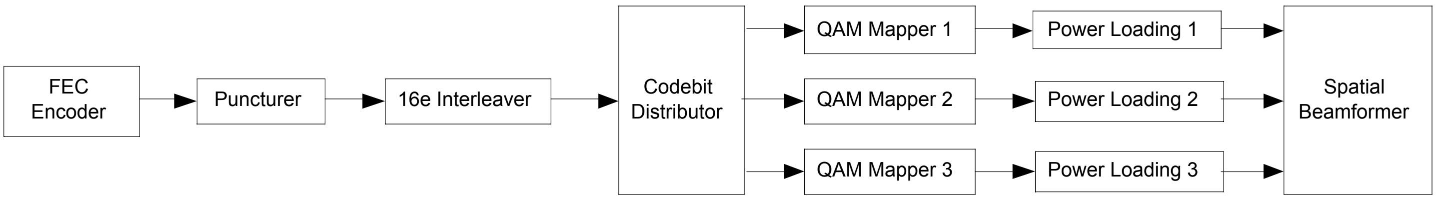

Figure 3. Transmitter architectures for per-stream adaptive bit loading using existing 16e building blocks and an additional bit distributor.

2 Conclusion

We proposed an efficient feedback scheme for the 802.11e closed-loop MIMO. Compared to the existing draft, the new scheme has an overhead at least five times lower. This proposal does require additional SVD computation and codebook searching on the subscriber side.

3 Specific Text Changes

Add section 8.4.8.3.6.1 on page 242 of [1] as follows

8.4.8.3.7 Additional bit loading schemes for MIMO Precoding

In addition to uniform bit loading scheme defined from 8.4.8.3.3 to 8.4.8.3.5, transmitter is allowed to load different numbers of bits specified in Table 3to different precoded spatial streams according to the status of the spatial channels.

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Constellation 1	16	64	64	16	64	16	16	64	64	64
Constellation 2	Q	Q	16	16	64	16	16	16	64	64
Constellation 3				Q	16	Q	16	Q	Q	16
Constellation 4						Q	Q	Q	Q	Q

References:

[1] IEEE P802.16e/D5 Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, 2004.

[2] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks, Part 16: Air interface for fixed broadband wireless access systems, 2004.