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Re:	IEEE 802.16m-08/016r1 Call for Contributions on Project 802.16m System Description Document (SDD). Specific topic : Downlink MIMO schemes
Abstract	Propose PMI restriction for IEEE 802.16m MIMO section
Purpose	For IEEE 802.16m discussion and adoption
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The PMI Restriction for the downlink Closed-loop MIMO

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Introduction

In general, it is known that closed-loop MIMO can enhance the average user-throughput and cell-edge throughput in the multi-cell environments. But cell-edge area users are still vulnerable to the inter-cell interference from adjacent cells. In particular, the usage of certain subset of codebook can give a bad influence on cell-edge users of other cells. This implies that the usage of a certain PMI (Pre-coding Matrix Index) affecting other cell-edge users should be restricted to obtain increased DL throughput and reduce inter-cell interference.

Proposed scheme

To increase the average user throughput and cell edge user throughput in DL closed-loop MIMO, we propose PMI restriction scheme in the multi-cell environments. This scheme restricts the usage of codebook subsets in part for the interfering cells with cell edge users' restricted PMI feedback information.

In each cell, cell-edge users search the optimal PMI for the interfering signals from other cells, for example, by calculating a received SINR per PMI that acts as the strongest interference. And then, the PMI information for restriction is reported to the serving BS periodically. Other related information of the PMI restriction can be also fedback along with the restricted PMI. Here, the 'restricted PMI' indicates the PMI of the interfering BS.

Inner cell users served by the interfering BS can use only the reduced codebook set due to the PMI restriction. On the contrary, cell edge users can use the full codebook without any restrictions of PMI in order to maximize beamforming gain. Like this, only cell edge users get benefits from the PMI restriction because of the mitigated ICI by sacrificing the inner users' throughput while total sector average throughput is enhanced.

Figure 1 shows an example for the operation principle of closed-loop MIMO for PMI restriction. Here, the restricted PMI is noted as red in the codebook for pre-coding and all BSs are connected via the backbone network. In the figure, we assume that all BSs use the same codebook for pre-coding. MS_{edge} means the cell-edge user located at the cell_A boundary and affected by the neighboring cells (cell_B and cell_C). The other MSs (MS_1, MS_2 and MS_3) that receive a high transmit power signal are located at the inner side of each cell.

For the PMI restriction, the MS_{edge} searches the optimal PMIs (w_2, w_3) from the reference signals of the interfering BSs (BS_2 ,BS_3) and feedbacks them to the serving BS (BS_1). And the serving BS (BS_1) transfers the PMI restriction information to the corresponding interfering BS (cell_B or cell_C) through the backbone network. If the BS_2 located in Cell_C receives the PMI (w_3) restriction information from the serving BS (BS_1), it does not allocate the PMI (w_3) to the inner user (MS_2) because the PMI is restricted in usage by the request of the MS_{edge} of the cell_A.

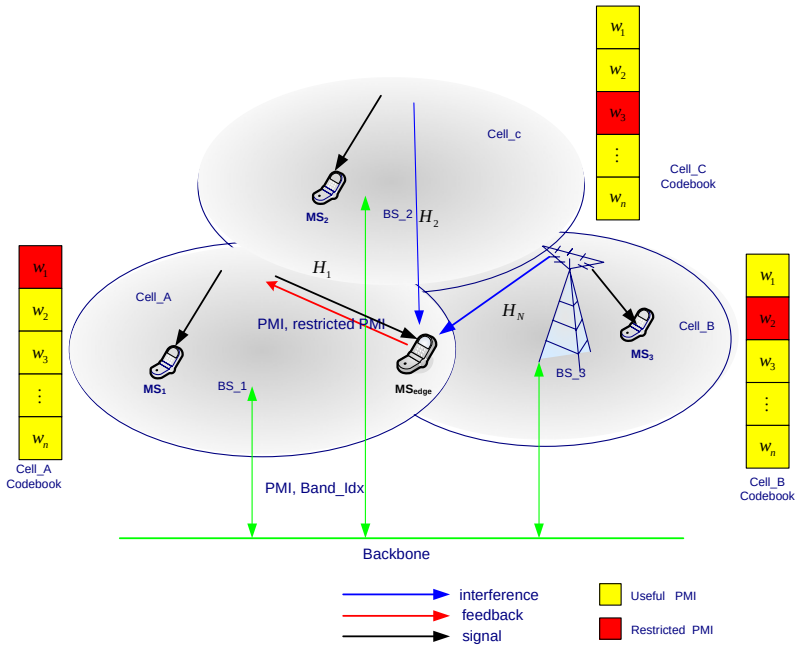

Figure 1 Example of the PMI restriction Scheme for DL Closed-loop MIMO

There are two kinds of method for the PMI restriction at the interfering BS side. First method is that the interfering BS does not assign the restricted PMI to the inner users who request the PMI. This is a scheduling issue but could impact the system performance. The second method is that the inner cell users receive the information about the restricted PMI from its serving BS and search PMI except for the restricted PMI.

Performance Evaluation

In this section, we show the performance of the codebook-based pre-coding MIMO with PMI restriction.

Table 1 lists the basic parameters for the system-level evaluation.

Table 1 Parameters for the system-level evaluation

Parameter	Assumption
Cellular Layout	19 cell, 3 sectors per cell
Inter-site distance (ISD)	1500m
Fading Channel	IEEE 802.16m ITU-PEDB
MS speed	3 km/h,
Center frequency	2.5GHz
Bandwidth	10 MHz
Number of MS per Sector	10
Feedback delay	3 subframes
PMI/CQI Feedback period	1 subframe
‘Restricted PMI’ feedback period	30 subframes

Channelization	Band AMC mode
Subframe_duration	2.5 ms
Antenna configuration	2 x 2
Receiver type	MMSE
Codebook size	3bit

Here, we assumed the perfect channel estimation and no rank adaptation. And we compared the performance of the proposed PMI restriction scheme with that of the conventional closed-loop MIMO scheme in multi-cell environments.

In Table 2, we compared the average user throughput of with and without PMI restriction. As we can see from the result, about 3% gain in the aspect of average user throughput has been obtained in case of the PMI restriction.

Table 2 Average user throughput

case	Without PMI Restriction	With PMI Restriction
Normalized throughput	1	1.03

Table 3 shows the performance of cell edge user throughput for both cases. As shown in the table 3, we could have achieved up to 38% gain in the case of PMI restriction over the case of no PMI restriction.

Table 3 Cell edge user throughput

case	Without PMI Restriction	With PMI Restriction
Normalized throughput	1	1.38

We can confirm the above results from Figure 2. Figure 2 shows the CDF of user throughput at cases with and without PMI restriction.

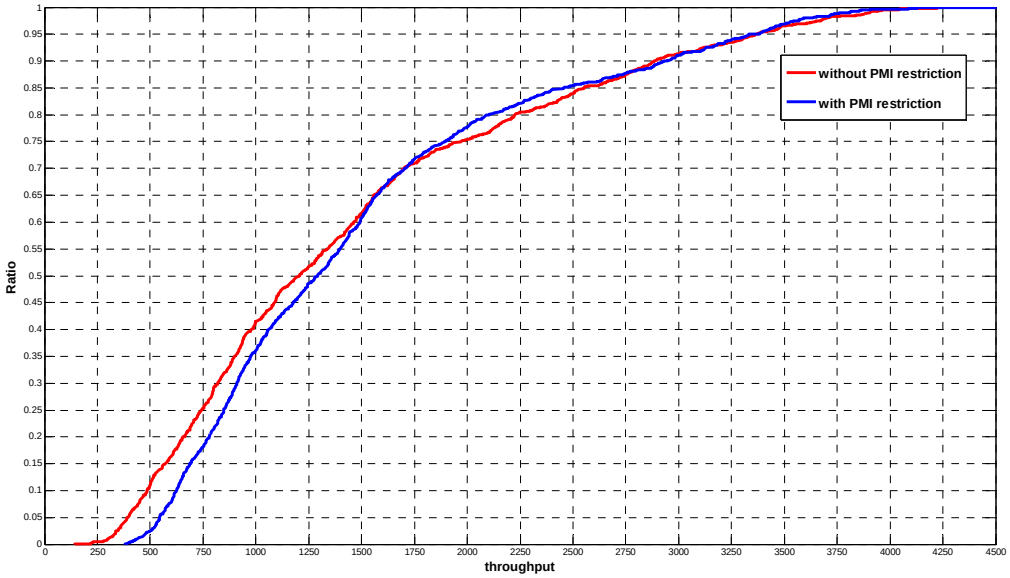

Figure 2 CDF of user throughput

For the PMI restriction, cell edge user can consider one or more interfering BSs and measure the restricted PMI per interfering BS. In table 4, we show the performance of throughput according to the number of interfering BS which is measured by the cell edge user for PMI restriction.

Table 4 performance per interfering BS

# of interfering BS	1	4	8
Normalized throughput	1	0.993	0.986

From the above results, we can know that the best performance can be obtained when the cell edge user considers only the strongest interfering BS for the PMI restriction.

Conclusions

The simulation results show that the introduction of PMI restriction into the codebook based closed-loop MIMO in the downlink provides significant gains on sector throughput and cell edge user throughput, as amount of 3% and 38% respectively. These meaningful benefits can be obtained at very low cost of infrequent feedback of one interfering PMI per MS which is in low geometry below certain threshold.

Based on the above observation, we propose the codebook based closed-loop MIMO scheme with PMI restriction as one of technologies to achieve target requirements for IEEE 802.16m.

Proposed Texts

---------- Text Start ----------

11.x.y PMI restriction

The cell edge user searches the PMI for restriction from the transmitted signal of the interfering BS that acts as

the strongest interference. Its related information is reported to the serving BS periodically and transferred to the interfering BS via the backbone network. Even if there are requests for the PMI from the inner cell user, the interfering BS does not assign the restricted PMI to the user. Otherwise, in case that the inner cell users of the interfering BS receive the PMI restriction information from its serving BS through the downlink control channel, they search PMI from codebook except for the restricted PMI.

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