Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Downlink CL-MIMO Mode Adaptation for IEEE802.16m**
Date Submitted	**2008-05-05**
Source(s)	Wookbong Lee Bin-Chul Ihm LG Electronics LG R&D Complex, 533 Hogye-1dong Dongan-gu, Anyang, 431-749, Korea Voice: +82-31-450-1931 E-mail: wbong@lge.com bcihm@lge.com
Re:	IEEE 802.16m-08/016r1 Call for Contributions on Project 802.16m System Description Document (SDD). Specific topic : Downlink MIMO schemes
Abstract	Propose downlink mode adapted CL-MIMO for IEEE 802.16m MIMO section
Purpose	For IEEE 802.16m discussion and adoption
Notice	
Release	
Patent Policy	

Downlink CL-MIMO Mode Adaptation for IEEE802.16m

Wookbong Lee and Bin-Chul Ihm
LG Electronics

Introduction

In this contribution, we propose downlink closed-loop MIMO mode adaptation for IEEE 802.16m MIMO section. Here we assumed codebook based precoding.

MIMO Mode

There are several modes in MIMO-OFDMA system. Mode is defined based on how many users are allocated in a resource block. For example, single-user MIMO (SU-MIMO) means that all spatial resources are assigned to one MS while multi-user MIMO (MU-MIMO) shares resources to multiple MSs. For MU-MIMO, we can further divide it into how many streams are transmitted together. For four transmit antennas, we have following modes; SU-MIMO, MU-MIMO with rank2, MU-MIMO with rank3, MU-MIMO with rank4.

For single user MIMO, each MS selects preferred rank, and feedback the rank and corresponding CQI and PMI. BS selects a MS to a resource block.

For multi user MIMO, each MS feedback CQI and PMI for a given MU-MIMO condition such as transmit rank, precoding matrix set, MU-MIMO type. BS selects MSs to a resource block with a certain criteria such as orthogonal transmission.

Depending on feedback mechanism, MIMO transmission chain will be different. So, for simplicity, we propose one CQI per frequency sub-band per MS. In this case, we do not have to change uplink feedback structure based on operating MIMO mode. Moreover, if we assume MS knows the interference vector when feedbacks CQI, CQI mismatch will be reduced and AMC gain will be maximized. So we assume orthogonal pairing for MU-MIMO mode in this contribution.

How many frequency sub-bands will be reported is for further study. Example of frequency selective feedback mechanisms are full feedback (ideal), best M sub-bands individual/average, best M sub-bands + remaining sub-band, whole sub-band feedback etc. In this contribution, we assumed feedback of 12 frequency sub-bands (one sub-band is consist of 4 resource unit of 18 subcarriers), but the results will be very similar for different frequency selective feedback mechanism.

Mode adaptation

In this section, we propose cell specific mode adaption with very limited feedback.

Generally, cell specific mode adaptation is desirable since if we allow different mode transmission for different MS within cell then either feedback overhead is increased or multi user diversity gain is reduced.

Usually SU-MIMO is better than MU-MIMO in terms of throughput when small number of MSs are in a cell, on the other hand, MU-MIMO outperforms when large number of MSs are in a cell. The reason for this is SU-MIMO mainly depends on precoding gain while MU-MIMO depends on pairing gain. So, large codebook size is preferable for SU-MIMO while small codebook size is preferable for MU-MIMO. System performance shall follow envelop of the best mode.

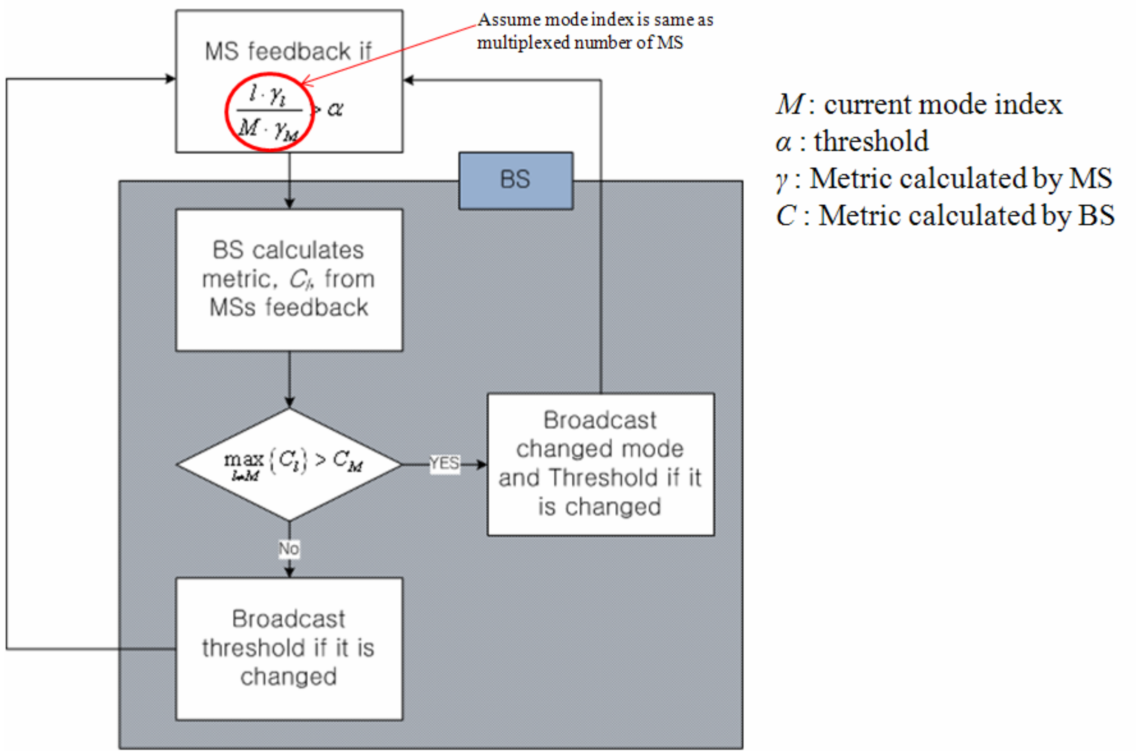

Fig 1 example of mode adapted closed loop MIMO procedure

Fig 1 shows an example of mode adapted CL-MIMO procedure. Transmission begins with one mode, and broadcast threshold for each mode. Each mode's threshold can be set to one value. For this case, BS broadcast the current operation mode and the threshold. An example of threshold is capacity/throughput increase ratio. MS calculates CQI for each mode occasionally. If a certain mode's metric comparing with current operating mode exceeds the threshold, then MS feedback for that mode. BS gathers MSs' feedback and determines operating mode and updates the threshold.

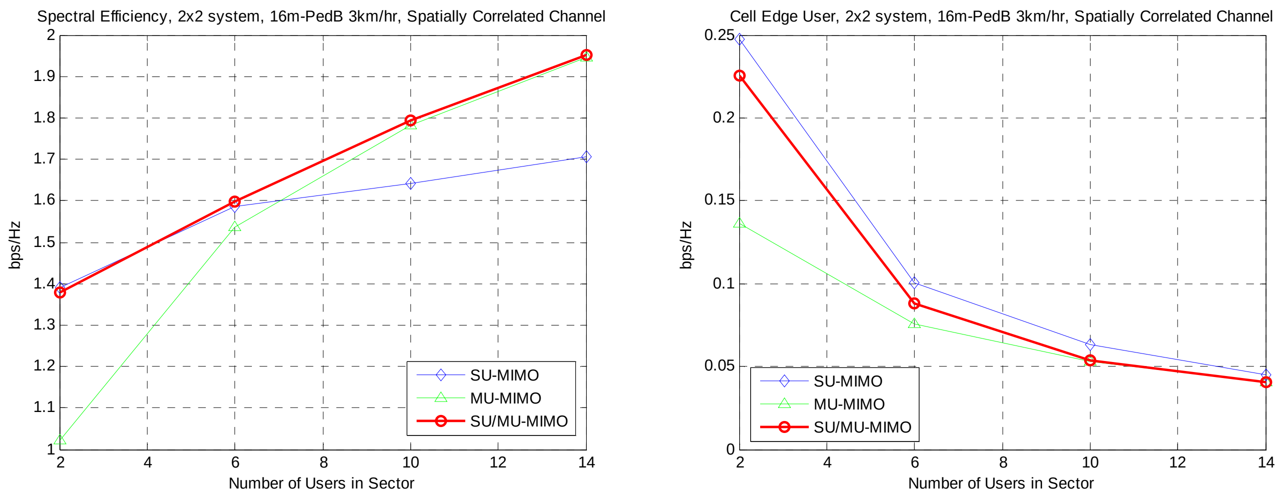

Fig 2 performance of SU/MU-MIMO

Fig 2 shows performance of SU-MIMO, MU-MIMO and SU/MU mode adaptation for 2x2 MIMO system. As you can see in the figure, the system spectral efficiency of SU/MU mode adaptation follows envelop of the two modes. Since only one CQI is feedback most of the time, the amount of feedback is almost same as one mode operation. However, cell edge user's performance is little bit degraded since SU-MIMO mode is more preferable for cell edge user. So, we further propose cell edge user, who may use FFR region, can be operated with only SU-MIMO mode or Co-MIMO mode.

Codebook construction

Assume SU-MIMO rank$N$ codebook full set is $\{\{v_{N,1,1}, \ldots, v_{N,1,N}\}, \{v_{N,2,1}, \ldots, v_{N,2,N}\} \ldots, \{v_{N,K,1}, \ldots, v_{N,K,N}\}\}$, where K is codebook size. We can improve MU-MIMO beamforming gain by choosing MU-MIMO codebook by MS's SU-MIMO mode feedback. So, for rank$N$ MU-MIMO mode, the codebook is constructed by choosing K' number of codeword from rank$N$ SU-MIMO mode. The codeword and K' can be predetermined or BS broadcasts K' and the codeword.

In this contribution, we choose 3 bit IEEE 802.16e codebook for SU-MIMO mode, and we select two codeword (1bit) out of SU-MIMO codebook for MU-MIMO mode. Choice of codebook is for further study.

Proposed Texts

--- Text Start ---

11.x Multiple antenna transmission

11.x.1 MIMO structure

11.x.2 Downlink

11.x.2.1 Open-loop MIMO

11.x.2.2 Closed-loop MIMO

11.x.2.2.1 SU-MIMO

For single user MIMO, each MS selects preferred rank, and feedback the rank and corresponding CQI and PMI. BS selects a MS to a resource block.

11.x.2.2.1.1 Codebook construction

Rank$N$ codebook full set is defined, for each number of transmit antenna case, as $\{\{v_{N,1,1}, \ldots, v_{N,1,N}\}, \{v_{N,2,1}, \ldots, v_{N,2,N}\} \ldots, \{v_{N,K,1}, \ldots, v_{N,K,N}\}\}$, where K is codebook size.

11.x.2.2.1.1.2 Transmission chain

Vertical encoding shall be used in SU-MIMO mode to reduce the number of feedback for higher rank.

11.x.2.2.2 MU-MIMO

For multi user MIMO, each MS feedback CQI and PMI for a given MU-MIMO condition such as transmit rank, precoding matrix set, MU-MIMO type. BS selects MSs to a resource block with a certain criteria such as orthogonal transmission.

11.x.2.2.2.1 Codebook construction

For rank$N$ MU-MIMO mode, the codebook is constructed by choosing K' number of codeword from rank$N$ SU-MIMO codebook set. Each BS determines and broadcasts K' and codewords. When BS determines the codewords, MS feedback or preference is considered.

11.x.2.2.2.2 Transmission chain

Horizontal encoding shall be used for MU-MIMO mode.

11.x.2.2.3 Mode adaptation

SU/MU mode switching shall be done by each BS. Mode is a MIMO transmit scheme such as SU-MIMO, MU-MIMO with rank2, MU-MIMO with rank3, etc.

The chosen mode is broadcasted, and MS calculates and reports corresponding CQI and PMI. To reduce feedback overhead while maximizing system performance, BS broadcasts threshold for non-operating mode. An example of threshold is capacity increase ratio. MS calculates CQI for each mode occasionally. If a certain mode's capacity increase comparing with the current operating mode exceeds the threshold, then MS requests for feedback of that mode. BS gathers MSs' feedback and determines operating mode and updates threshold. FFR region is not affected by mode adaptation, which means SU-MIMO or Co-MIMO mode is operated in FFR region no matter which mode is operated outside of FFR region.

11.x.2.3 Collaborative MIMO

-- Text End --

Appendix

General simulation assumptions;

- IEEE 802.16m modified ITU-PedB 3km/hr
- Spatially correlated antennas at BS with the correlation derived as in EMD with 4 lambda spacing
- Full FDD
- 6 OFDMA symbol per one sub-frame

SU-MIMO assumptions;

- Codebook size = 8 : 3bits as defined in IEEE 802.16e standard
- Vertical encoding (SCW), one CQI feedback
- Rank feedback duration : every 20 ms
- CQI and PMI feedback duration : every 5ms

MU-MIMO assumptions;

- Orthogonal transmission (also known as PU2RC)
- Codebook size = 2 : 1bit, two codeword has been picked out of IEEE 802.16e 3 bit codebook
- Feedback one CQI, stream index and PMI
- CQI and PMI (+steam index) feedback duration : every 5ms

Topic	Description	Baseline Simulation Assumptions	Proposal Specific Assumptions
Basic modulation	Modulation schemes for data and control	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM
Duplexing scheme	TDD, HD-FDD or FD-FDD	TDD	Full-FDD
Subchannelization	Subcarrier permutation	PUSC	Band-AMC
Resource Allocation	Smallest unit of resource	PUSC: Non-: 1 slot, : 2 slots (1 slot	Band-AMC (18 subcarriers x 6

Granularity	allocation	= 1 subchannel x 2 OFDMA symbols)	OFDM symbols)
Downlink Pilot Structure	Pilot structure, density etc.	Specific to PUSC subchannelization scheme	Specific to Band-AMC subchannelization scheme
Multi-antenna Transmission Format	Multi-antenna configuration and transmission scheme	MIMO 2x2 (Adaptive MIMO Switching Matrix A & Matrix B) Beamforming (2x2)	2x2 codebook based precoding
Receiver Structure	MMSE/ML/MRC/ Interference Cancellation	MMSE (Matrix B data zone) MRC (MAP, Matrix A data zone)	MMSE
Data Channel Coding	Channel coding schemes	Convolutional Turbo Coding (CTC)	Convolutional Turbo Coding
Control Channel Coding	Channel coding schemes and block sizes	Convolutional Turbo Coding, Convolutional Coding (CC) for FCH only	-
Scheduling	Demonstrate performance / fairness criteria in accordance to traffic mix	Proportional fairness for full buffer data only *, 10 active users per sector, fixed control overhead of 6 symbols, 22 symbols for data, 5 partitions of 66 slots each, latency timescale 1.5s	Proportional fair, N active users per sector, fixed control overhead of 1 symbol out of 6 OFDM symbol (1 sub-frame), 5 data symbols, 6 partitions of 16 slots each, latency timescale 1.5s
Link Adaptation	Modulation and Coding Schemes (MCS), CQI feedback delay / error	QPSK(1/2) with repetition 1/2/4/6, QPSK(3/4), 16QAM(1/2), 16QAM(3/4), 64QAM(1/2), 64QAM(2/3), 64QAM(3/4) 64QAM(5/6), CQI feedback delay of 3 frames, error free CQI feedback **	QPSK(1/2) with repetition 1/2/4/6, QPSK(3/4), 16QAM(1/2), 16QAM(3/4), 64QAM(1/2), 64QAM(2/3), 64QAM(3/4) 64QAM(5/6), CQI feedback delay of 3 subframes, error free CQI feedback **
Link to System Mapping	EESM/MI	MI (RBIR) ***	RBIR
HARQ	Chase combining/ incremental redundancy, synchronous/asynchronous, adaptive/non-adaptive ACK/NACK delay, Maximum number of retransmissions, retransmission delay	Chase combining asynchronous, non-adaptive, 1 frame ACK/NACK delay, ACK/NACK error, maximum 4 HARQ retransmissions, minimum retransmission delay 2 frames****	Chase combining asynchronous, non-adaptive, 4 subframe ACK/NACK delay, ACK/NACK error free, maximum 4 HARQ retransmissions, minimum retransmission delay 6 sub-frames
Power Control	Subcarrier power allocation	Equal power per subcarrier	Equal power per subcarrier
Interference Model	Co-channel interference model, fading model for interferers, number of major interferers, threshold, receiver interference awareness	Average interference on used tones in PHY abstraction (Refer to Section 4.4.8)	Average interference on used tones in PHY abstraction (Refer to Section 4.4.8)
Frequency Reuse	Frequency reuse pattern	3 Sectors with frequency reuse of 1 *****	3 Sectors with frequency reuse of 1

Table 1 System-level simulation assumptions for the downlink