Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Multi-cell MIMO in DL**
Date Submitted	**2008-7-14**
Source(s)	Sunam Kim Jaewan Kim Dongguk Lim Bin-Chul Ihm HanGyu Cho LG Electronics LG R&D Complex, 533 Hogye-1 dong Dongan-gu, Anyang, 431-749, Korea Voice: +82-31-450-7903 E-mail: snkim816@lge.com lgjohnkim@lge.com dongguk@lge.com bcihm@lge.com hgcho@lge.com *<http://standards.ieee.org/faqs/affiliationFAQ.html>
Re:	TGm, DL_MIMO RG – Call for comment of final draft : SDD Text on Downlink MIMO Schemes (IEEE 802.16m-08/657r2)
Abstract	Propose collaborative MIMO on IEEE 802.16m MIMO section
Purpose	For IEEE 802.16m discussion and adoption by DL MIMO RG
Notice	
Release	
Patent Policy	

Multi-cell MIMO in DL

Sunam Kim, Jaewan Kim, Dongguk Lim, Bin-Chul Ihm and HanGyu Cho
LG Electronics

Introduction

According to 802.16m system requirements, performance of cell edge user must be improved relative to Wireless MAN-OFDMA system. Multi-cell MIMO is another method to enhance the cell edge user performance. Two categories exist in multi-cell MIMO. One is open loop multi-cell MIMO (OL multi-cell MIMO) and the other one is closed loop multi-cell MIMO (CL multi-cell MIMO). These can be distinguished by whether uplink feedback signaling is available or not.

In this contribution, we propose the OL multi-cell MIMO and the CL multi-cell MIMO for the performance enhancement of cell-edge user in downlink

Mulit-Cell MIMO

Multi-cell MIMO is categorized into OL multi-cell MIMO and CL multi-cell MIMO. OL multi-cell MIMO is suitable for the case when the uplink feedback signaling not available. This will be occurred when a MS is moving with medium speed. If a MS is moving with low speed or the CSI information reported from MS is available at collaborative BSs, CL multi-cell MIMO can be operated. CL multi-cell MIMO is suitable for getting the beamforming gain as well as AMC gain.

Procedure for multi- cell MIMO is as below.

- MS operates in the normal MIMO (Non multi-cell MIMO) :
  - Every MS reports the feedback message (CQI etc.) to the serving BS
- Initiation for multi-cell MIMO (BS-initiated or MS-initiated)
  - Includes acquisition of additional information such as CSI, CQI etc., for multi-cell MIMO operation
- Negotiation between the serving BS and the target BS(s)
  - MIMO type, scheduling information, service time etc.
- Severing BS and collaborative BSs operate multi-cell MIMO for the target MS

Considering the complexity and feasibility, features of multi-cell MIMO are as below.

Feature	Note
CSI	Codebook based precoding
Number of coordinating BSs (N_{bs})	2~3
Application scenario	OL multi-cell MIMO - Low/medium speed - No CSI information sharing

	- CQI information sharing CL multi-cell MIMO - Low/medium speed - CSI information sharing - Long or short term - Full or partial - CQI information sharing
Antenna configuration	Same with each BS's antenna configuration
The number of streams	Single stream
Operation mode	Switching between single cell MIMO and multi-cell MIMO Operate within SU MIMO

- OL Multi-Cell MIMO

OL MIMO scheme can be used for OL milti-cell MIMO. To get more spatial diversity gain, CDD scheme can be applied at BS to BS.
Transmit diversity modes in single-user MIMO at single cell are supported for open-loop multi-cell MIMO:

Single cell MIMO	Multi cell MIMO
2Tx rate-1: STBC/SFBC	$2xN_{bs}Tx$ rate-1: STBC/SFBC with precoder
4Tx rate-1: STBC/SFBC with precoder	$4xN_{bs}Tx$ rate-1: STBC/SFBC with precoder
8Tx rate-1: STBC/SFBC with precoder	$8xN_{bs}Tx$ rate-1: STBC/SFBC with precoder

The MIMO architecture at each BS refers [1]. The input to the MIMO encoder at each BS operating multi-cell MIMO is represented a 2 × 1 vector,

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$$

where s1 and s2 is the symbol vector.
The output of MIMO encoder at each BS is a 2 × 2 matrix

$$\mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$$

The output (y_s)of the precoder at serving BS is a $N_T \times 2$ matrix and the output(y_c)of the precoder at collaborative BS is a $N_T \times 2$ matrix

$$y_s = D_s W_s \mathbf{z}$$

$$y_c = D_c W_c \mathbf{z}$$

where D_s and D_c are $N_T \times N_T$ diagonal delay matrix at serving BS and collaborative BS, respectively. And W_s

and W_c are $N_T \times 2$ precoder and antennas selection matrix at serving BS and collaborative BS, respectively. So, the output of the precoder for multi-cell MIMO is

$$\mathrm{Y} = \begin{bmatrix} \mathrm{y_s} \\ \mathrm{y_c} \\ \vdots \end{bmatrix} = \begin{bmatrix} \mathrm{D_s W_s} \\ \mathrm{D_c W_c} \\ \vdots \end{bmatrix} \mathbf{z}$$

Note that W and D may be frequency dependent.

Evaluation

Simulation environment is as below.

The number of Collaborative BS	1
Cell deployment	3 sectors/cell and 19 cell wrap-around
The number of User	10/sector
The number of Antennas (BS, MS)	(2, 2)
Rank adaptation	rank 1 only (STBC)
The number of strong interference	8
Channel model	VehA (30Km/h)
Operation mode	localized

The SINR will be improved when the multi-cell MIMO is applied for the cell edge user. Figure 1 shows the SINR when the multi-cell MIMO is used for cell edge user.

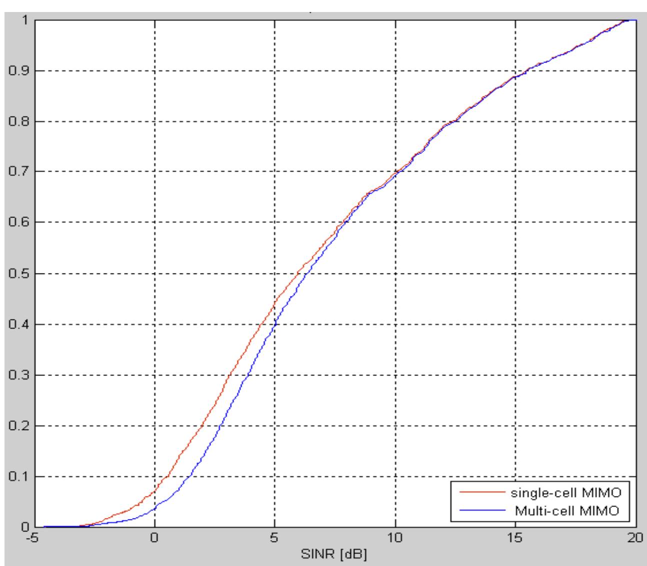

Figure 1. SINR of single-cell MIMO and multi-cell MIMO

Figure 3 shows the relative performance gain of the FFR, multi-cell MIMO, and multi-cell MIMO in FFR over that of single-cell MIMO without FFR, respectively. The performance of cell edge user is enhanced about 16% when the FFR is applied, about 29% when multi-cell MIMO is applied, and about 43% when multi-cell MIMO is applied in FFR. Here the cell edge user is defined by the 5th percentile point of the CDF of average packet call throughput.

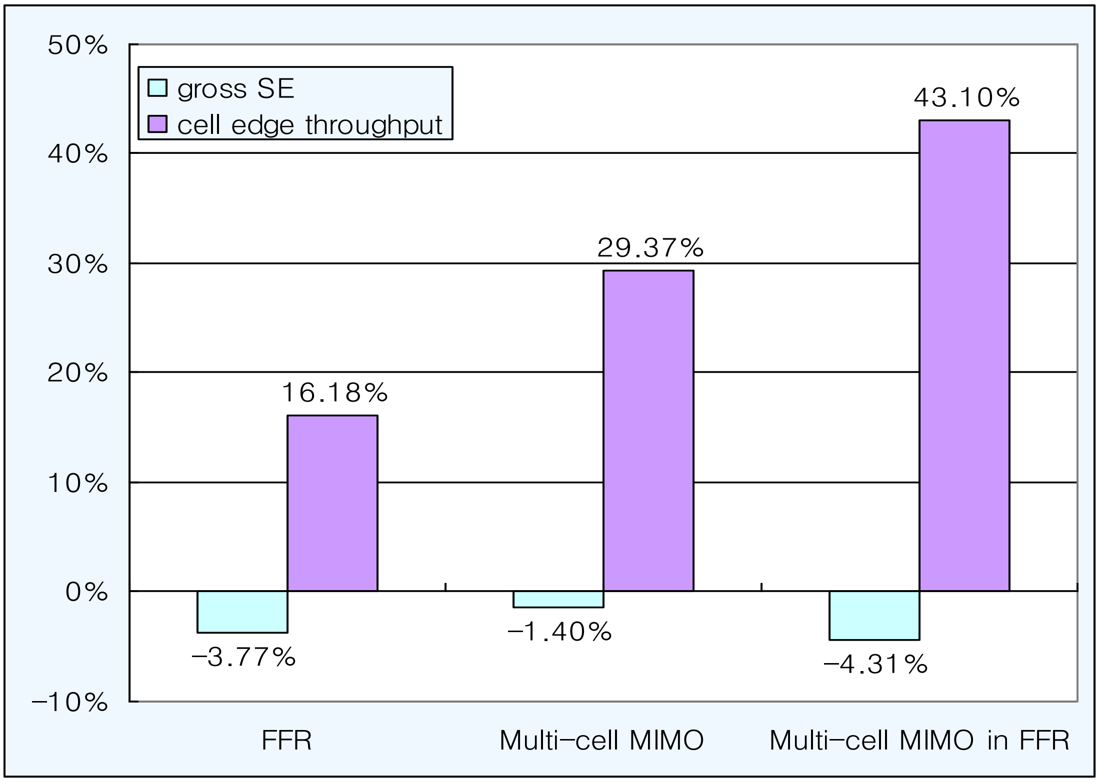

Figure 3. Relative performance gain of the FFR and multi-cell MIMO

Figure 4 shows the performance of low geometry users (below -2.5dB). The performance of low geometry users is enhanced by about 17% in throughput when FFR is applied, and about 54% when multi-cell MIMO is applied, and about 80% when multi-cell MIMO is applied in FFR.

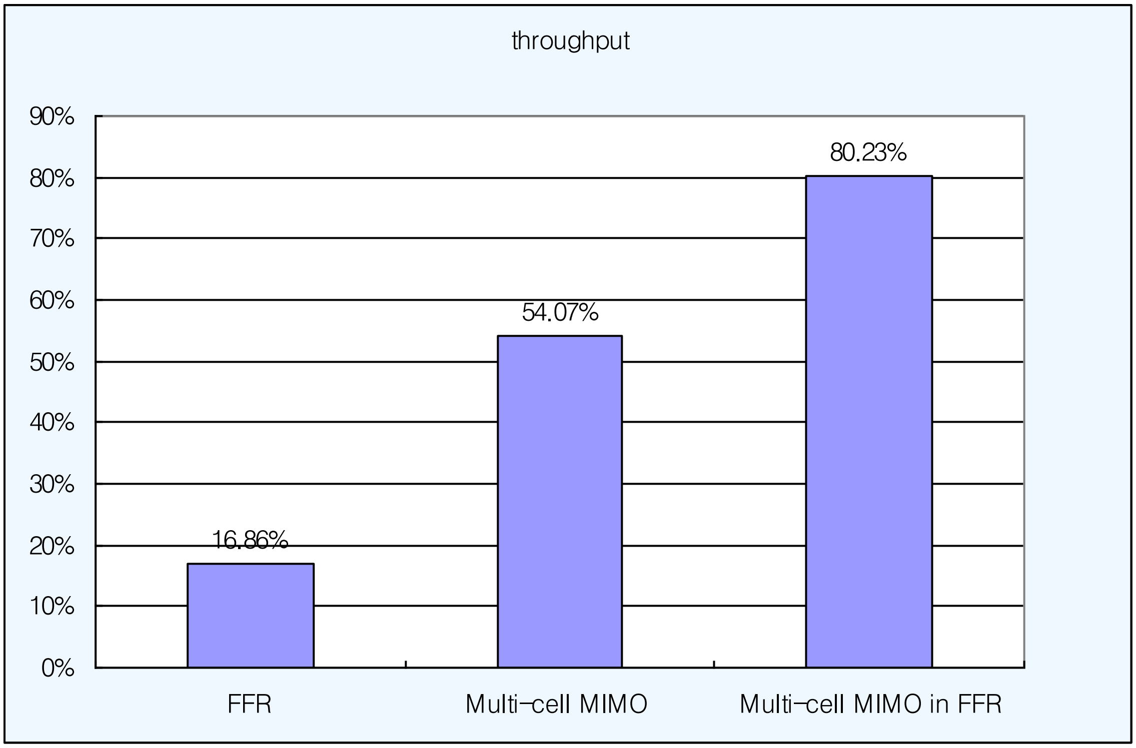

Figure 4. Relative performance gain of low geometry users

References

[1] IEEE C802.16m-08/657r2, IEEE 802.16m SDD Test on Downlink MIMO Schemes.

Proposed Texts

--- Text Start ---

11.x.4.2 Multi-cell MIMO

Multi-cell MIMO techniques are supported for improving sector throughput and cell-edge throughput through multi-BS collaborative precoding, network coordinated beamforming, or inter-cell interference nulling. Both open-loop and closed-loop multi-cell MIMO techniques can be considered. For open-loop multi-cell MIMO, RF combining or CDD based on 11.x.2.1.1 is supported in IEEE802.16m. For closed-loop multi-cell MIMO, CSI feedback via codebook based feedback or sounding channel will be used. Codebook of 11.x.2.1.2.1 should be used for multi-cell MIMO. The feedback information may be shared by neighboring base stations via network interface, air interface or relay station. Mode adaptation between single-cell MIMO and multi-cell MIMO is utilized.

--- Text End ---