Interference Mitigation using Multi-BS Precoding with UL Sounding

Document Number: IEEE C80216m-09_1072r2

Date Submitted: 2009-04-27

Source:

Mohammed Abdelaziz, Mohammed Nassar, Mohamed Abdallah, Mohammed Nafie, Mohamed Khairy, Yassmine Fahmy, Ahmed Shalash, Fadel Digham

Center for Wireless Studies (CWS), Cairo University, Cairo

E-mail: mabdalah@ieee.org

WINC, Nile University, Cairo mnafie@nileuniversity.edu.eg

NTRA, Cairo mkhairy@ieee.org

Venue:

Cairo, Egypt. In response to the TGm Call for Contributions on Project 802.16m Amendment Working Document (AWD) Content IEEE 802.16m-09/0020

Topic: Interference Mitigation

Purpose: To discuss in TGm for appropriate action.

Presentation Outline

- Introduction.
- Interference Mitigation in Multi-cell MIMO:
  - Interference-aware Precoding Scheme for Multi-cell MIMO/TDD Systems.
  - Multi-BS precoding using UL Sounding.
- Simulations.
- Conclusions.
- Proposed SDD Text

Introduction

- Employing multiple antennas at both transmitter and receiver, provides many advantages in wireless communication systems.

- For Single-cell MIMO, if CSI is available at the transmitter, capacity can be maximized using linear precoding with water filling power allocation.

- In Multi-cell MIMO, each cell is subject to interference from adjacent cells which reduces the throughput and increase the error rate.

Introduction *(Cont.)*

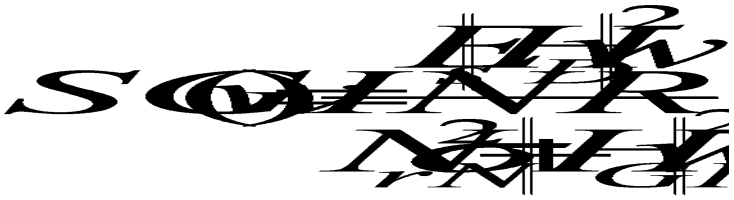
- Precoding can be employed for Multi-cell MIMO by providing the CSI to the Bs (in DL) via codebook based feedback or UL sounding.

Interference Mitigation in Multi-cell MIMO

- In DL transmission, each BS generates interference on the MSs in its neighboring cells.
- Precoding is used at each BS to balance maximizing the desired signal power at the desired MS and minimizing the interference power generated on the neighboring MSs in the adjacent cells.
- For closed-loop multi-BS MIMO, CSI feedback via codebook based feedback or sounding channel can be used.

Interference-aware Precoding Scheme for Multi-cell MIMO/TDD Systems

- In order to balance the desired signal power and the interference power, anew metric is defined called signal to generating interference and noise power (SGINR).



Where, N_r : Number of MS receive antennas.

σ_N^2 : Noise variance.

H_D : Channel Matrix between the BS and the desired MS.

H_{GI} : Channel Matrix between the BS and adjacent cells.

E_s : Desired Signal Energy

Interference-aware Precoding Scheme for Multi-cell MIMO/TDD Systems *(cont.)*

- The numerator of the previous equation represents the desired signal power at the receiver, and the denominator consists of the noise power at the receiver and the total power of interference generated by the i-th transmitter to adjacent cells.

The generating interference Channel matrix H_{GI} for the i-th BS can be given by:

$$H_{GI} = \begin{bmatrix} \sqrt{\eta_{1,i}} H_{1,i} \\ \sqrt{\eta_{2,i}} H_{2,i} \\ .... \\ \sqrt{\eta_{L,i}} H_{L,i} \end{bmatrix}$$

Where,
$\eta_{j,i}$:Received interference Power at the j-th MS from the i-th BS

Interference-aware Precoding Scheme for Multi-cell MIMO/TDD Systems

(cont.)

- As a result, the best precoding matrix used by the BS is the one that maximizes the SGINR.

Multi-BS precoding using UL Sounding *(cont.)*

- It should be noted that all the interfering MSs can use the same sounding band without multiplexing. In this case, the BS can only estimate the *aggregate covariance matrix of generating interference channel*. For the i-th BS, this aggregate covariance matrix can be defined as:

Which is equal to the summation of the covariance matrices between the i-th BS and each MS in adjacent cells, thus it represents the covariance matrix of total received interference signals coming from adjacent cells.

Codebook-based multi-cell precoding

- Different kinds of codebooks are available in 802.16m for both correlated and uncorrelated channels.

- In case of Multi-BS, each MS can feedback to its BS the precoder matrix index from the codebook set to be used in DL transmission. The feedback information can be shared by multiple BS via network interface.

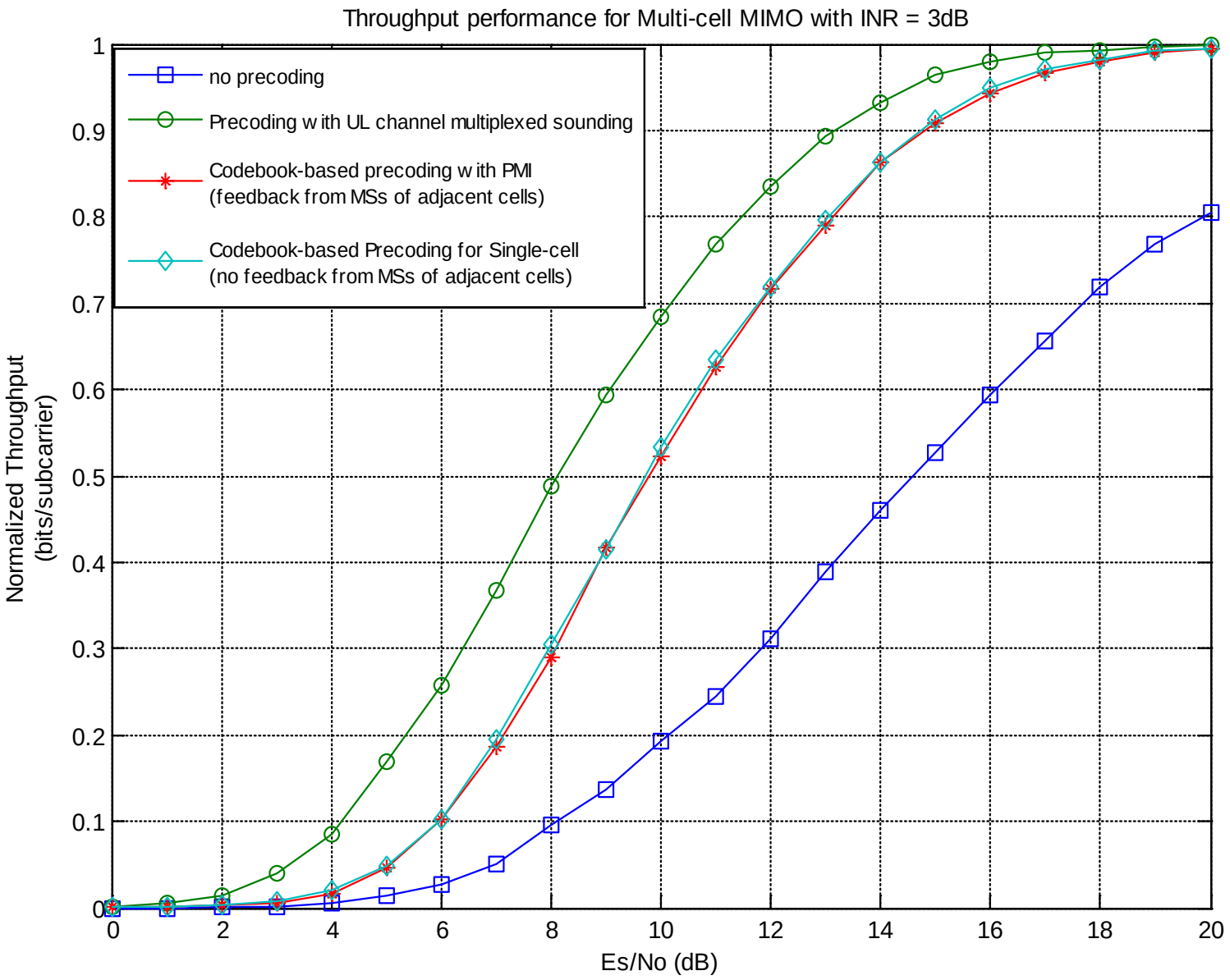
- Another method can be proposed, in which each MS can feedback to the BSs of neighboring cells, the PMIs corresponding to max interference.

Simulations

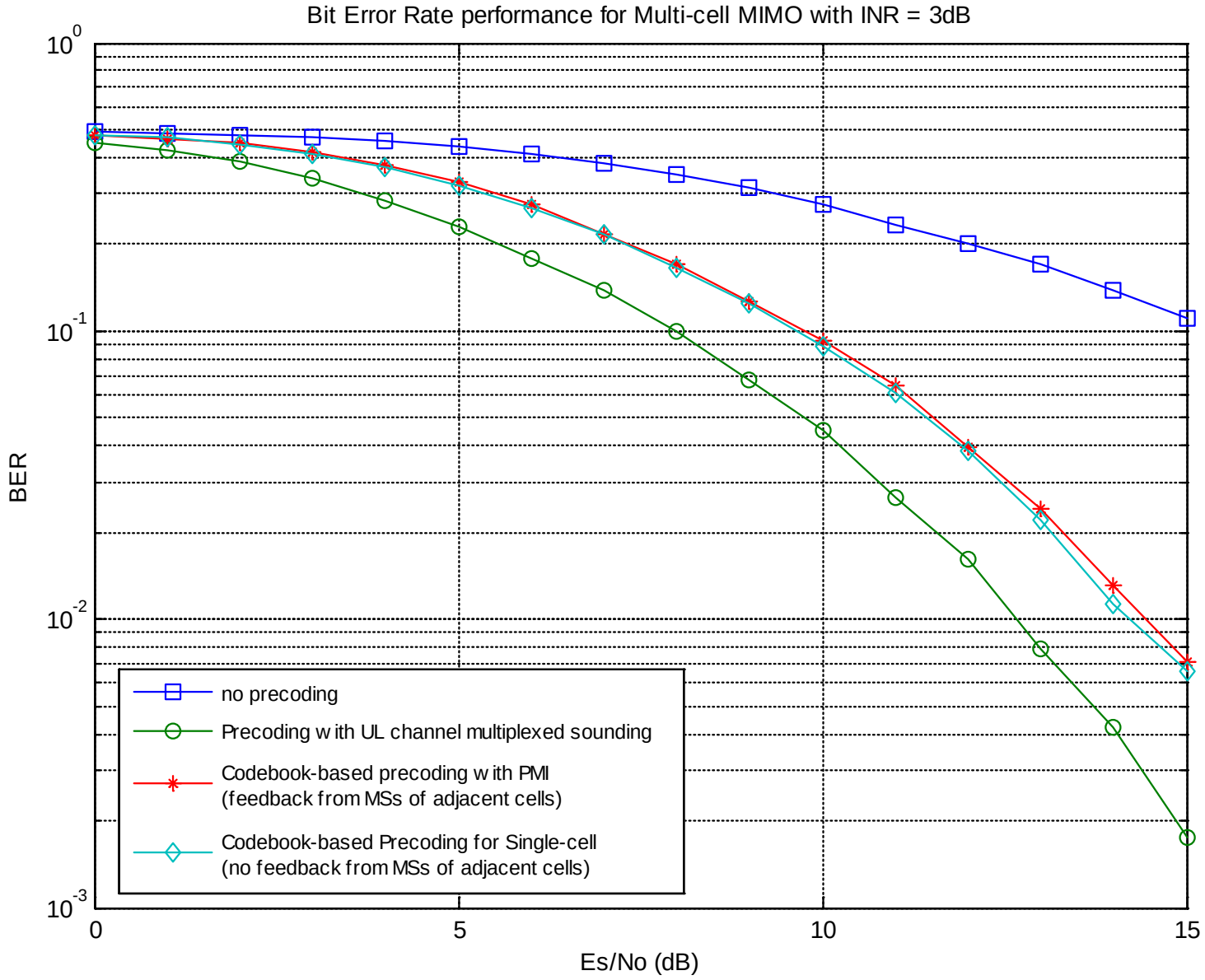
Simulation Parameters

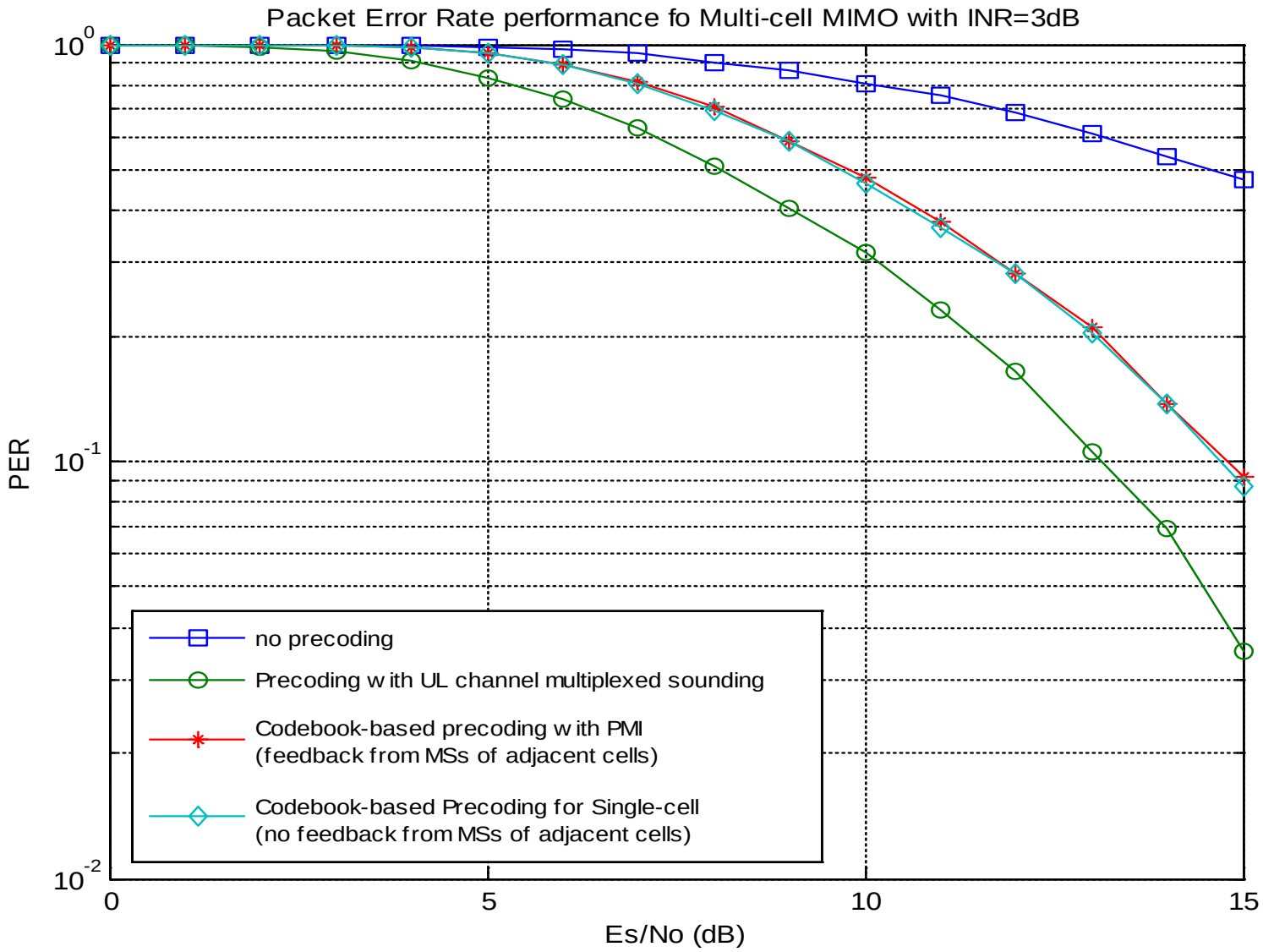
Parameters	Values
Bandwidth	10MHz
FFT size	1024
Carrier Frequency	2.5GHz
Subframe structure	16m
Multi-Cell Model	3 BSs each has a desired MS and two interfering MSs
Radio environment	Urban Macrocell
Mobile speed	10 m/s
Linear precoding schemes	Maximum SNR
Antenna configuration	2 transmit antennas for each BS 1 receive antenna for each MS
Transmission Rank	1 (single stream)
BS antenna spacing	0.4λ
Receiver algorithm at the MS	MMSE Linear Receiver
Interference to Noise ratio (INR)	3 dB
Channel Coding	16e CTC
Modulation	QPSK
Code rate	1/2
Channel Estimation	Perfect channel estimation

Throughput Performance for Multi-BS MIMO



Error Performance for Multi-BS MIMO




Packet Error Rate performance fo Multi-cell MIMO with INR=3dB
PER
Es/No (dB)
10^{0}
10^{-1}
10^{-2}
0
5
10
15
no precoding
Precoding w ith UL channel multiplexed sounding
Codebook-based precoding w ith PMI
(feedback from MSs of adjacent cells)
Codebook-based Precoding for Single-cell
(no feedback from MSs of adjacent cells)

Conclusions

- Significant performance gain over non-precoding case can be obtained using multiplexed sounding of the desired MS and all the interfering MSs on the UL channel.

- Codebook-based precoding with PMI feedback from MSs of adjacent cells provide almost no gain over Codebook-based precoding with PMI feedback only from the desired MS (Single-cell precoding).

- UL sounding-based precoding provide a significant gain over Single-cell precoding.

- Each BS should be able to instruct the MSs from adjacent cells to send sounding signal in the assigned sounding band, so the BS can estimate the total interference covariance matrix and use it in DL precoding in Multi-Cell system.

Proposed AWD Text

- *15.3.11.x Interference Mitigation via Sounding*

- The ABS can configure multiple AMSs **on its cell or in the adjacent cells** to transmit UL sounding signals on the corresponding UL sounding channels. Mutiple AMSs can be configured to use single UL sounding channel. The UL sounding channels from multiple users or multiple antennas per user can be CDM, FDM, or TDM.

References

[1] B.O.Lee, H. W. Je, I. Sohn, and K. B. Lee, “Interference-aware Precoding Schemes for Multicell MIMO/TDD Systems,”.

[2] IEEE 802.16m-08/003r8: “IEEE 802.16m System Description Document [Draft],” April 2009.

[3] P802.16Rev2/D6, Part 16: “Air Interface for Broadband Wireless Access Systems”.