Proposal for Uplink MIMO Schemes in IEEE 802.16m

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Re: IEEE 802.16m-08/024 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topic of "Uplink MIMO Schemes"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Scope

- This contribution presents uplink (UL) MIMO schemes for IEEE 802.16m.

IEEE 802.16m System Requirements

- The TGm SRD (IEEE 802.16m-07/002r4) specifies the following requirements:
  - Section 5.7 Support of Advanced Antenna Techniques
    - IEEE 802.16m shall support MIMO, beamforming operation or other advanced antenna techniques
  - Section 7.2.1 Relative Sector Throughput
    - UL > 2x
- The proposed design targets the above requirement.

Introduction (1/2)

- In 16e, mobile station (MS) has one transmitter antenna.
- BS has multiple receiver antennas, thus form maximum ratio combining (MRC).
- This is essentially single stream per MS.
- We propose multiple transmitter antennas for 16m uplink transmissions.
- This contribution considers at most 2 transmit antennas at a mobile station. More than 2 transmit antennas is FFS.

Introduction (2/2)

- Benefits of UL MIMO
  - User perspective
    - High data rate (due to multiple streams)
    - Transmit diversity for high speed MS and cell-edge MS
  - System perspective
    - Enable closed-loop MIMO to boost system throughput and coverage
    - Enable rank adaptation for different geometry users
- Cost of UL MIMO
  - Multiple antennas at MS, assume maximum 2 Tx antennas

Outline

- Uplink MIMO for Data Transmission
  - Uplink single-user (SU) MIMO schemes
    - Open-loop
    - Closed-loop
  - Uplink multi-user (MU) MIMO schemes
    - Collaborative Open-loop MIMO
    - Collaborative Closed-loop MIMO
  - SU/MU MIMO Adaptation
- Uplink MIMO for Control Transmission
- Proposed Text

UL SU MIMO (1/5)
Open-Loop

- Schemes
  - Transmit Diversity
    - 1Tx antenna, rate 1: MRC
    - 2Tx antennas, rate 1: STBC/SFBC
  - Spatial Multiplexing
    - 2Tx antennas, rate 2: rate 2 SM
    - SCW is supported. MCW is FFS.
  - Rank adaptation
    - Semi-static rank adaptation, e.g., based on geometry
    - Dynamic rank adaptation
- Channelization
  - Diversity or Localized

UL SU MIMO (2/5)
Open-Loop

- Open-loop parameter selection
  - Parameters include rank, MCS, etc
  - Methods for FDD and TDD system
    - Uplink Data/Control channel based
      - MS feeds back the power headroom to BS. BS decides rank (e.g., transmit diversity or spatial multiplexing) and MCS based on previous transmissions on data/control channels.
    - Sounding based
      - MS sends sounding signals and feeds back the power headroom to BS. BS decides rank and MCS.

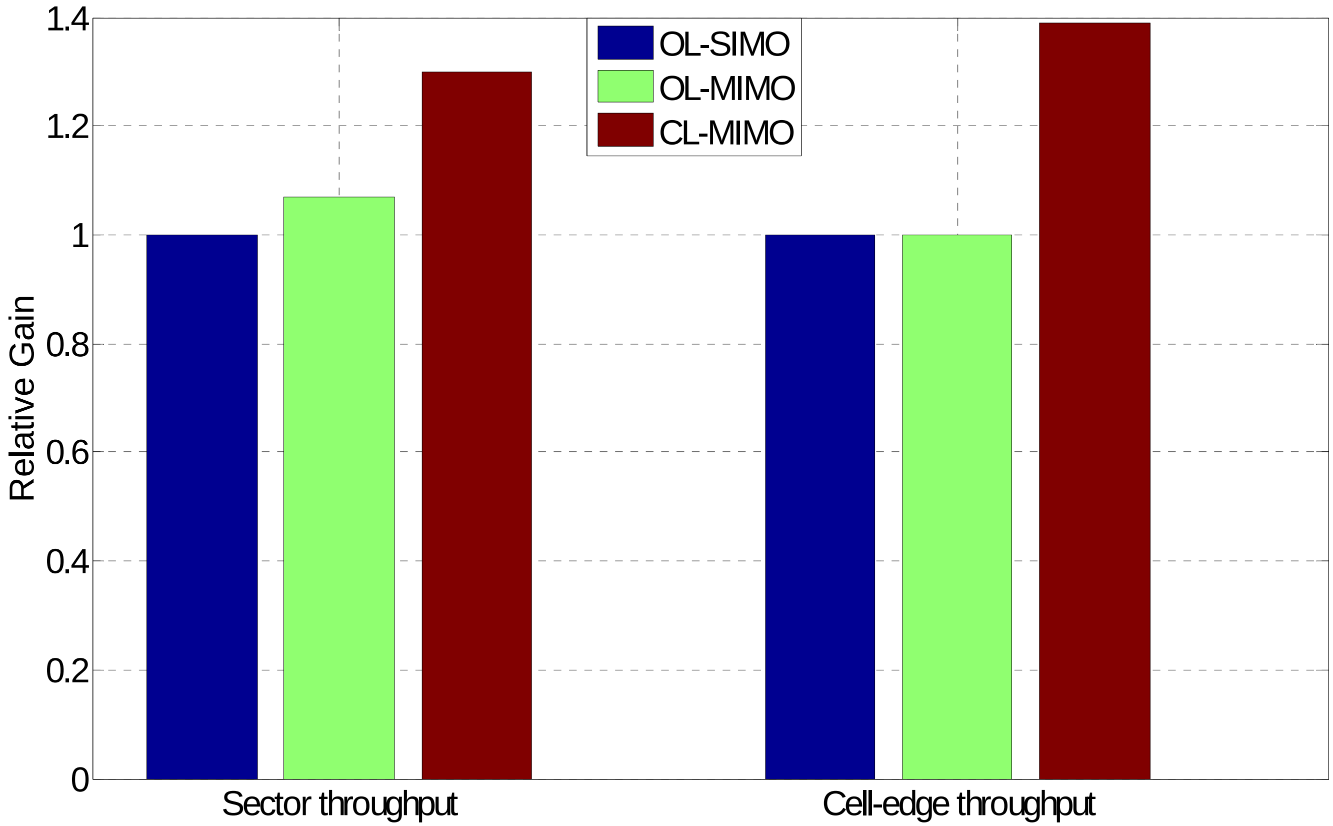
UL SU MIMO (3/5)
Closed-Loop

- Schemes
  - Rank 1
    - 2Tx antennas, rate 1
  - Rank 2
    - 2Tx antennas, rate 2
    - SCW is supported. MCW is FFS.
  - Rank adaptation
    - Semi-static rank adaptation, e.g., based on geometry
    - Dynamic rank adaptation
- Codebook design is FFS
- Channelization
  - Localized

UL SU MIMO (4/5)
Closed-Loop

- Close-loop parameter selection
  - Parameters include rank, PMI, MCS, etc
  - Method for TDD and FDD system
    - MS sends sounding signals and feeds back power headroom to BS. BS decides rank, PMI (codebook-based) and MCS.
  - Method for TDD system only
    - MS estimates uplink channel from downlink pilots. BS sends the received/estimated interference-plus-noise to the MS. MS decides rank, PMI and MCS based on power headroom. MS feeds back rank, MCS and power headroom to BS.
    - The pilots are dedicated, therefore no PMI is reported to BS.

UL SU MIMO (5/5)
System-Level Performance for SU-MIMO



Closed-loop MIMO brings large gain in sector throughput and cell-edge coverage

*See simulation assumptions in Appendix.

UL MU MIMO (1/3) Collaborative Open-Loop MIMO

- Conventional Collaborative MIMO
  - MS has one Tx antenna
  - BS has at least two Rx antennas
  - Two MSs form collaborative MIMO. Each MS transmits one stream.
- Higher-order Collaborative MIMO
  - Case 1
    - MS has two Tx antennas for diversity only
    - BS has at least two Rx antennas
    - Each MS transmits one stream (STBC/SFBC).
  - Case 2
    - MS has two Tx antennas for diversity and spatial multiplexing
    - BS has at least four Rx antennas
    - Each MS transmits one stream (STBC/SFBC) or two streams (SM).
- Channelization
  - Diversity or Localized

UL MU MIMO (2/3)
Collaborative Open-Loop MIMO

- Open-loop parameter selection
  - Parameters include rank, MCS, etc
  - Methods for FDD and TDD system
    - Uplink Data/Control channel based
      - MS feeds back the power headroom to BS. BS decides user pairing, rank and MCS based on previous transmissions on data/control channels.
    - Sounding based
      - MS sends sounding signals and feeds back the power headroom to BS. BS decides user pairing, rank and MCS per user.
- Collaborative MIMO, and MS pairing for CMIMO, can also be supported by group messages for applications such as VoIP.

UL MU MIMO (3/3)
Collaborative Closed-Loop MIMO

- Case 1
    - MS has two Tx antennas for rank 1
    - BS has at least two Rx antennas
    - Each MS transmits one stream.
- Case 2
    - MS has two Tx antennas for rank 1 or rank 2
    - BS has at least four Rx antennas
    - Each MS transmits one or two streams
- Codebook design is FFS
- Channelization
  - Localized
- Closed-loop parameter selection
  - Parameters include rank, PMI, MCS, etc
  - Method for FDD and TDD system
    - MS sends sounding signals and feeds back the power headroom to BS. BS decides user paring, PMI (codebook-based), rank and MCS per user.

SU/MU MIMO Adaptation

- SU/MU MIMO adaptation is supported based on geometry-based (long-term) and/or channel-based (short-term) methods.

UL MIMO for Control Transmission

- Open-loop UL MIMO is employed. Methods of MIMO transmissions for UL control information is FFS.
- Use tile-based diversity channelization.

Conclusions

- UL MIMO improves user peak rate, transmission diversity, and system capacity
- UL CL-MIMO boosts sector throughput as well as cell-edge user coverage.

Proposed Text

- 11.x.1. UL MIMO Architecture and Data Processing
- 11.x.2. Transmission for Data Channels
  - 11.x.2.1. UL SU MIMO
    - 11.x.2.1.1. Open Loop
      - [*Add content of slide 7 and 8 to this section*]
    - 11.x.2.1.2. Closed Loop
      - [*Add content of slide 9 and 10 to this section*]
  - 11.x.2.2 UL MU MIMO
    - 11.x.2.2.1. Open Loop
      - [*Add content of slide 12 and 13 to this section*]
    - 11.x.2.2.2. Closed Loop
      - [*Add content of slide 14 to this section*]
  - 11.x.2.3 SU/MU MIMO Adaptation
      - [*Add content of slide 15 to this section*]
- 11.x.3 Transmission for Control Channels
      - [*Add content of slide 16 to this section*]

Appendix: Simulation Assumptions & Parameters (1/4)

Parameters	Value
Number of cells	19
Number of sectors per cell	3
Total number of sectors	57
BS-BS distance	1.5 km
Center frequency	2.5 GHz
Channel bandwidth	10 MHz TDD
Frequency reuse	Reuse-1
Penetration loss	10 dB
Path loss model	Loss (dB) = 130.62 + 37.6log10(R) (R in km)
Lognormal shadowing	μ=0 dB, σ_{SF} =8 dB
Shadowing correlation	100% inter-sector, 50% inter-BS
Channel model	ITU PB3
Time correlation	Jakes spectrum
Spatial correlation	specified as in 16m EMD (none correlation) with 4 wavelength antenna spacing

Simulation Assumptions & Parameters (2/4)

Parameters	Value
BS height	32 m
BS antenna pattern	70^o (-3dB) with 20 dB front-to-back ratio
BS antenna gain	17dBi
BS RX antennas	2
BS noise figure	5 dB
BS antenna spacing	4 lambda
MS maximum transmission power	23dBm @ 10 MHz bandwidth
MS height	1.5 m
MS antenna pattern	Omni directional
MS antenna gain	0 dBi
MS TX antenna	1 or 2
Hardware losses (Cable, implementation, etc.)	2 dB

Simulation Assumptions & Parameters (3/4)

Parameters	**Value**
Frame duration	5 ms
UL OFDM symbols	3 control symbol + 15 data symbol
DL channelization	AMC 2x3
Antenna modes	OL: 1x2 MRC, 2x2 STTD, 2x2 SM, CL: 2x2 rank1, 2x2 rank 2
Initial PER	10% for data,
Receiver Structure	MRC or MMSE
Channel Coding	Convolutional Turbo Code
Scheduling	PF
Link adaptation	QPSK (1/2) with repetition 1/2/4/6, QPSK(3/4), 16QAM(1/2), 16QAM(3/4)
Link to system mapping	MI (QFACTOR)
HARQ type	Chase Combining
Channel estimation	Ideal

Simulation Assumptions & Parameters (4/4)

Parameters	Value
Number of active users per sector	10
Traffic type	Full buffer
Scheduling algorithm	PF
Sounding period	Every 3 frames
Uplink Power Control	Fractional Power Control
Inter-cell interference	Frequency selective MIMO interfers
Codebook for close-loop	Wimax 3bits codebook for rank1 and rank2