Supporting MIMO and Advanced Antenna Array Technology in IEEE 802.16m

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Venue:

TGm Call for comments on SDD, IEEE 802.16m-07/040

Base Contribution:

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Abstract:

Discussion of the functional implications of MIMO and Advanced Antenna Array Technology for IEEE 802.16m

Purpose:

Adoption of recommendations into Table of Contents / Outline for 802.16m System Description Document

Supporting MIMO and Advanced Antenna Array Technology in IEEE 802.16m

- Specific Recommendations for Enhanced Functionality
- Propose components for the Outline / Table-of-Contents for the SDD for MIMO / Advanced antenna array technology and related functionality
  - Transmission methods
  - Transmission enablers
  - Feedback methodologies
  - Functionality impacting or impacted by MIMO
- Proposed way forward

Key Message

- MIMO and advanced antenna array techniques are key technologies for meeting the performance requirements of the System Requirements Document
- MIMO and advanced antenna array techniques impact and are impacted by a large portion of the overall system
  - Link adaptation
  - Subchannelization & pilot formats
  - Feedback channels
  - Control channels
  - Cell/sector coordination for interference management
- All system aspects must be optimized together!

Recommendations for Enhanced MIMO & Advanced Antenna Array Functionality (1/5)

- Enhance and optimize closed-loop MIMO transmission methodologies
  - Beamforming
  - SU-MIMO
  - MU-MIMO
  - Areas of focus:
    - Develop enhanced modes and supporting signaling mechanisms
    - Improve support for frequency selective transmission
    - Optimize linear transmission methodologies and explore advanced methodologies
    - Enable multi-user diversity gain
    - Interference management, avoidance, cooperation

Recommendations for Enhanced MIMO & Advanced Antenna Array Functionality (2/5)

- Optimize MIMO & AA Link Adaptation
  - 16e has basic features to support link adaptation
    - MIMO mode selection, beamforming support, CQI estimation, etc.
  - Enhanced MIMO & AA modes require optimization of the link adaptation methodologies jointly with control channel and feedback mechanisms
  - Decisions that must be made for any transmission:
    - Open-Loop vs Closed-Loop Array Transmission
    - Frequency-selective (narrowband) transmission versus Diversity (broadband) transmission
    - Single user transmission (BF & SU-MIMO) versus multiple user (MU-MIMO)
      - User selection/grouping, Codebook index/user matching
    - Transmission mode / Spatial rank per user
    - Single Codeword vs Multi Codeword
    - MCS level per codeword
  - High level design issues for link adaptation decisions:
    - What information is needed to make the decision?
    - Who collects/measures that information?
    - How does that information get conveyed to the entity that ultimately makes the decision?

Recommendations for Enhanced MIMO & Advanced Antenna Array Functionality (3/5)

- Support both FDD and TDD
  - Although many aspects of the TDD and FDD air interface can be common, we must consider the option to optimize TDD antenna methodology separately from FDD antenna methodology
    - May want FDD-only modes and TDD-only modes
- Support of up to 8 BS TX antennas
  - 8 Tx antenna midamble
  - Not necessarily an 8 Tx antenna pilot pattern in data region
    - Dedicated pilot preferred for supporting up to 2-stream to a MS
    - Does not imply support for 8 stream MIMO nor 8 user SDMA
- Optimize the subchannelization and pilot formats
  - Enhance channel estimation performance for dedicated pilots and for common pilots
  - Improve support for interference estimation & suppression
  - Cell/site synchronization of resource allocations for supporting interference management
  - Optimize support for diversity scheduling and frequency-selective scheduling

Recommendations for Enhanced MIMO & Advanced Antenna Array Functionality (4/5)

- Closed-Loop MIMO enablers:
  - UL Channel Sounding
    - Enhance and optimize
    - Improve support for different MS types (switched & multi-antenna)
    - TDD and FDD
  - Codebooks:
    - Codebooks extensible to 8 TX with possibly a smaller number of streams/users supported
    - Low complexity search at MS is a requirement
  - Direct / Analog feedback methodologies
- Improved support for frequency selective scheduling
  - Optimize in conjunction with multi-antenna transmission
  - Enable on the UL (e.g., UL Channel Sounding in FDD)
- Enable beamforming of control channel
  - Enhance coverage performance

Recommendations for Enhanced MIMO & Advanced Antenna Array Functionality (5/5)

- Strive for minimizing the number of MIMO mode options that the MS is required to support
  - Rather than requiring MS to support all MIMO modes where a different subset is preferred by different BS vendors in a network deployment, require only the best-performing and proven options
- Study/explore multi-antenna UL transmission methods
- Study/explore additional advanced techniques for the BS
  - Advanced interference management methods
  - Opportunistic beamforming, grid of beams
  - Antenna aggregation / virtual antennas
  - Cooperative relaying (multi-antenna aspects)
  - Cooperative-BS Tx/Rx
    - Virtual Antenna Array, coordinated beamforming/null steering
  - Non-linear transmission methodologies (e.g. sphere encoding, dirty paper coding)

Proposed Table of Contents for MIMO / AA in the System Description Document

SDD Outline / Table of Contents: Detail MIMO on DL (1/2)

- MIMO Modes – Downlink
  - Open-Loop Transmission Methods
    - STBC and SU-MIMO
    - Antenna virtualization / aggregation
  - Closed-Loop Transmission Methods
    - Beamforming
    - SU-MIMO
    - MU-MIMO
    - Feedback and Transmission Enablers
      - MIMO Midamble
      - UL Channel Sounding (TDD and FDD)
      - Precoding Matrix Index (PMI) Feedback
      - Direct / Analog Feedback
      - Quantized Feedback
      - Channel State Feedback
    - Antenna virtualization / aggregation

SDD Outline / Table of Contents: Detail MIMO on DL (2/2)

- Link Adaptation for MIMO for DL
  - Decisions needing to be made:
    - Open-Loop vs Closed-Loop Array Transmission
    - Frequency-selective (narrowband) transmission versus Diversity (broadband) transmission
    - Single user transmission (BF & SU-MIMO) versus multiple user (MU-MIMO)
      - User selection/grouping
      - Codebook index/user matching
    - Spatial rank / transmission mode per user
    - Single Codeword vs Multi Codeword
    - MCS selection per codeword
  - Feedback methodologies for enabling link adaptation decisions
    - Channel related feedback (e.g., Doppler)
- MIMO on DL Control Channels
  - Open-Loop Transmission for Broadcast Control
  - Closed-Loop Transmission for Dedicated Control
  - Antenna virtualization/aggregation

SDD Outline / Table of Contents: Detail MIMO on UL

- MIMO Functionality – Uplink
  - Single-User Transmission
    - SIMO
    - Diversity transmission modes / STC / MIMO
    - Support for MS Beamforming / CL MIMO
  - Multi-User Transmission
    - Collaborative MIMO/ RX-SDMA
- Link Adaptation for MIMO for UL
  - User grouping for collaborative MIMO
  - UL Channel Sounding for supporting UL Frequency Selective Scheduling

SDD Outline / Table of Contents: Detail Subchannels and Pilot Formats

- Subchannels and Pilot Formats – DL
  - Resource Blocks (RB) – basic building block
    - Define for 1Tx, 2Tx, 4Tx BS antennas
  - Narrowband Subchannel Format
  - Diversity Subchannel Format
  - Dedicated Pilots
  - Broadcast Pilots
  - Cell/Sector synchronization of RBs
- Subchannels and Pilot Formats – UL
  - Resource Blocks (RB) – basic building block
  - Narrowband Subchannel Format
  - Diversity Subchannel Format
  - Cell/Sector synchronization of RBs

Proposed Way Forward

- Solicit and harmonize contributions describing MIMO / AA functionality and supporting enablers within the SDD.
- Each proposal in the MIMO / Antenna Array technology area should identify/discuss the following:
  - The modes supported
    - E.g., Open Loop, Closed Loop, single/multi user
  - The required/preferred enablers
    - E.g., UL sounding, channel feedback, PMI feedback, etc.
  - Associated pilot and resource formats and their impact
  - Link adaptation procedure
- There can be independent but related proposals for uplink and downlink
- There can be independent but related proposals for TDD and FDD