Proposal for IEEE 802.16m Uplink Sounding Pilot

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

Re: IEEE 802.16m-08/016r1 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topic of "Uplink Pilot Structure and DL MIMO schemes"

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

Scope

- This contribution proposes a new uplink sounding pilot structure for IEEE 802.16m to support DL MIMO.
- The uplink pilot for channel estimation and uplink resource allocation and control structure are presented in separate contributions (see C802.16m-08/348 "Proposal for IEEE 802.16m UL Pilot Structure" and C802.16m-08/350 "Proposal for IEEE 802.16m UL Resource Blocks and Channelization").

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. IEEE 802.16m shall further support single-user and multi-user MIMO techniques."
  - Section 6.10 System overhead:
    - "Overhead, including overhead for control signaling as well as overhead related to bearer data transfer, for all applications shall be reduced as far as feasible without compromising overall performance and ensuring proper support of systems features."
  - Section 7.11 Relative Performance and Section 7.2.1 Relative sector throughput and VoIP capacity:
    - 2x performance gain over the legacy system is required
- The proposed pilot structure targets the above requirements by optimizing the uplink sounding pilot overhead for multi-antenna support

Background and Motivation

- Channel state information at transmit will enable advanced features in downlink of 16m system
  - DL MIMO
    - DL Closed-loop MIMO (see IEEE 802.16m-08/342)
    - DL SDMA and beamforming(see IEEE 802.16m-08/345)
    - DL Network MIMO((see IEEE 802.16m-08/346)
  - Channel dependent scheduling in DL and UL
- Approaches to acquire channel state information at BS
  - Pilot for channel estimation is allocate in the limited channel bandwidth. Special pilot allocation is need for channel measurement, which is carried out in full bandwidth, or the bandwidth of interest.
  - Channel is measured at MS using DL common pilots and/or channel measurement pilots and feed back to BS (see IEEE 802.16m-08/343)
    - Apply to both TDD and FDD
    - More accurate at CQI and interference estimation
    - Trade-off between UL feedback overhead versus feedback accuracy
      - Codebook feedback is quantized
    - Incur feedback delay
  - Channel is measured at BS by using UL sounding pilot
    - Channel measurement in more accurate
    - No feedback delay
    - Apply to TDD only
    - Trade-off between UL feedback overhead versus feedback rate
- This contribution focuses on UL sounding pilot design for TDD system

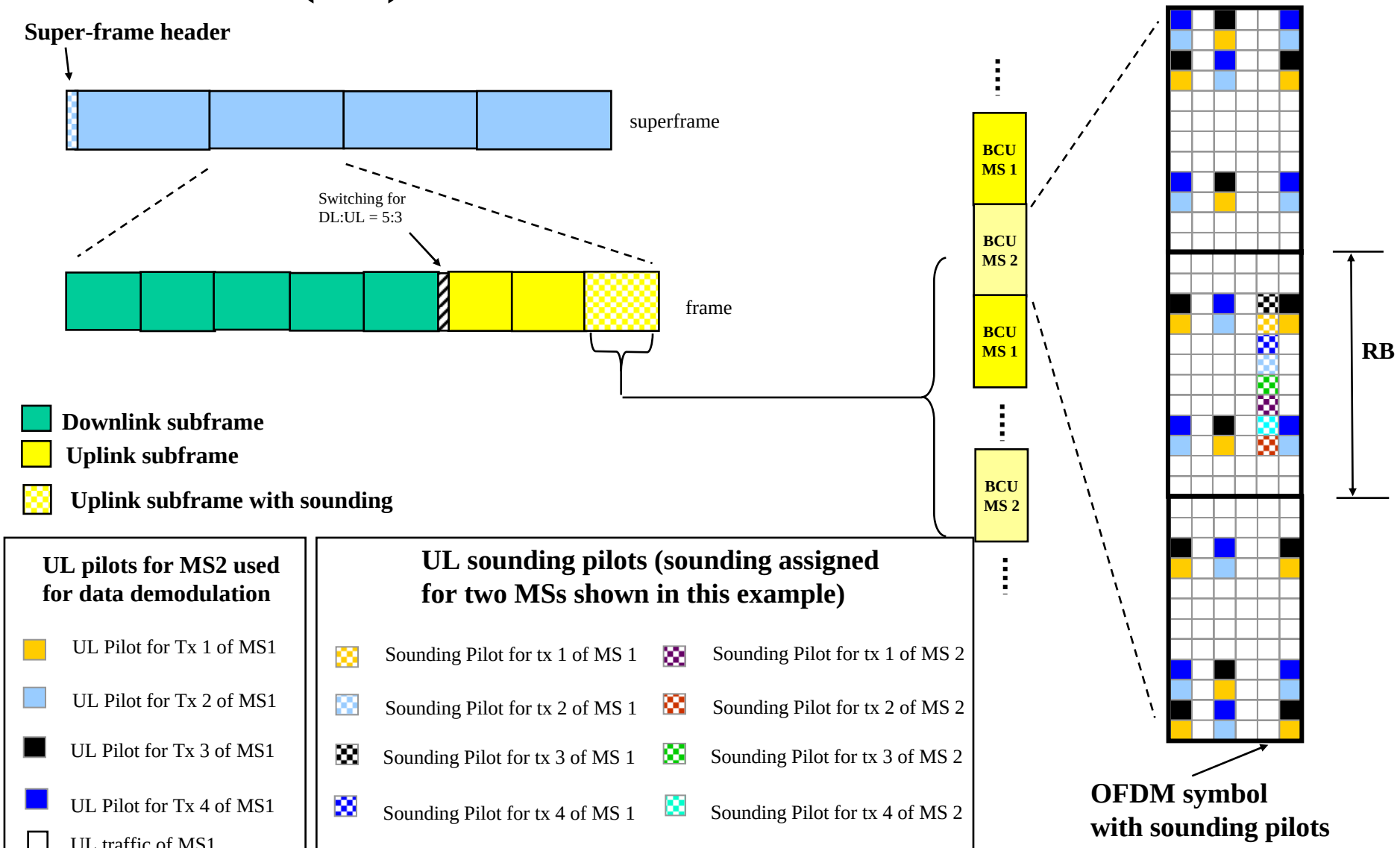
Sounding Approach in Legacy System

- In legacy system, sounding zone is allocated in the frame where sounding is required
- Up to 8 OFDM symbols are reserved per sounding zone
- Sounding zone can be shared by one or several MS
- Resource may not be fully utilized
- Overhead for sounding resource is high because of TDM zone partitioning in legacy system
- TDM allocation of sounding zone affects other traffic permutations zones in the frame

Uplink Sounding Pilot Design: Sounding pilot allocation (1/2)

- In 16m system, resource partitioning is FDM and more granular (see IEEE 802.16m-08/350 “Proposal for IEEE 802.16m UL Resource Blocks and Channelization”). Sounding resource can be allocated in a more efficient way.
- Sounding periodicity for each MS is configurable. Different MS may have different periodicity
  - Non-periodic, or periodic every N frames (N = 1, 2, …)
- For a sub-frame where sounding is required, one or several OFDM symbols in a UL sub-frame is used to allocate sounding pilots
- OFDM symbol(s) are shared by both sounding pilots and MS traffic transmission
  - One or multiple MS’s sounding pilot can allocated in the same OFDM symbol
- Sounding band coincide with one basic channel unit (BCU) in UL channelization
- Sounding pilots are allocated at predefined subcarriers in sounding band
  - Sounding pilots do not collide with UL MS pilot for channel estimation
  - Sounding pilot do not collide with data subcarriers
- Number of sounding pilot per antenna per MS in a sounding band is configurable (1 to 4)
  - Determined by granularity and quality of channel measurement
- Sounding pilots for multiple antenna are multiplexed at different subcarriers in sounding band
- The amount of sounding pilots resource allocated in each sub-frame is signaled in the superframe header or sub-frame control (FFS).

Uplink Sounding Pilot Design: Sounding pilot allocation (2/2)



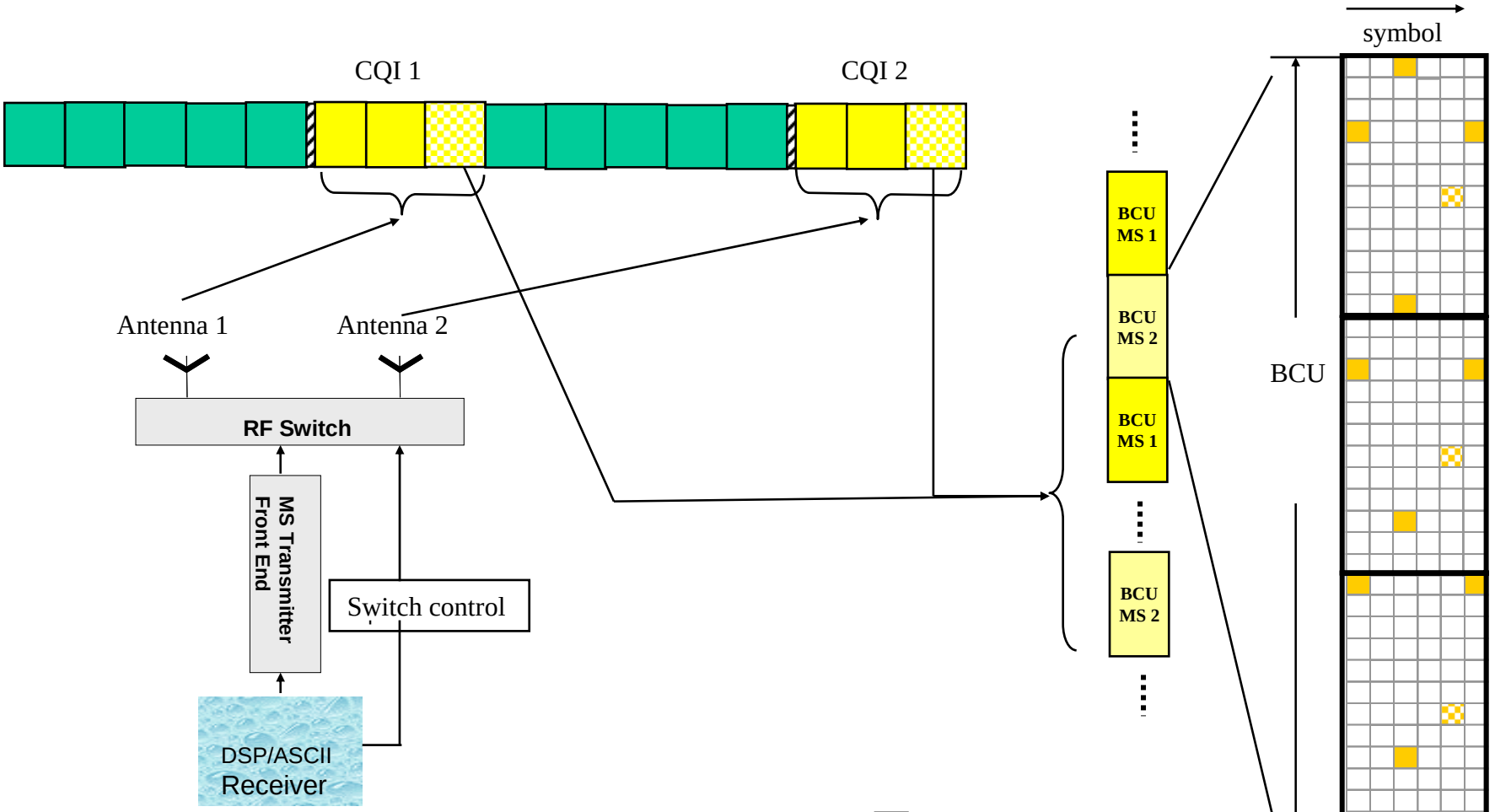
Issues with MS having Less Transmitter Chains than Receiver Chains

- UL sounding pilot signals are received by BS to measure MIMO channel information in UL. For TDD system, measured UL channel coefficients can be used as DL channel coefficients with assumption of TDD reciprocity.
- However, MS may have less transmitter RF chains than receiver chains for a MIMO system. With current legacy channel sounding, DL channel coefficients derived from UL sounding pilot signal may not be enough for DL MIMO transmission
  - For example, MS may have only 1 Tx capability and 2 Rx capability. For BS with 2 Rx, UL sounding can only provide 2x1 channel coefficients, instead of 2x2 channel coefficients as needed for MIMO transmission
- Antenna switching among available physical antenna at the MS can be applied to make channel sounding providing full MIMO channel information for DL transmission

Applying Antenna Switching to Sounding (1/2)

- Antenna switching occurs every N sub-frames. N is configurable.
- In case of MS has 2 physical antenna and one transmitter chain
  - BS configures the MS to switch antenna every N sub-frames to transmit the sounding pilot.
  - The MS can also transmit data on the same antenna as that of the sounding pilot within the N-sub-frame window.
    - As channel dependent information (e.g. CQI) is different for Antenna 1 and Antenna 2. BS is responsible to keep track of channel related information for different antennas of MS to assign appropriate modulation/coding and transmit power for data transmission.
  - BS measures channel coefficients for each MS antenna at respective sub-frame.

Applying Antenna Switching to Sounding (2/2)



Summary

- Sounding resource allocation scheme is proposed based on needs
- Antenna switched sounding is proposed for MS with less transmitter RF chain than available antenna elements.

Text Recommendations for SDD Section 11 Physical Layer

- Section 11.x UL Pilot structure
  - Section 11.x.y UL sounding
    - Section 11.x.y.1 Resource allocation of UL sounding

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    - Section 11.x.y.2 UL sounding pilot allocation

      [*Copy the content of slide 6 into this section*]
    - Section 11.x.y.3 UL antenna switched sounding

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