

Signaling Methods to Support Closed-Loop Transmission in 802.16e TDD OFDMA

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Purpose:

Introduce signaling methodology to enable fast, efficient uplink channel sounding to support closed-loop transmission in mobile 802.16e TDD OFDMA systems.

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Contribution 103r2 Summary

- Provides improved support for Closed-Loop transmit antenna techniques in mobile TDD-OFDMA
 - Optional alternative to Feedback for TDD systems
 - Provides much lower channel measurement latency than feedback in TDD systems
 - Important for mobile channels
 - Usable with or without the AAS zone
- Defines a flexible and efficient scheme for the SS to transmit channel sounding waveforms on the UL
 - BS performs simple channel estimation to determine BS-SS channel response (assumes TDD and calibration)
 - SS transmits sounding waveforms only when needed

Closed-Loop Transmit Antenna Arrays

- Exploit knowledge of the Tx-Rx Channel Response
 - Per-carrier coherent beamforming (MRT, TXAA)
 - Concurrent multi-user beamforming (TX-SDMA)
 - Closed-Loop MIMO
- **Advantages** over Open-Loop Methods
 - Beamforming gain for range enhancement
 - Concurrent Transmissions (SDMA) on DL
 - Closed-Loop MIMO (Spatial Multiplexing) is more robust to low scattered channels than Open-Loop MIMO

Enabling Closed-Loop Transmission on DL

- Feedback

- SS measures DL channel, sends channel information back to BS on feedback channel
- **FDD** or **TDD**
- Already in the standard

- Uplink Channel Reuse

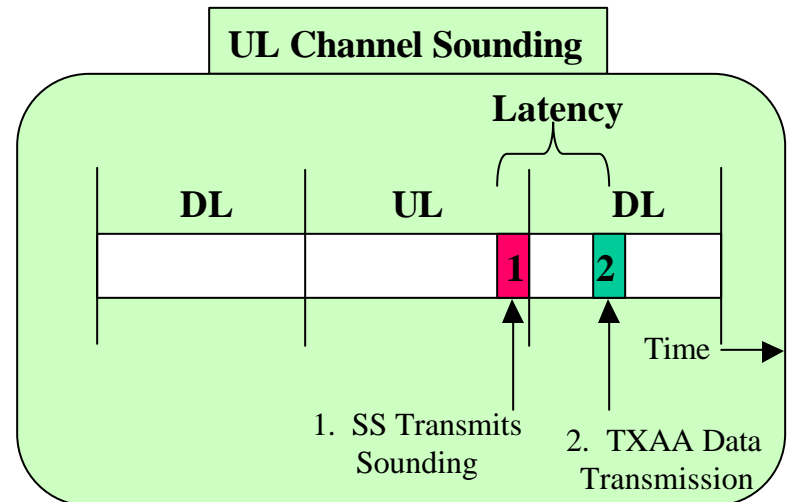
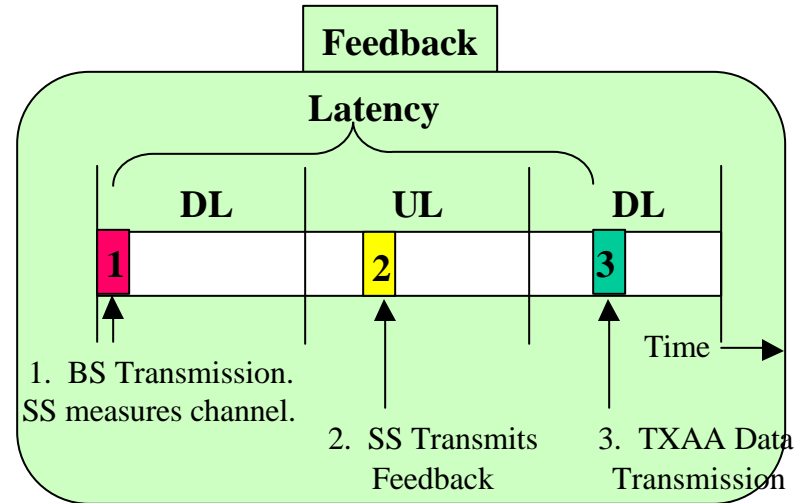
- BS determines DL channel response by measuring UL channel response from desired SS.
- **TDD** only: (cannot use in FDD)
 - Assumes reciprocity in RF propagation and appropriately calibrated BS transmit and receive hardware
- Can be used in current Standard but is not well supported!
- 103r2 provides explicit support for Uplink Channel Reuse through the SS transmitting UL channel sounding waveforms

Advantages of UL Channel Reuse over Feedback in TDD

- Leverage UL SS data transmissions for free in some cases
- Feedback has poor scalability with the # of BS antennas
 - Feedback becomes difficult with large number of BS TX antennas
 - Amount of required feedback information becomes large
 - UL Channel Reuse schemes are independent of the # of BS antennas
- Channel estimation more difficult in feedback schemes:
 - Example: BS=8Tx, SS=1Rx
 - Feedback: SS must perform 8-source channel estimation on the DL
 - UL Channel Reuse: BS performs 1-source channel estimation on UL
- UL Channel Reuse has lower channel measurement latency
 - Reduces the velocities that can be supported

Channel Measurement Latency in TDD

- Feedback:
 - Min Latency = UL duration
 - Max Latency = 2DL + UL
- UL Channel Reuse
 - Nominal Latency = $\frac{1}{2}$ DL
 - Min Latency = a few symbols
 - Max Latency < UL + DL
- Extra latency reduces the max velocity that can be supported



UL Channel Reuse in 802.16 TDD systems

- UL Channel Reuse can already be used in a TDD 802.16 system by leveraging UL data transmissions
- **Problem:** BS can leverage UL data transmissions only when their frequency occupancy encompasses the upcoming DL data transmission
 - Difficult to achieve in broadband data systems, especially when DL traffic levels \gg UL traffic levels
- **Solution:** Use uplink sounding waveforms when needed
 - Transmitted by SS to enable the BS to calculate UL channel response
 - Not needed if UL data transmissions are sufficient for estimating desired channel response
 - Sounding strategy independent of the number of BS antennas
- **Purpose:** Introduce optional signaling methodology to support Closed-Loop Transmission based on Uplink Channel Reuse

Outline of Proposed Solution

- Optional Sounding Zone
- Explicit Sounding Instructions in the UL Map
- Piggybacking of sounding instructions onto DL data allocations in the DL-MAP
 - Coupled Sounding Instructions appended to DL Data allocations (new IE)
 - Uncoupled Sounding Instructions appended to DL Data allocations (new IE)
- Support for Closed-Loop MIMO

Sounding Zone Construction

- UL Map indicates location within the UL
 - Presence and characteristics can be made dynamic
- Consists of a small number of OFDMA symbols
- Frequency bandwidth divided into:
 - 192 frequency bins, each bin containing 9 subcarriers
- Frequency bandwidth divided into:
 - 48 Sounding Frequency Bands, each containing $192/48=4$ frequency bins
 - 36 subcarriers in a Sounding Frequency Band
- Sounding Zone = 48 Sounding Frequency Bands by 1-8 OFDMA symbol intervals

Sounding Instructions (1/2)

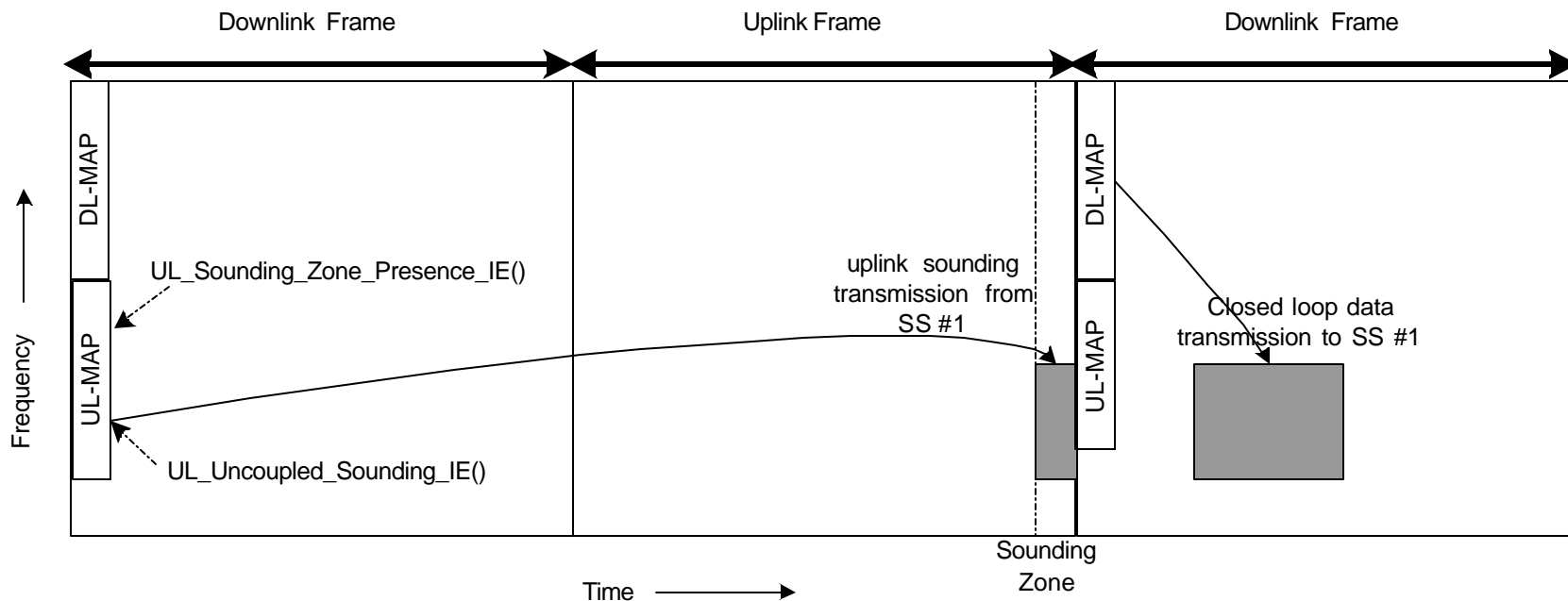
- Sounding Allocation:
 - Contiguous set of Sounding Frequency Bands
 - OFDMA Sounding Symbol
- Sounding Sequence Index
 - Multiple Sectors use different groups of sounding sequences (GCL sequences)
 - Sequence to use partially determined from CellID
 - Sequence waveform implicitly determined by the allocated subcarriers within the sounding allocation
 - All transmissions sharing the sounding allocation use the same underlying sequence with one of two means for enabling the BS to separate the transmissions....

Sounding Instructions (2/2)

- “Separability” Mode with Separability Parameter to handle multiple soundings on a single sounding allocation
 - Sequence Separability:
 - Frequency-domain phase shifts induce cyclic time shifts for multiple soundings on a sounding allocation
 - Decimation (i.e., frequency-interleaved allocation):
 - Decimation offset
- Multi-Antenna Mode
 - Sound one SS antenna or sound all SS antennas
- Implicit determination of separability parameters

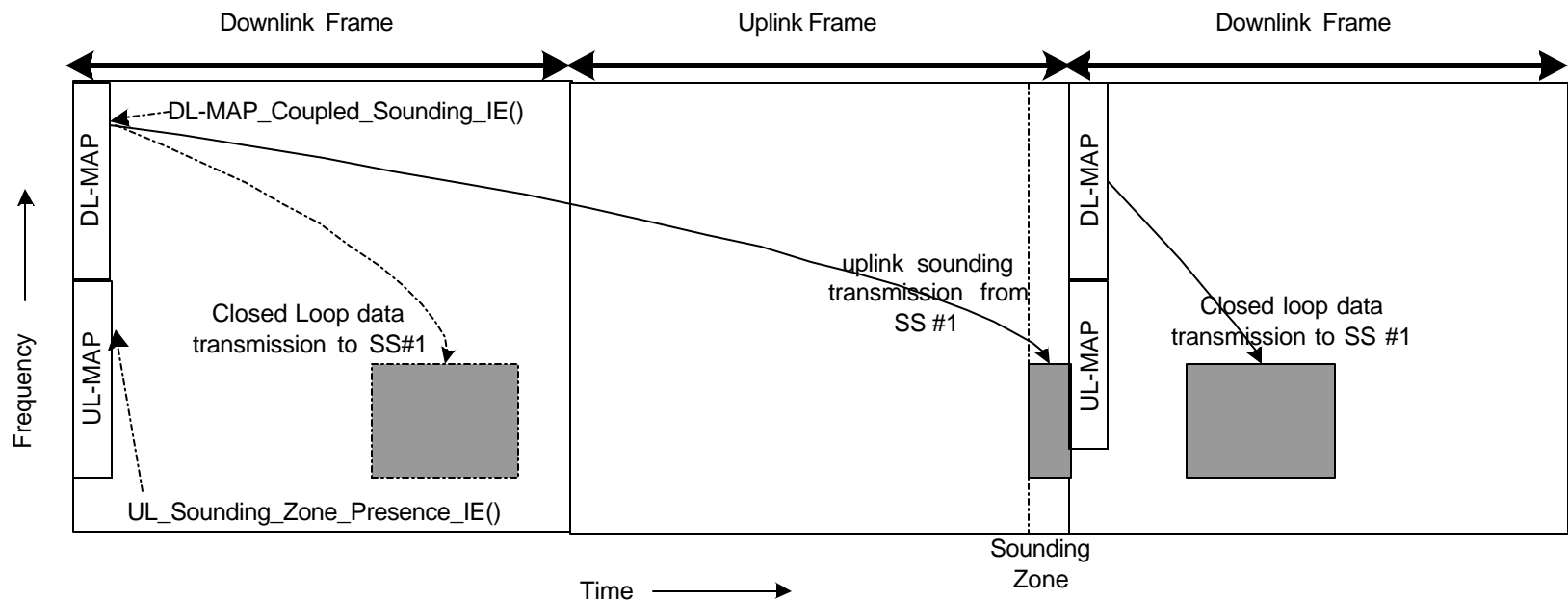
Explicit Sounding Instructions

- Presence of Optional Sounding Zone indicated in UL-MAP
- New IE for providing sounding instructions in the UL-MAP



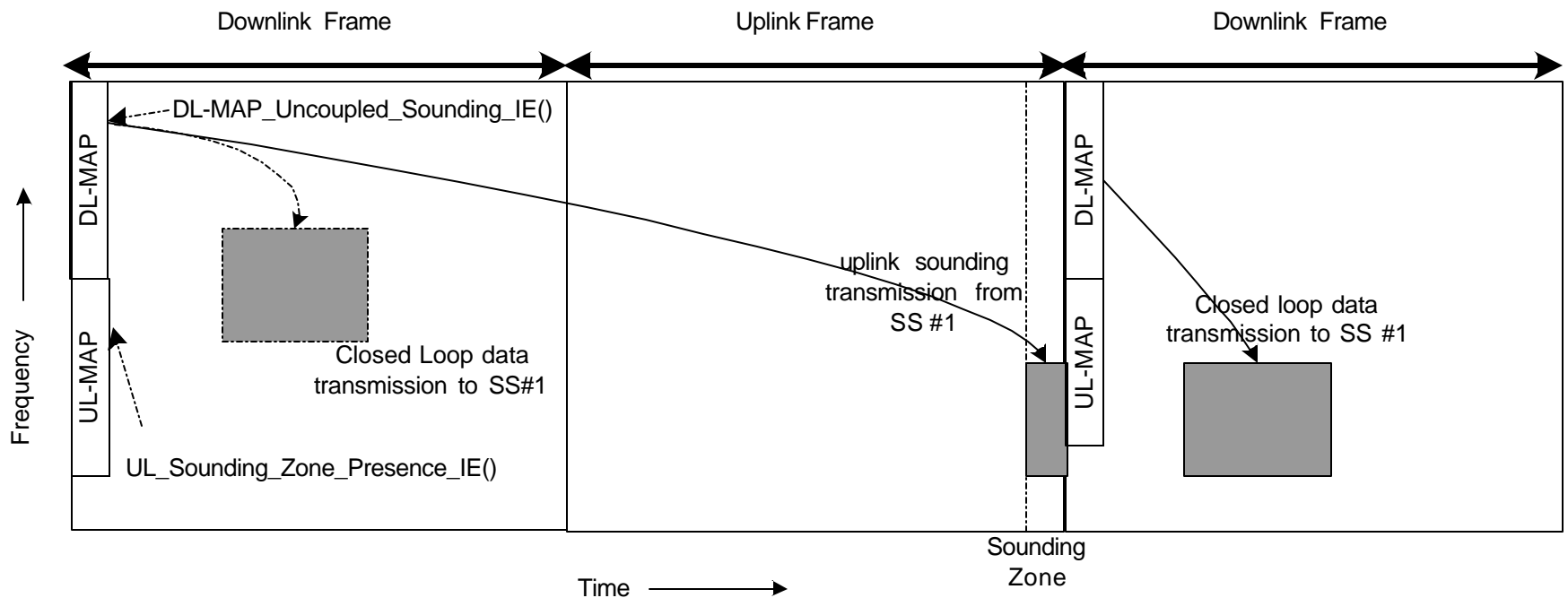
Combining Data Allocations and Sounding Instructions – Coupled Method

- Simultaneously allocate a DL data transmission and UL sounding in the DL-MAP
- Coupled Sounding: Frequency occupancy of Sounding implicitly determined by DL data transmission



Combining Data Allocations and Sounding Instructions – Uncoupled Method

- Simultaneously allocate a DL data transmission and UL sounding in the DL-MAP
- Complete set of sounding instructions independent of the DL data transmission



Closed-Loop MIMO Support

- Create new extended IEs for the DL-MAP
 - Combine MIMO allocations and sounding instructions with additional fields needed for CL-MIMO
 - Signaling strategy identical to non-MIMO case

Backward Compatibility Proposal

- 2048 FFT sizes:
 - Technique is optional
 - BS must not schedule legacy SSs in UL frames that have a sounding zone
- All other FFT sizes:
 - Technique is optional
 - SSs must know how to handle the presence of an UL Sounding Zone

Comments Received & Our Response

- Concerns about ability to accurately estimate the channel
 - 103r2 shows performance results in mobile spatial channels
- Cannot provide indication of Interference received by SS
 - Not needed by generic closed-loop transmission techniques
 - 103r2 would not replace existing methods of telling the BS the average SINR seen at the SS
- Collisions in sounding waveforms without cell planning
 - 103r2 add support for optional scrambling of the sounding waveforms based on PRBS generator

Summary

- Lower Latency solution compared to Feedback
- Fast turnaround to support mobile channels
- Dynamic and flexible sounding instructions
- Low overhead transmissions
- Support for multiple concurrent sounding transmissions on a sounding allocation
- Solution independent of number of BS antennas
- Flexibility in handling SSSs with varying # of antennas
- Sequence “reuse” strategy for multi-cell co-channel deployments
- Support for Closed-Loop MIMO

Proposed Text Changes

- See Document C80216e-04/103r2