Proposal for IEEE 802.16m Evaluation Methodology of Downlink Pilot Structure

Source:

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Venue:

   Call for comments on IEEE C802.16mDL_PHY-08/046 ("802.16m DL PHY Structure Baseline Content Suitable for Use in the 802.16m SDD")

Base Contribution:

   None

Purpose:

   For review and discussion by TGm

Evaluation Methodology (1)

- Projection of effective SNR on throughput hull curve from link level simulation

  - Assumption

    - Linear MMSE receiver for Spatial Multiplexing, STBC/SFBC [1]
    - Channel Estimation Effect
    - Effective SNR using RBIR PHY abstraction [1]
    - Noise limited

  - Spectral Efficiency (SE)

  $$SE = \left(1 - OH_{pilot}\right) \times \sum_{t=1}^{N_T} SE_{eff}\left(SNR_{eff}\left[t\right]\right)$$

    - $SNR_{eff}[t]$: Effective SNR for the t-th Tx stream
    - $SE_{eff}()$: Spectral efficiency obtained from throughput hull curve
    - OH_{pilot}: Total pilot overhead
    - N_T: number of Tx streams

Evaluation Methodology (2)

- Linear MMSE receiver for Spatial Multiplexing
  - Post-processing SNR for the t-th Tx stream [1]

$$SNR_t(n) = \frac{diag\left[\mathbf{D}(n)\mathbf{D}^H(n)\right]_{tt}}{diag\left[\mathbf{I}_{self}\mathbf{I}_{self}^H + \sigma^2\mathbf{W}^H(n)\mathbf{W}(n)\right]_{tt}}$$

  - $\mathbf{H}(n)$: $N_R \times N_T$ channel matrix at the n-th subcarrier
  - σ^2: Noise variance
  - L-MMSE weight
    $$\mathbf{W}(n) = \left(\mathbf{H}(n)\mathbf{H}^H(n) + \sigma^2\mathbf{I}_{N_R}\right)^{-1}\mathbf{H}(n)$$

  - Desired signal component at the n-th subcarrier,
    $$\mathbf{D}(n) = diag\left[\mathbf{W}^H(n)\mathbf{H}(n)\right]$$

  - Self interference between MIMO streams,
    $$\mathbf{I}_{self} = \mathbf{W}^H(n)\mathbf{H}(n) - \mathbf{D}(n)$$

Evaluation Methodology (3)

- Channel Estimation Effect
  - Post-processing SNR of L-MMSE receiver for the t-th Tx stream

$$SNR_t^1(n) = \frac{diag\left[\hat{\mathbf{D}}(n)\hat{\mathbf{D}}^H(n)\right]_{tt}}{diag\left[\hat{\mathbf{I}}_{self}\hat{\mathbf{I}}_{self}^H + \sigma^2\hat{\mathbf{W}}^H(n)\hat{\mathbf{W}}(n)\right]_{tt}}$$

  - $\mathbf{H}(n)$: $N_R \times N_T$ channel matrix at the n-th subcarrier
  - $\hat{\mathbf{H}}(n)$: $N_R \times N_T$ **estimated** channel matrix at the n-th subcarrier
  - σ^2: Noise variance
  - L-MMSE weight,
    $$\hat{\mathbf{W}}(n) = \left(\hat{\mathbf{H}}(n)\hat{\mathbf{H}}^H(n) + \sigma^2\mathbf{I}_{N_R}\right)^{-1}\hat{\mathbf{H}}(n)$$

  - Desired signal component at the n-th subcarrier,
    $$\hat{\mathbf{D}}(n) = diag\left[\hat{\mathbf{W}}^H(n)\mathbf{H}(n)\right]$$

  - Self interference between MIMO streams,
    $$\hat{\mathbf{I}}_{self} = \hat{\mathbf{W}}^H(n)\mathbf{H}(n) - \hat{\mathbf{D}}(n)$$

Evaluation Methodology (4)

- Effective SNR using RBIR PHY Abstraction [1]
 - Normalized mutual information per received bit (RBIR)

$$RBIR_t = \frac{\sum_{n=1}^{N} SI\left(SNR_t^1(n), m(n)\right)}{\sum_{n=1}^{N} m(n)}$$

  - SI(): Mapping function from SNRs to RBIR values
  - m(n): number of bits at the n-th subcarrier

  - Effective SNR

$$SNR_{eff}[t] = SI^{-1}(RBIR_t)$$

  - SI^{-1}: Demapping function from RBIR value to SNR

Evaluation Methodology (5)

- Throughput hull curve from Link FER
  - $SE_{eff}()$: Mapping function from SNR to Spectral Efficiency
  - 10 MCS levels
    - Mod: QSK, 16QAM, 64QAM, FEC: CTC, 1/12~5/6
  - AWGN channel

  [Example]
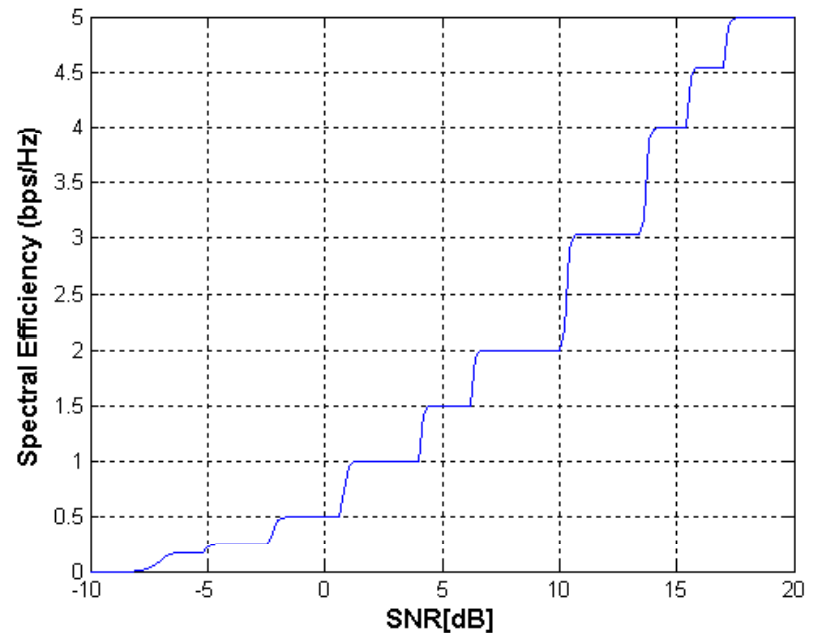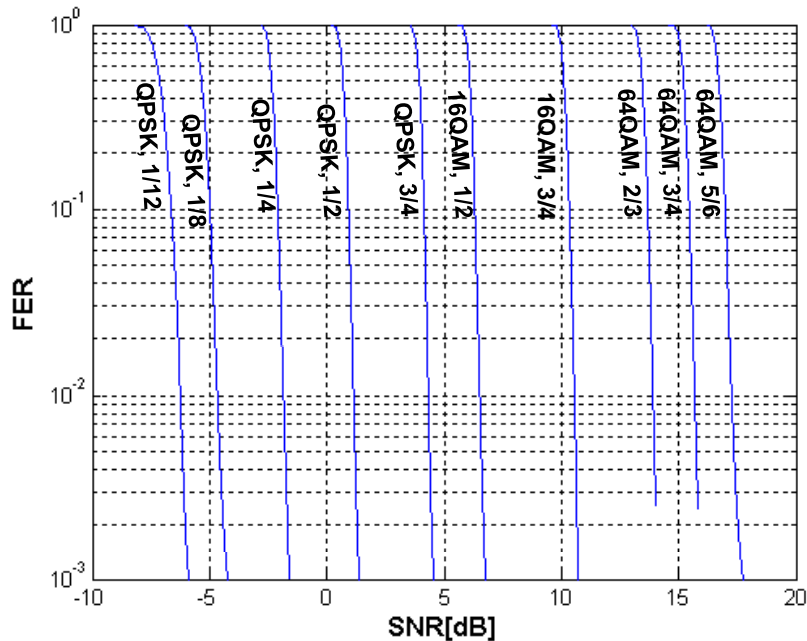
Simulation parameters and assumption

- System assumption
  - System bandwidth: 10MHz
  - PRU size: 18 subcarriers x 6 symbols

- Simulation parameters
  - Antenna configuration: 2x2, 4x4 with zero correlation
  - Transmission scheme
    - OL MIMO (Spatial Multiplexing, SFBC/STBC)
  - Interference type: Noise limited (single cell), Interference limited (2 or more interfering BS signals)
  - Channel model [1]
    - Extended ITU PedB 3km/h, VehA 120km/h
  - Channel estimation: Narrowband MMSE over one PRU
    - 2D MMSE Channel Estimation
    - With perfect knowledge regarding power and delay profile
  - Number of resource unit: more than 2 PRUs
  - Performance metrics
    - Average spectral efficiency vs. SNR with pilot overhead accounting and assuming perfect link adaptation
    - MSE vs. SNR

Reference

[1] IEEE 802.16m-08/004, Roshni Srinivasan, et al, "Project 802.16m Evaluation Methodology Document (EMD)", March 4, 2008.