

Proposal for IEEE 802.16m Evaluation Methodology of Downlink Pilot Structure

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None

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For review and discussion by TGm

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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)

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

- $SNR_{eff}[t]$: 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]

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

- $\mathbf{H}(n)$: $N_R \times N_T$ channel matrix at the n-th subcarrier
- σ^2 : Noise variance
- L-MMSE weight

$$\mathbf{W}(n) = (\mathbf{H}(n)\mathbf{H}^H(n) + \sigma^2\mathbf{I}_{N_R})^{-1} \mathbf{H}(n)$$

- Desired signal component at the n-th subcarrier,

$$\mathbf{D}(n) = \text{diag}[\mathbf{W}^H(n)\mathbf{H}(n)]$$

- 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

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

- $\mathbf{H}(n)$: $N_R \times N_T$ 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,

$$\hat{\mathbf{D}}(n) = \text{diag} \left[\hat{\mathbf{W}}^H(n) \mathbf{H}(n) \right]$$

- 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)

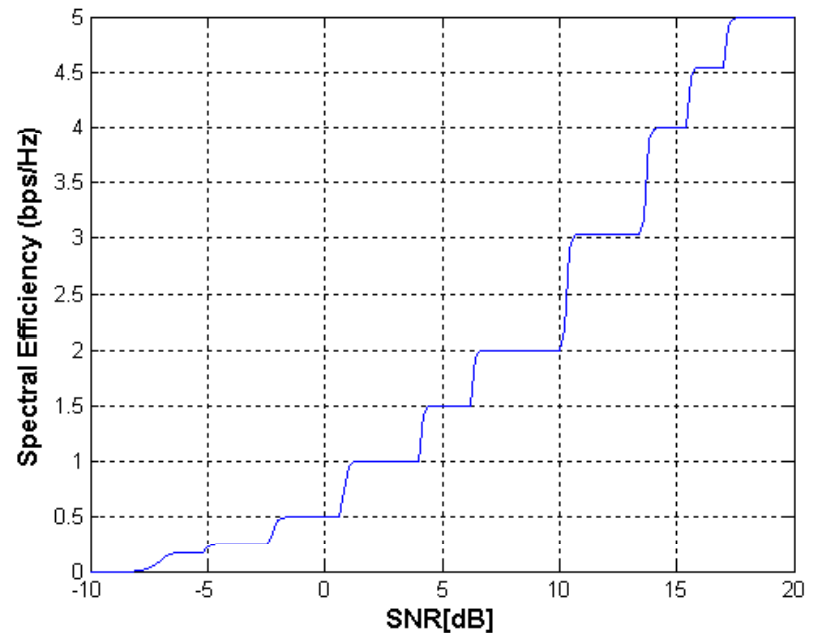
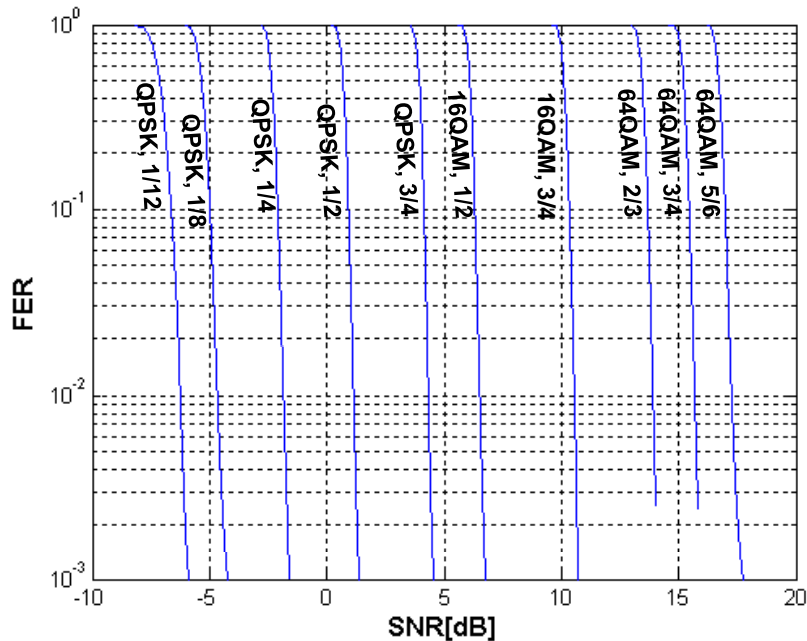
$$RBIR_t = \frac{\sum_{n=1}^N SI(SNR_t^1(n), m(n))}{\sum_{n=1}^N m(n)}$$

- $SI()$: 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
 - $SE_{\text{eff}}()$: 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.