Design Considerations of Pilot Structures for Downlink MIMO Transmission

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Source:
Chih-Yuan Lin (chihyuan.lin@mediatek.com), Pei-Kai Liao (pk.liao@mediatek.com), Ciou-Ping Wu (ciouping.wu@mediatek.com), and Paul Cheng (paul.cheng@mediatek.com)

MediaTek Inc.
No.1, Dusing Road 1,
Science-Based Industrial Park,
Hsinchu, Taiwan 300, R.O.C.

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Purpose:
Propose to be discussed and adopted by TGm for the use in Project 802.16m SDD

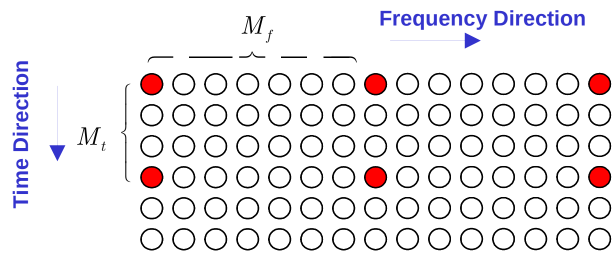
Design Considerations

- Design of pilot pattern should meet following two properties

  1. Minimally satisfy pilot spacing constraints derived from 2-D sampling theorem

  - Guarantee that MS can reconstruct channels at data tones, but with least pilot overhead

$$M_t \le \frac{1}{2 f_d T_s} \qquad M_f \le \frac{1}{2\tau_{\max}\Delta f}$$



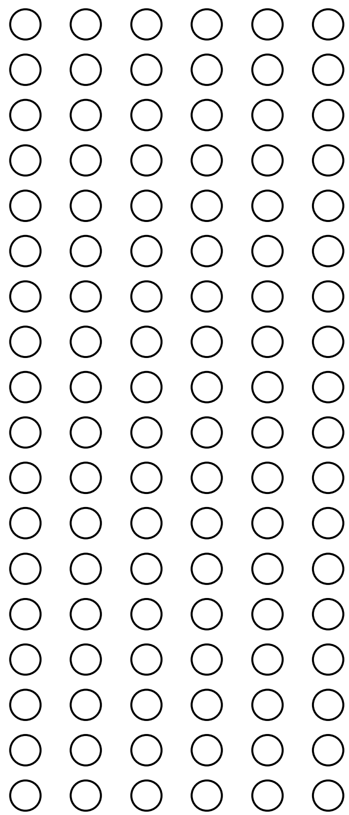
  2. Channel extrapolation is avoided as far as possible

$$MSE_{\text{interpolation}} \le MSE_{\text{extrapolation}}$$

  - Pilot tones frame most of data tones

Pilot Structure Examples

- Resource block for our example
  - 18 subcarriers over 6 OFDM symbols

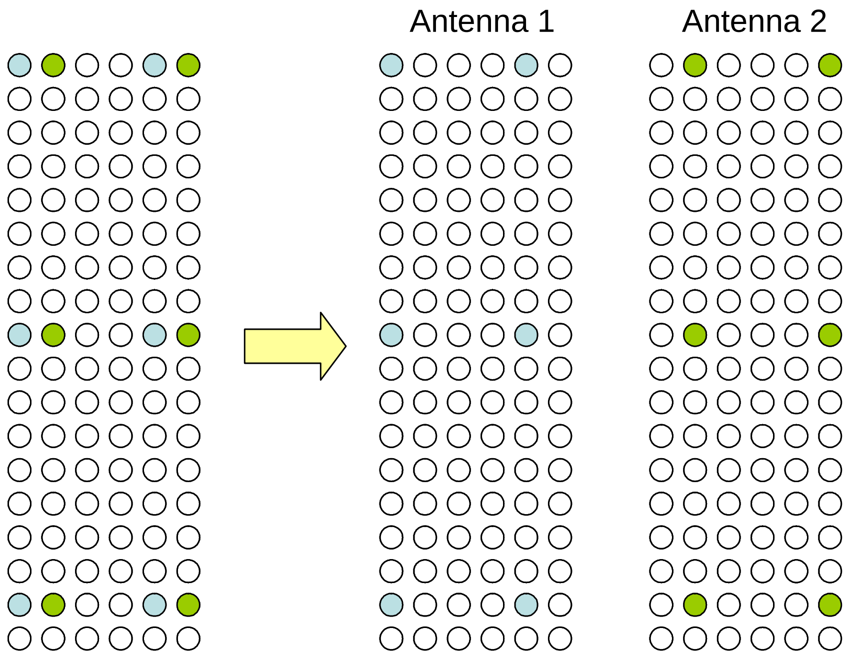


- Design parameters
  - $T_s = 102.82\ \mu s \qquad \Delta f = 10.94\ kHz$
  - According to 802.16m EVM document, delay spread in general does not exceed $5\ \mu$s
    - $\tau_{\max}$ is set to be $\tau_{\max} = 5\ \mu s$ without loss of generality
  - 802.16m supports mobility velocity up to 350 Km/h
    - $f_d = 810$ Hz under 2.5 GHz carrier frequency
  - Constraints on M_t and M_f

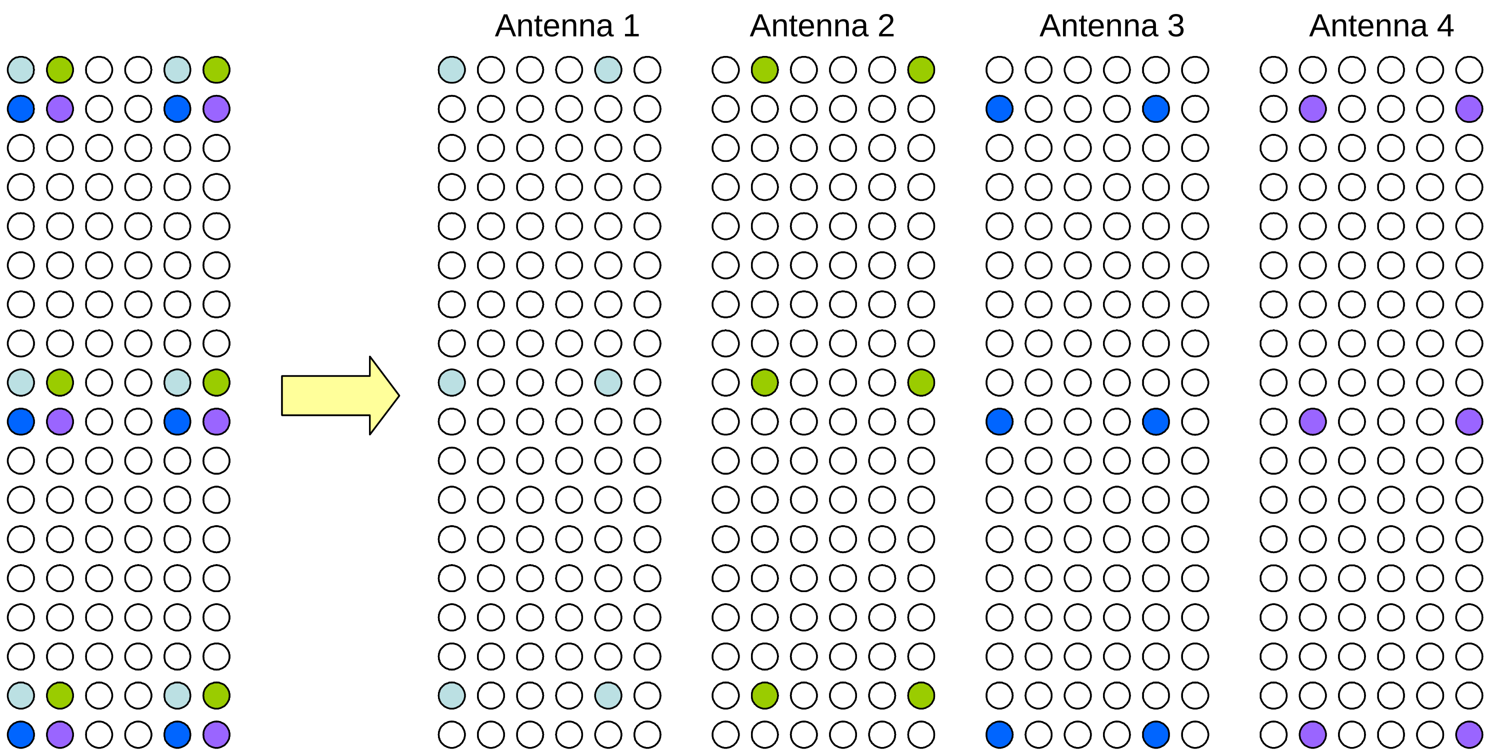
$$M_t \le 6$$

$$M_f \le 9$$

- 2-TX-antenna downlink MIMO transmission
  - Satisfy pilot spacing constraints $M_t \le 6 \quad M_f \le 9$
  - Pilot tones frame most of data tones
    - As possible as we can to avoid extrapolation
  - Pilot density: 0.11111
    - More spectrally efficient than STC PUSC (with pilot density 0.14286)
    - But has better BER performance
  - Suitable for randomized resource allocation



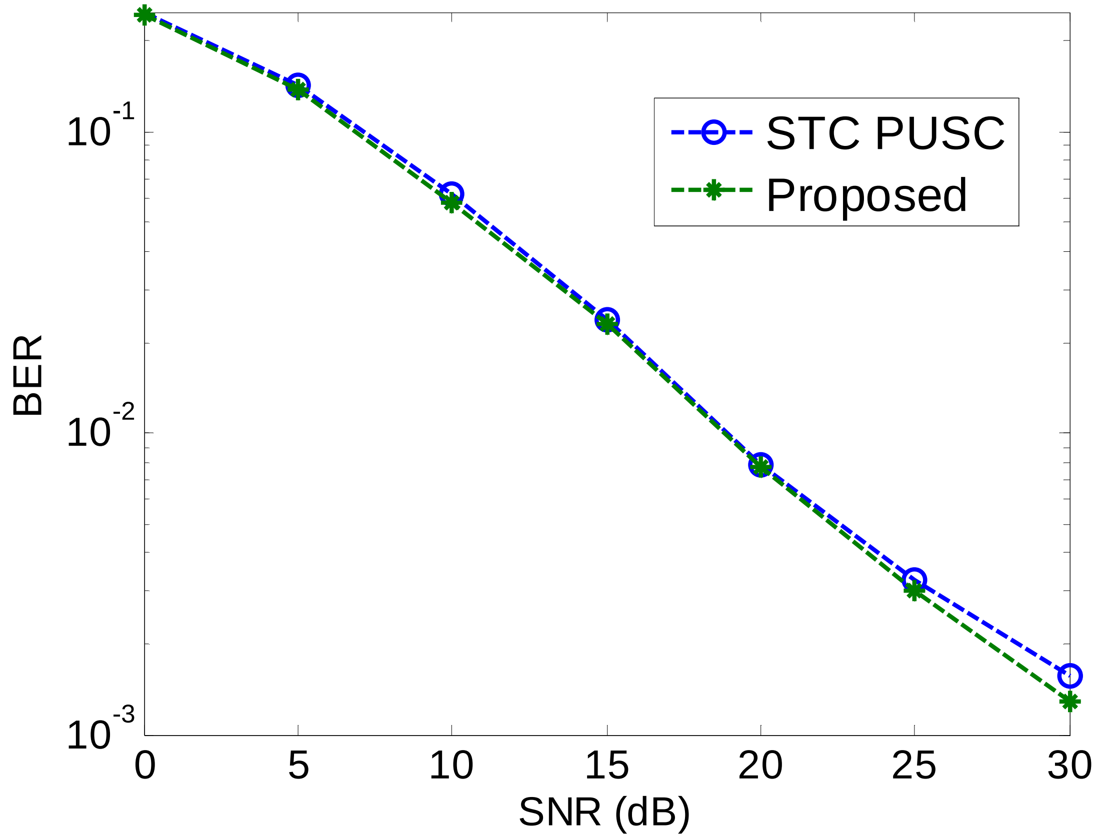
- 4-TX-antenna downlink MIMO transmission



Simulation Results

- Compare proposed example with STC PUSC (adopted in baseline system)
- System parameters
  - 2-by-2 MIMO system with Matrix B (MMSE detector)
  - FFT size $= 512$, 24 OFDM symbols
  - QPSK modulation
  - $\tau_{\max} = 2.51\ us$ (ITU vehicular A channel model)
  - $f_d = 250$ Hz (120 km/h vehicle speed)
  - Channel characteristics follow Jakes' model
  - Two 1-D linear interpolations
    - Time-direction interpolation first, and then frequency-direction one
    - Linear extrapolation is used at those data tones which are not in between pilot tones

- BER performance
  - Results justify, under the design considerations, proposed pilot pattern outperforms traditional PUSC, although with lower pilot density



Conclusion

- Two design considerations should be taken into account when designing pilot pattern
  - 2-D sampling theorem should be minimally satisfied
  - Pilot allocations should be designed to avoid channel extrapolation as possible as we can
- Our design considerations can be extended to other resource block designs