The Impact of SC-FDMA on UL SDMA

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Base Contribution:
none

Purpose:
To discuss the impact of SC-FDMA on UL SDMA.

Introduction

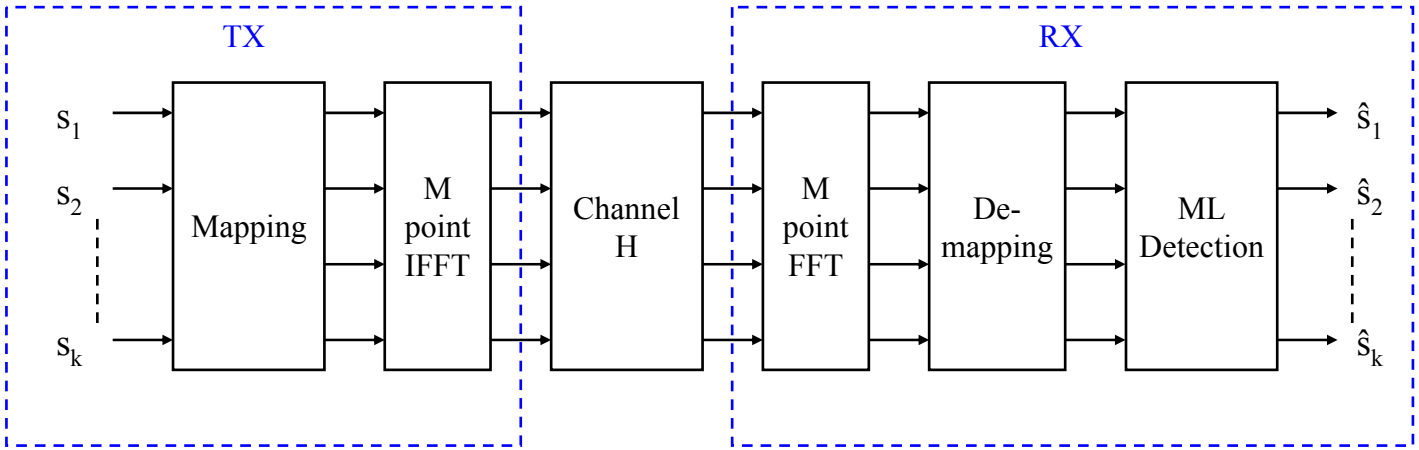
- SC-FDMA has been recently proposed by some companies as an alternative to OFDMA for the UL of 802.16m, due to roughly 2dB lower PAPR (in the time domain).
- However, in spatial multiplexing (SM), SC-FDMA makes ML decoding impractical, and one has to resort to very suboptimal decoders such as ZF or MMSE.

Introduction – cont.

- The degradation inflicted by suboptimal decoding in the case of Collaborative MIMO with 2 Rx antennas at the BS was investigated in [C80216m-08_045] and [UL MA_ link performance result_revised_LGE].
- Here we consider the case of 4×4 UL SDMA, in which the degradation due to SC-FDMA is significantly larger (about 10dB worse than OFDMA).

MIMO in OFDMA

- Block diagram for MIMO in OFDMA:



- After FFT, each subcarrier can be written as:

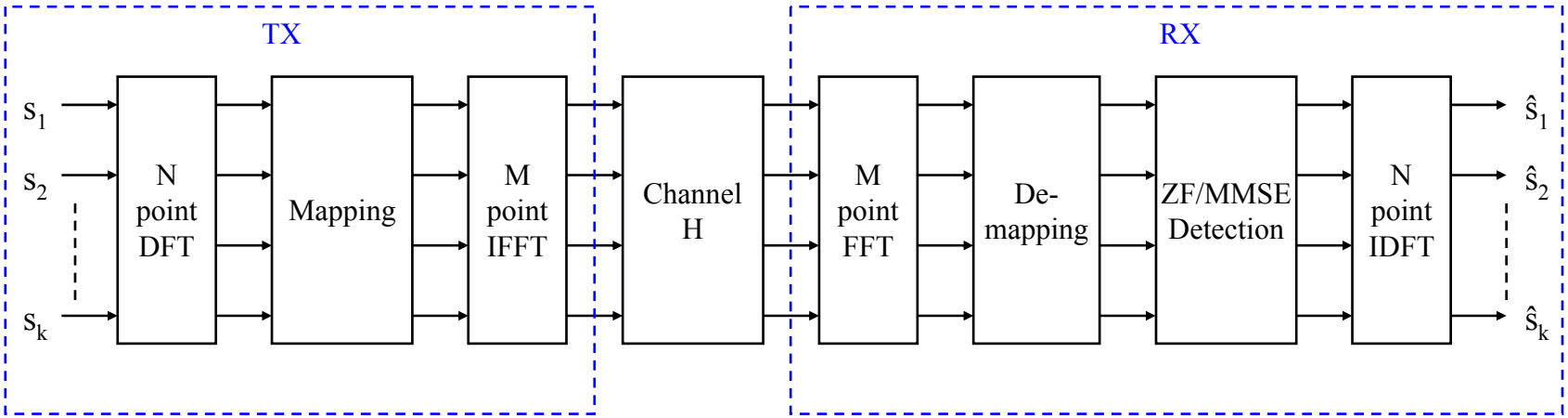
$$\mathbf{y} = \mathbf{Hs} + \text{noise}$$

where $\mathbf{s} \in \text{QAM}^{\mathbf{k}}$.

- In a 4 x 4 scenario, this would require a search over $\{\text{constellation size}\}^4$.

MIMO in SC-FDMA

- Block diagram for MIMO in SC-FDMA:



- After FFT, each subcarrier can be written as:

$$\mathbf{y} = \mathbf{Hx} + \text{noise}$$

where **x** is a combination of kN symbols (DFT result).

- In a 4 x 4 scenario, this would require a search over {constellation size}^{4N} – too much for ML!!!

MIMO in SC-FDMA – cont.

- The high search complexity requires simplified sub-optimal algorithms, such as Zero Forcing or MMSE.
- Higher performance sub-optimal schemes such as DFE impose a very high complexity.

Some Analytical Background

- Let us look at the Diversity Order and Array Gain of MMSE vs. that of ML, for M transmit & N receive antennas:

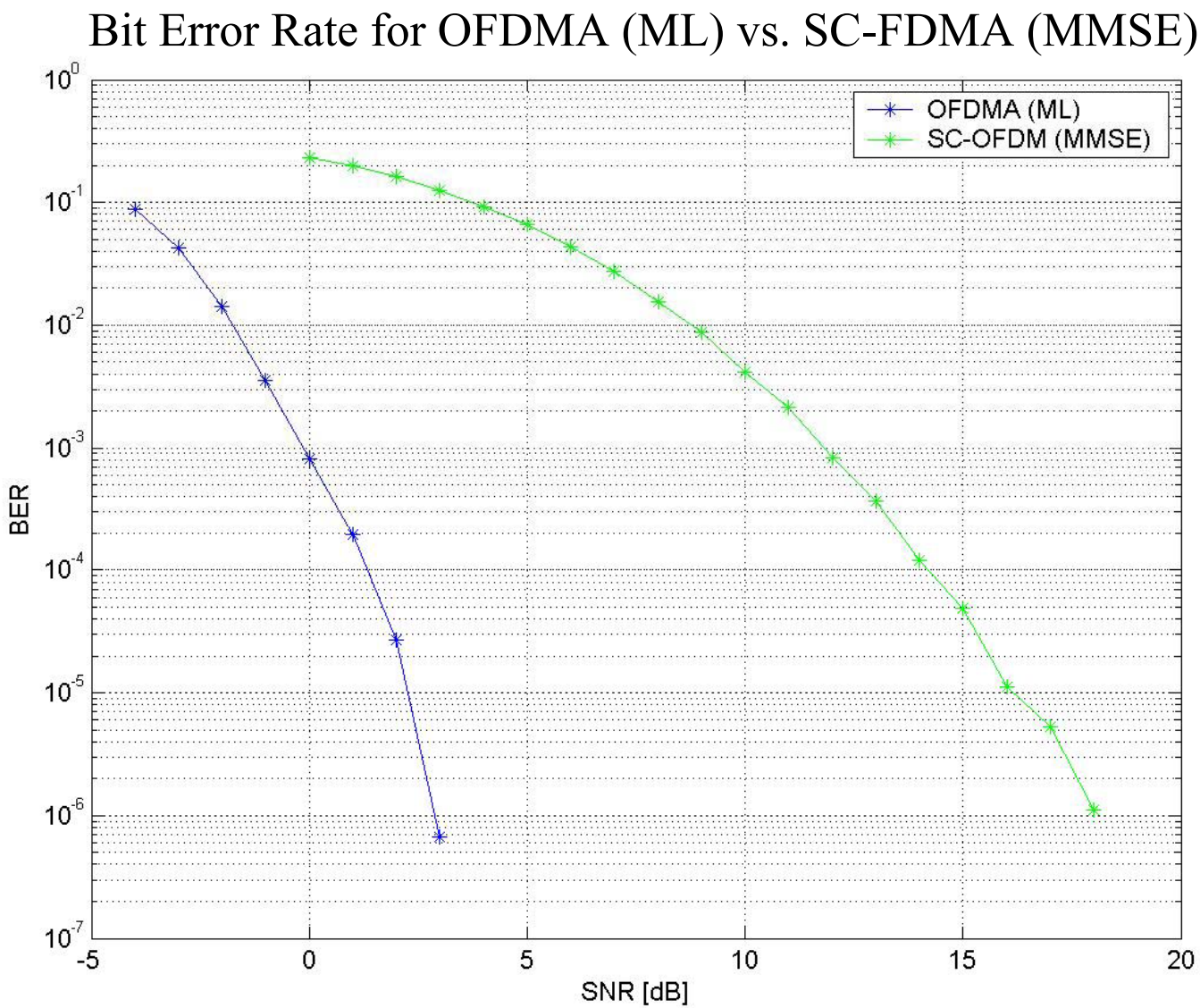
	Diversity Order	Array Gain
ML	N	N-M+1
MMSE	N/M	(N-M+1)/M

- In a 4×4 scenario, the difference is 6dB in array gain + 4^{th} order diversity which amounts to roughly 10dB at PER = 10^{-1}

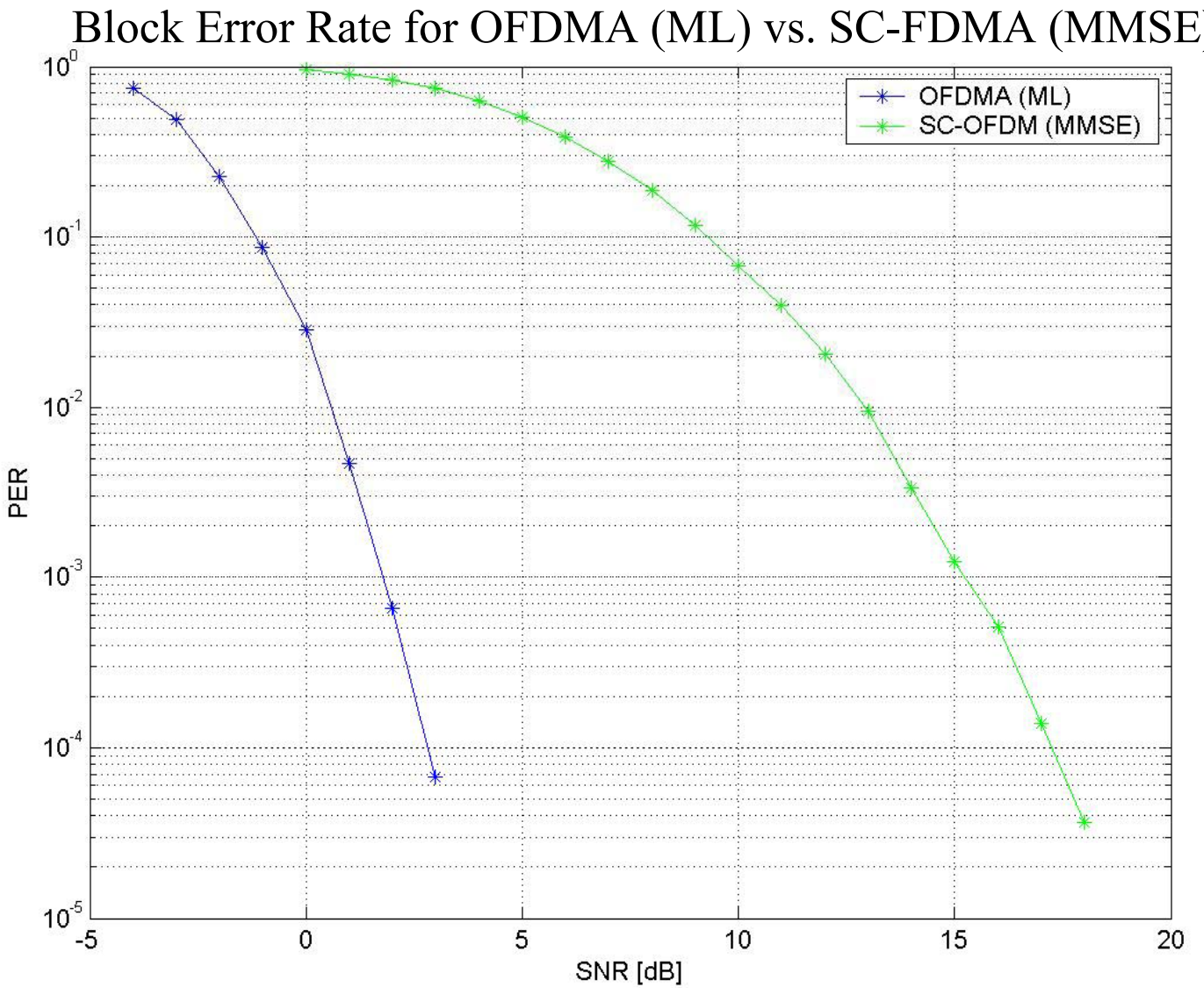
Simulation Results

- We compare the performance of 4x4 UL SDMA with ML (OFDMA) and MMSE (SC-FDMA) detectors with the following assumptions:
  - Ped-B 3km/h.
  - Uncorrelated channels.
  - QPSK rate ½ with CTC.
  - Perfect channel knowledge.
  - FEC Block Size = 480 bits.

Simulation Results – cont.



Simulation Results – cont.



Conclusions

- At PER = 10^{-1} there is a 10dB gap between SC-FDMA (MMSE) & OFDMA (ML)
- Taking SC-FDMA's 2dB lower PAPR into account, OFDMA still has an 8dB advantage
- Even when assuming a realistic near optimal ML scheme for OFDMA (decreasing performance by ~ 2dB) and a better performing scheme for SC-FDMA, there is still a large gap in favor of OFDMA!

Conclusions – cont.

- If 16m considers PAPR reduction as an important issue, plenty of alternatives are available: SLM, TR, XNN technology, etc.
- These schemes reduce the PAPR without compromising the UL SDMA performance.
- Having taken into account the UL SDMA performance degradation caused by SC-FDMA, we conclude that OFDMA should be used as the UL transmission scheme.