Low complexity MMSE interference cancellation for LTE/LTE-A uplink MIMO receiver

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Motivation

- Interference degrades receiver performance.
- Current cancellation schemes for LTE/LTE-A are not suitable for SDR implementation.
  - Not flexible to support different configuration.
  - Large feedback latency -> low throughput.
  - High complexity -> huge resource.

Low complexity interference cancellation.

Outline

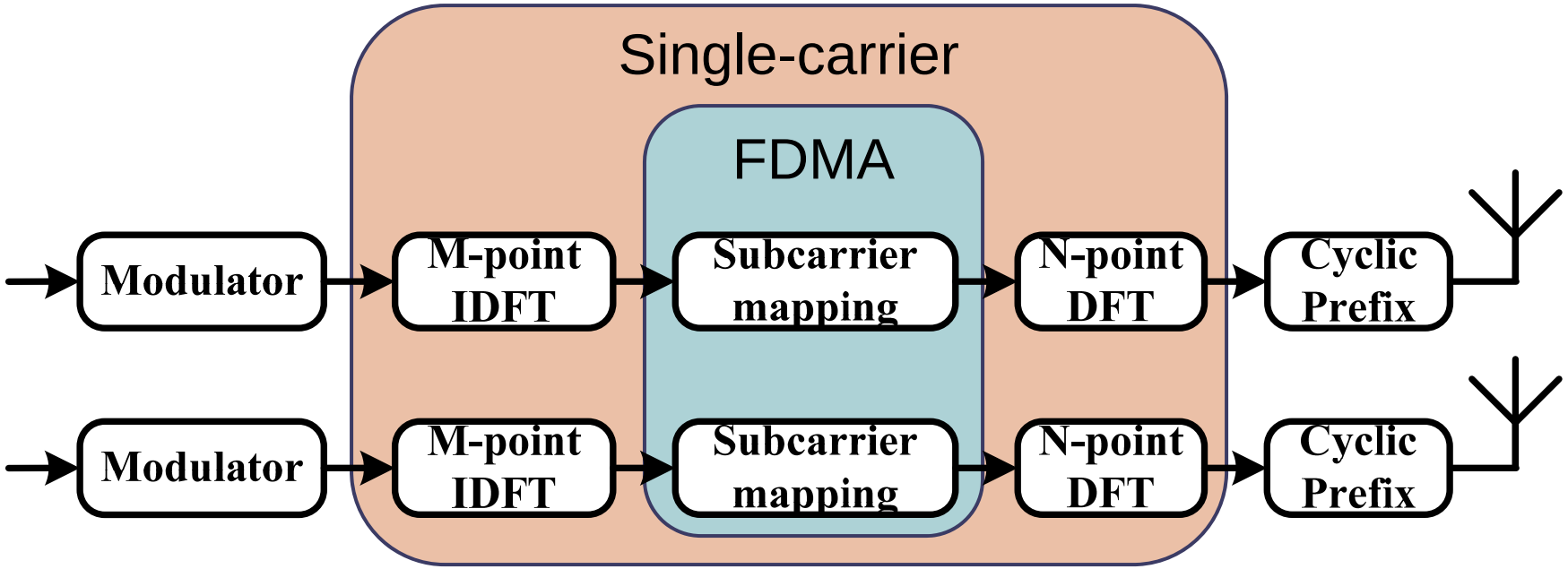
- LTE/LTE-A and SC-FDMA
- Interference and cancellation
- Proposed partial interference cancellation
- Performance comparison
- Complexity analysis

LTE/LTE-A uplink

- LTE (release 8)
  - Peak rate from 5 Mbps to 75 Mbps.
  - MIMO from 1x2 to 4x4.
  - Modulation from QPSK to 64-QAM.
  - Bandwidth from 1.4 MHz to 20 MHz.
- LTE-A
  - Carrier aggregation.
  - Backward compatible with LTE.
  - Peak rate up to 500 Mbps.
  - Bandwidth up to 100 MHz.
- SC-FDMA is adopted for uplink.

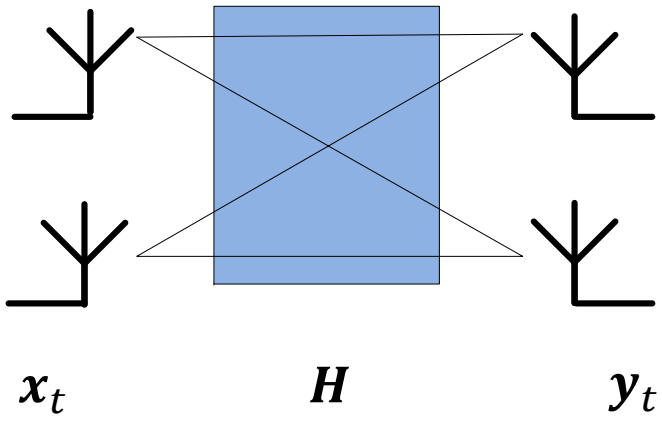
Single-carrier FDMA

- DFT-precoded OFDM.
- Low Peak to Average Power Ratio (PAPR) to OFDM -> Low power for user equipment.



Interference

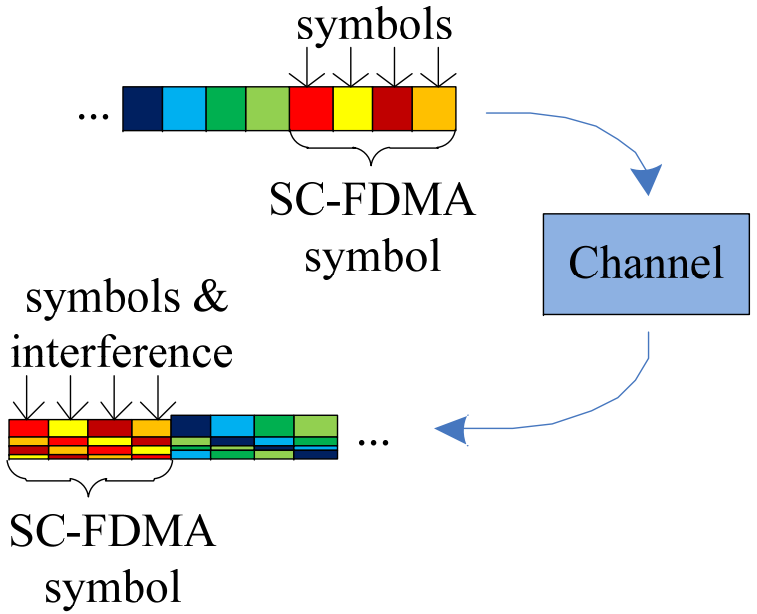
- Inter-antenna interference



$$y_t = Hx_t + n_t$$

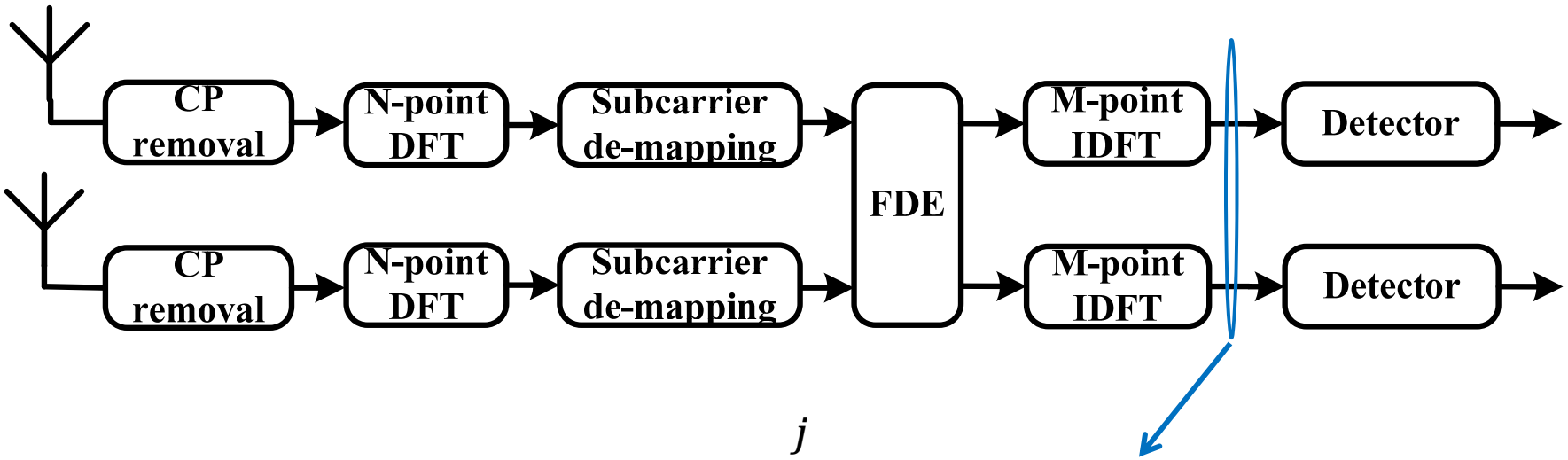
From all other antennas.

- Inter-symbol interference



From all symbols in the same SC-FDMA symbol.

Residual interference after FDE



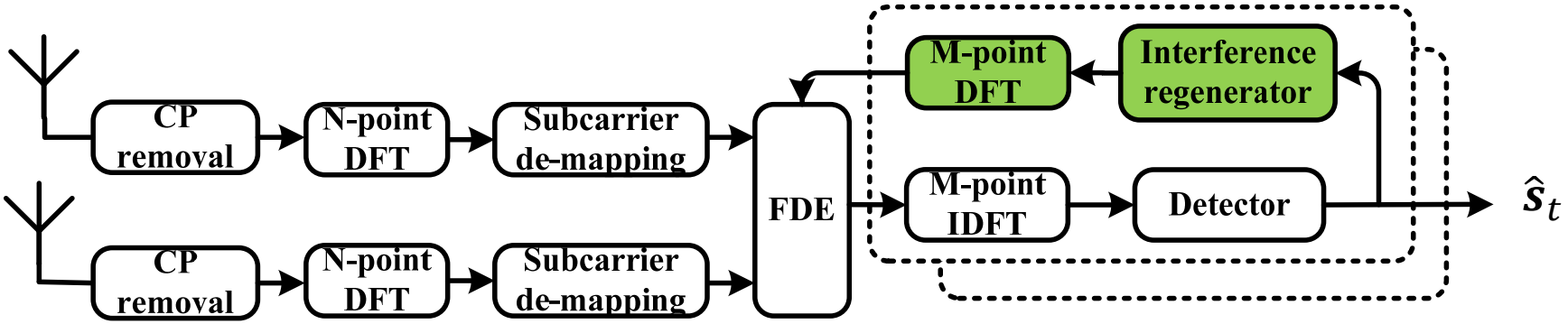
$$\boldsymbol{y}_t = \boldsymbol{h}_0\boldsymbol{s}_t + \sum_{\substack{i=j-M+1 \\ i\neq 0}}^{j} \boldsymbol{h}_i\boldsymbol{s}_{t-i} + \boldsymbol{n}_t$$

Desired symbols

Residual interference

Noise

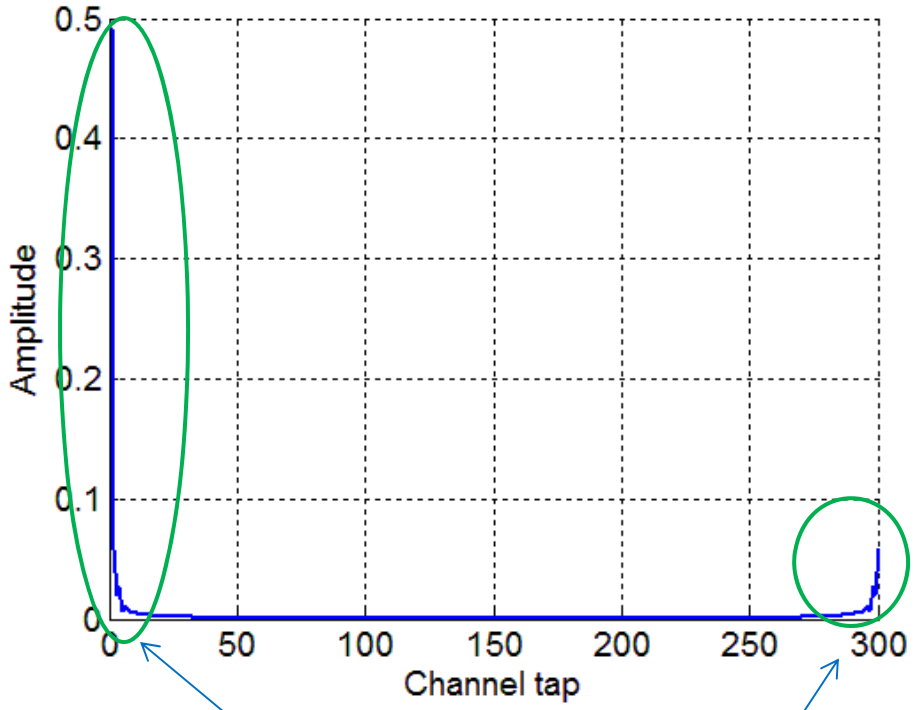
Conventional interference cancellation



$$\boldsymbol{y}_t = \boldsymbol{h}_0\boldsymbol{s}_t + \sum_{\substack{i=j-M+1 \\ i\neq 0}}^{j} \boldsymbol{h}_i\boldsymbol{s}_{t-i} - \underbrace{\sum_{\substack{i=j-M+1 \\ i\neq 0}}^{j} \boldsymbol{h}_i\hat{\boldsymbol{s}}_{t-i}}_{\text{Regenerated interference}} + \boldsymbol{n}_t$$

Interference power

- Necessary to cancel all the interference?

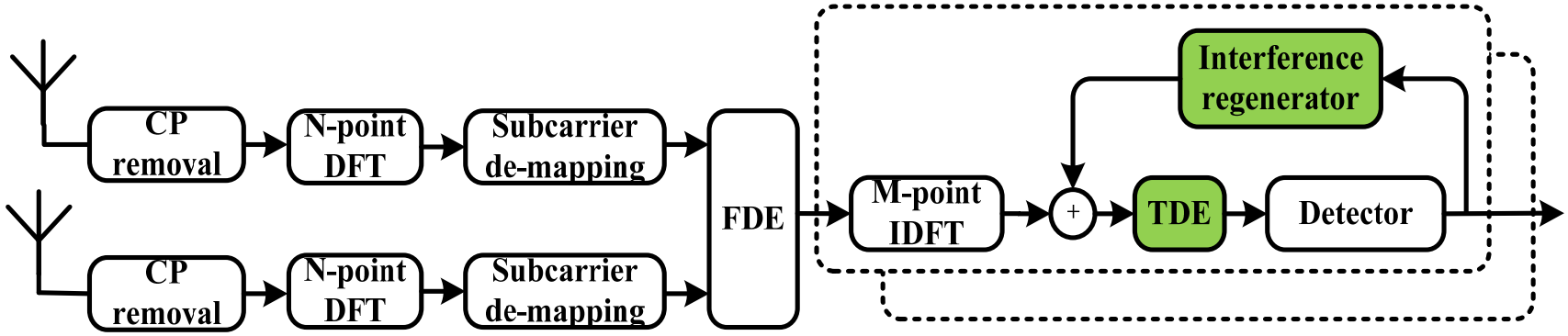


Strongest interference

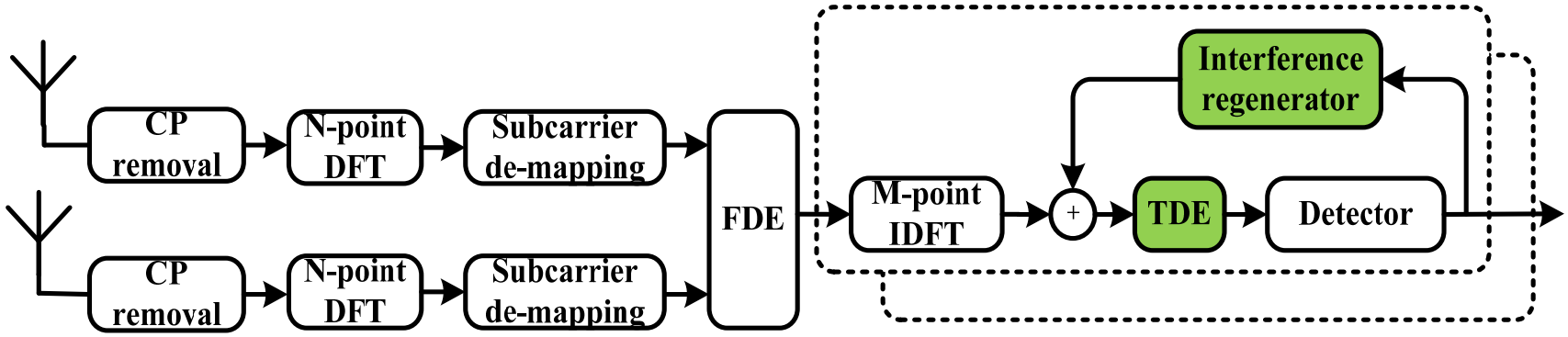
Enough to only cancel these?

Proposed low complexity scheme

- Two improvements
  - Only cancel the strongest interference.
    - Less feedback symbols needed -> Less storage.
  - Time domain cancellation without extra DFTs.
    - Shorter feedback latency.
    - Lower complexity.



Partial interference cancellation



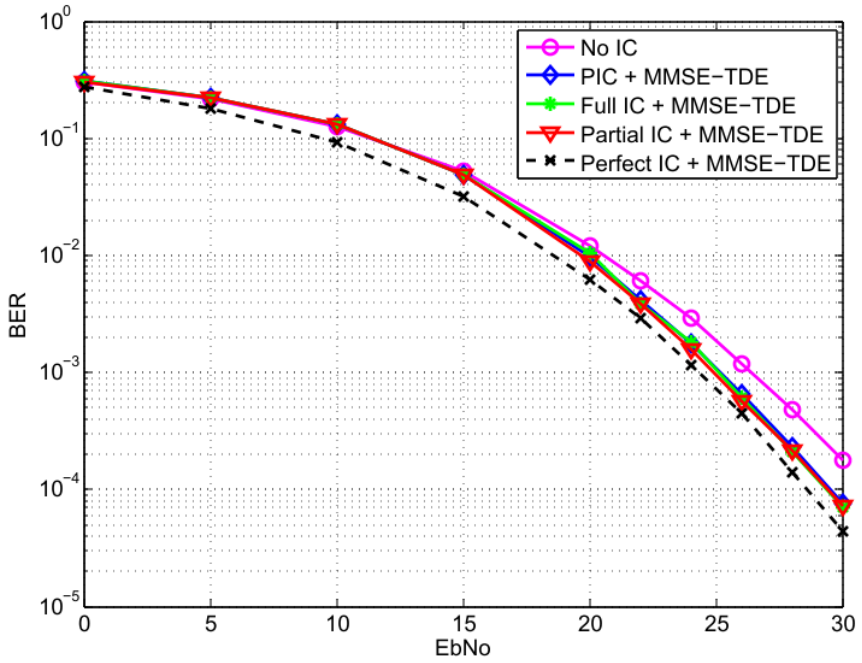
$$\boldsymbol{y}_t = \boldsymbol{h}_0\boldsymbol{s}_t + \sum_{\substack{i=j-M+1 \\ i\neq 0}}^{j} \boldsymbol{h}_i\boldsymbol{s}_{t-i} - \underbrace{\sum_{\substack{i=-L_{FF} \\ i\neq 0}}^{L_{FB}} \boldsymbol{h}_i\hat{\boldsymbol{s}}_{t-i}}_{\text{Regenerated partial interference}} + \boldsymbol{n}_t$$

Simulation parameters

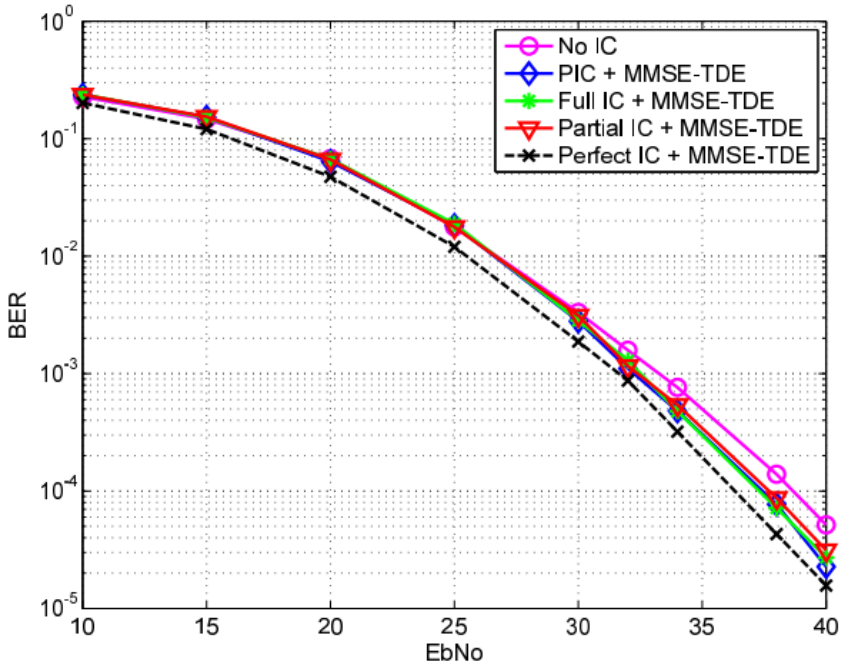
- Different configuration of LTE/LTE-A standard
  - Length of DFT: 512
  - Length of IDFT: 300
  - Length of CP: 36
  - Modulation order: 16-QAM, 64-QAM
  - Number of antennas: 2x2, 4 x 4
- Channels: Rayleigh; Winner C1
- FDE: MMSE-FDE
- TDE: MMSE-TDE
- L_{FF}: 15
- L_{FB}: 15

Performance comparison

4x4 MIMO;16-QAM;Rayleigh channels

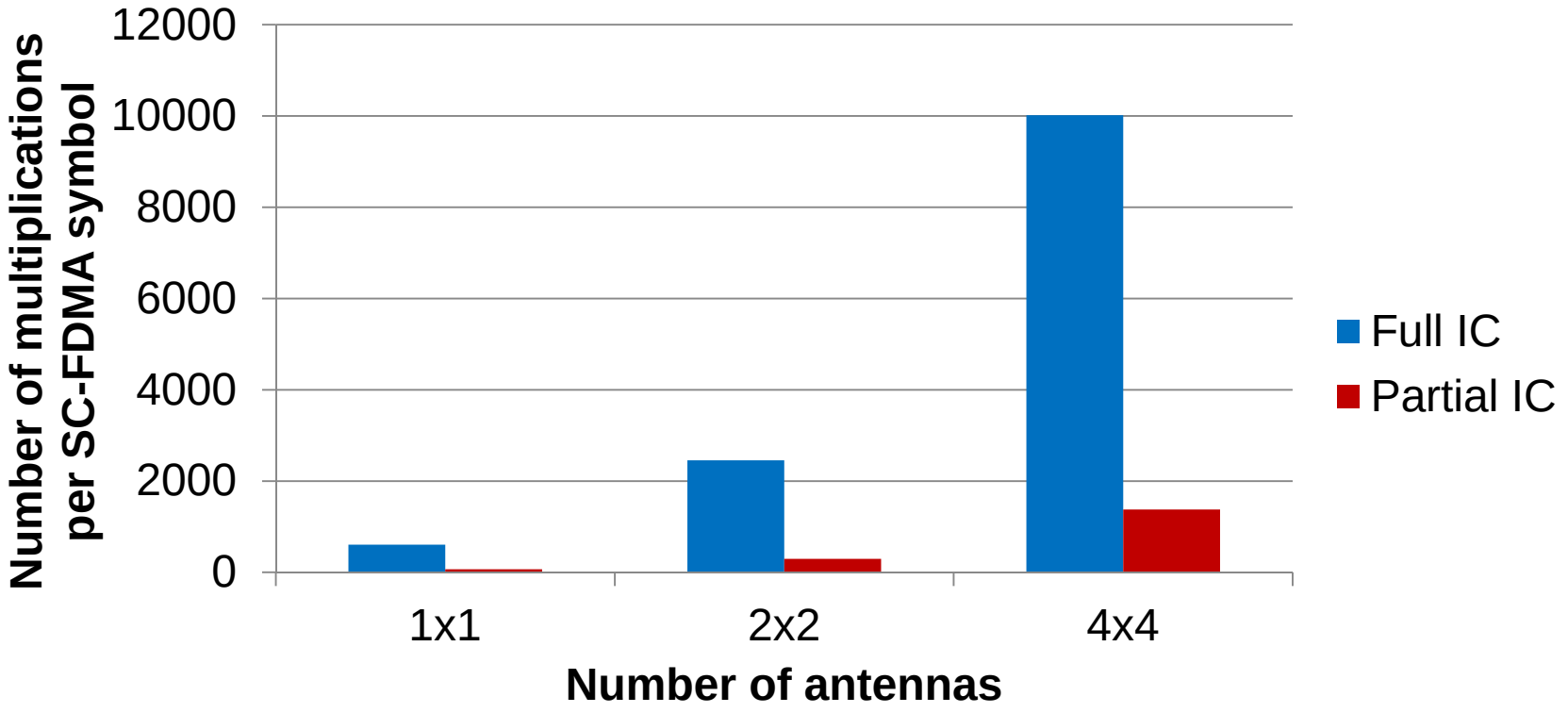


4x4 MIMO;64-QAM;Rayleigh channels



- Partial IC improves the performance by a few dB from no IC.
- No performance loss compared with conventional full IC.

Complexity analysis



- Partial IC is less than 13.7% of conventional full IC.
- Reduction is from less IC and removal of extra DFTs.

Summary

- Performance of partial interference cancellation is almost same as full interference cancellation.
- Complexity of partial interference cancellation is 86.3% lower than full interference cancellation.
- Feasible for SDR receiver.
  - Support different configuration.
  - Shorter feedback latency.
  - Lower complexity.
  - Less data storage.