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Simulation and field test results of MMSE-IRC receiver at LTE BS

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Outline

- Introduction
- Simulation results
- Field test results
- Conclusions

Introduction

- The benefit of employing MMSE-IRC receiver at LTE BS and necessity of starting new work on related performance requirements in RAN4 are discussed in our companion contribution [1].
- In RAN4, the existing demodulation performance requirements for uplink channels are specified based on MMSE receiver without IRC capability.
- In this contribution, we provide some simulation results and field test results to show the performance gain with MMSE-IRC receiver compared to MMSE without IRC for LTE UL.

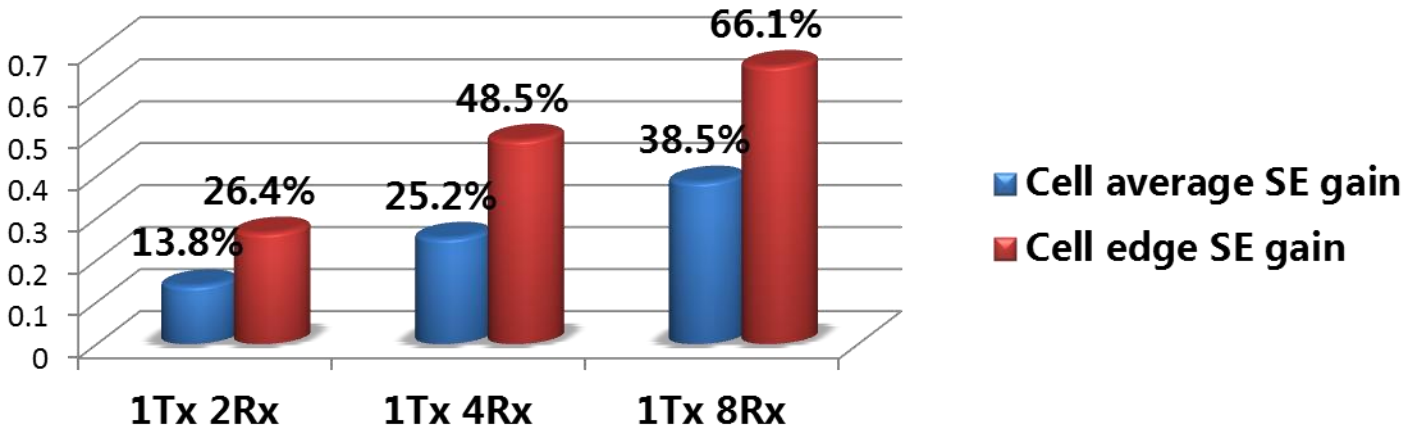
MMSE-IRC receiver for LTE BS: Simulation results (1/2)

System-level simulation assumptions

- UL, FDD, 2GHz, 10MHz bandwidth, full buffer
- Layout: ISD=500m, 57 macro-cells with wrap around
- Antenna configuration: Cross-polarized antennas, 0.5 wavelength spacing
- Estimation of covariance matrix: based on the DM-RS from a UE to its serving cell, and estimation error is modeled according to the methodology introduced in TR 36.829 [1].
- More detailed simulation assumptions are described in the Annex.

Gain of MMSE-IRC over MMSE in homogeneous network

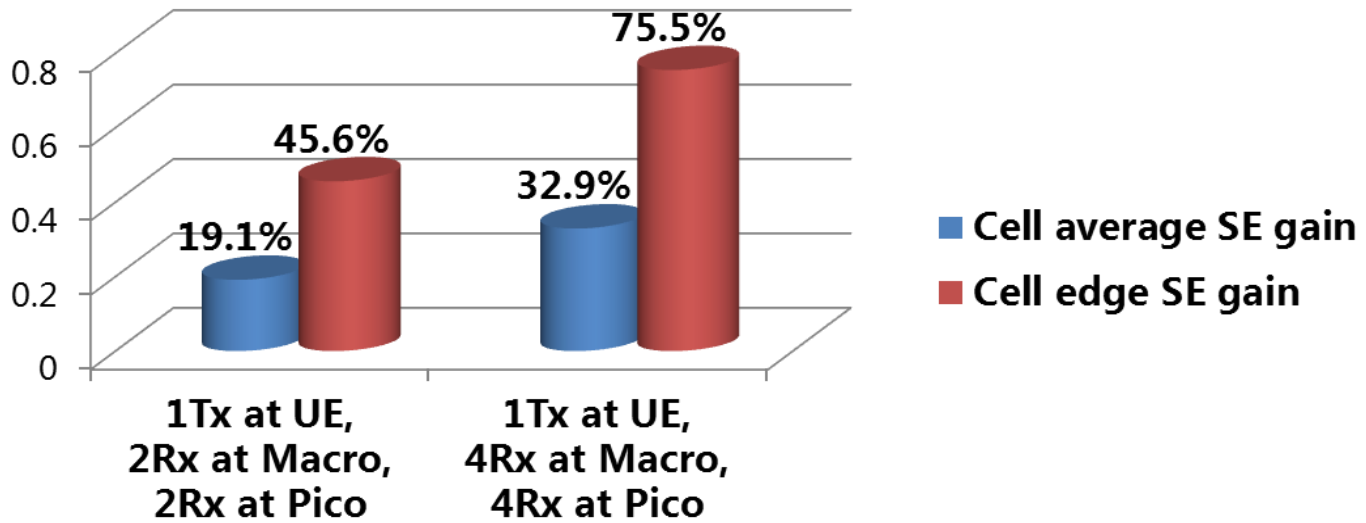
- UE density: 10 users in each Macro geographical area



MMSE-IRC receiver for LTE BS: Simulation results (2/2)

➢ Gain of MMSE-IRC over MMSE in heterogeneous network

- Pico deployment: co-channel deployed with Macro, 4 Picos per Macro area
- UE density: Configure #4b, totally 30 users in each Macro area
- CRE bias: 6dB



MMSE-IRC receiver could achieve big gain over MMSE receiver without IRC in both cell-edge and cell-average spectral efficiency.

- ✓ The performance gain increases with the number of Rx antennas.
- ✓ With a certain number of Rx antennas, the gain obtained in heterogeneous network is higher than that in homogeneous network.

MMSE-IRC receiver for LTE BS:
Field test results

- Field test configuration
  - UL, FDD, 10MHz bandwidth
  - Radio environment: urban with macro BS
  - Antenna configuration: 1 Tx at UE, 8 Rx at BS
  - No. of interfering UE: 1
  - Performance metric:
    - ✓ During the tests, the targeting UE is moving from cell center to cell edge, and the received SINR is changing with UE position.
    - ✓ The performance gain of MMSE-IRC over MMSE is measured in terms of SINR improvement for PUSCH, which is the average value of the results seen at multiple different positions of the targeting UE.
- Gain of MMSE-IRC compared to MMSE without IRC
  - Significant SINR improvements are observed in the field tests conducted by several companies.
    - ✓ At least 6.7dB SINR improvement, with 8dB IoT level
    - ✓ At least 3.3dB SINR improvement, with 5dB IoT level

Conclusions

- The contribution investigated the performance gain of using MMSE-IRC receiver at LTE BS.
- System-level simulation results showed that compared to MMSE, MMSE-IRC can achieve 13.8%~38.5% cell average SE gain and 26.4%~75.5% cell edge SE gain.
- Meanwhile, field test results showed that, MMSE-IRC can improve PUSCH SINR by at least 6.7dB and 3.3dB when the IoT levels are set as 8dB and 5dB respectively.

References

[1] R4-133917, Proposal for new work on performance requirements of MMSE-IRC receiver at LTE BS, RAN4 #68, August 2013.

[2] TR 36.829 V11.1.0, Enhanced performance requirement for LTE User Equipment (UE), December 2012.

Thank You!

Annex: System-level simulation assumptions

System-level simulation parameters

Parameters	Values
System layout	19 macro-sites (57 macro-cells), wrap-around
UE density	✓ Homogeneous network: 10 UEs per Macro cell ✓ Heterogeneous network: configure #4b, i.e., randomly and uniformly drop 4 Picos per Macro cell, 5 UEs per Pico cell and totally 30 UEs per Macro cell
ISD	500m
Carrier frequency	2GHz
Bandwidth	FDD, 10MHz
Antenna pattern	✓ Macro cell: 3D pattern defined in TR.36.814 with antenna down tilt 12 degrees ✓ Pico cell: 2D pattern, omni-directional
Power control	Fractional power control
Maximal UE TX power	23dBm
UE velocity	3km/h
Channel model	ITU Uma for Macro cell, ITU UMi for Pico cell
Antenna configuration at BS	Cross-polarized antennas with 0.5 wavelength spacing
MCS	29 MCS levels
Traffic model	Full buffer
BS scheduler	Proportional Fair
Link adaptation	SRS period: 5ms, total delay: 6ms
HARQ modelling	Chase combining with maximum 4 transmissions

System-level simulation: Receiver structure

- **The uplink received signal at cell 0 can be expressed as:**

$$\mathbf{y}(k,l) = \mathbf{H}_0(k,l)x_0(k,l) + \sum_{i=1}^{Ncell-1} \mathbf{H}_i(k,l)x_i(k,l) + \mathbf{n}(k,l)$$

  - $\mathbf{y}(k,l)$ is the received signal vector at the k-th subcarrier and l-th OFDM symbol
  - $\mathbf{H}_i(k,l)$ is the channel matrix from the UE scheduled by cell i to cell 0
  - $x_i(k,l)$ is the transmission data from the UE schedule by cell i
  - $\mathbf{n}(k,l)$ is additive white Gaussian noise vector

- **The receiver weight matrix for MMSE receiver is given as:**

$$W_{MMSE}(k,l) = \hat{\mathbf{H}}_0^H(k,l)\mathbf{R}^{-1} \qquad \mathbf{R}(k,l) = P_0\hat{\mathbf{H}}_0(k,l)\hat{\mathbf{H}}_0^H(k,l) + \sigma^2\mathbf{I}$$

  - $\hat{\mathbf{H}}_0(k,l)$ and σ^2 denote the estimated channel matrix and noise power
  - P_0 denotes the transmission power of the UE scheduled by cell 0

- **The receiver weight matrix for MMSE-IRC receiver is given as:**
  - DM-RS based covariance matrix estimation scheme is used in the simulation

$$W_{MMSE_IRC}(k,l) = \hat{\mathbf{H}}_0^H(k,l)\mathbf{R}^{-1}$$

$$\mathbf{R}(k,l) = P_0\hat{\mathbf{H}}_0(k,l)\hat{\mathbf{H}}_0^H(k,l) + \frac{1}{N_{DRMS}} \sum_{(k,l)\in DMRS} \tilde{y}(k,l)\tilde{y}^H(k,l)$$

$$\tilde{y}(k,l) = y(k,l) - \sqrt{P_0}\hat{\mathbf{H}}_0(k,l)x_0(k,l) \quad (k,l) \in DMRS$$