ChEG

Chinese Evaluation Group

Some Considerations on LTE-A Evaluation

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3GPP Workshop for the Independent Evaluation Groups

Outline

- Overview of LTE-A evaluation
- MU-MIMO considerations
- CoMP considerations
- Sounding modeling

LTE-A features in self-evaluation for ITU-submission

- Wider bandwidth support (40MHz) ⟷ Carrier aggregation
- Peak spectral efficiency ⟷ Downlink: **R8 (4x4),** HO-MIMO (8x8); Uplink: SU-MIMO (2x2, 4x4)
  - Downlink: 15 bits/s/Hz
  - Uplink: 6.75 bits/s/Hz
- Full buffer service ⟷ Downlink: **CoMP-JP / MU-MIMO**; Uplink: **UL MU-MIMO / SU-MIMO / CoMP**
  - Cell spectrum efficiency evaluation
  - Cell edge spectrum efficiency evaluation
  - R8 can't meet ITU RQ in UMi and UMa
  - CoMP and MU-MIMO satisfy UMi and UMa
  - Risk for R8 in UMi, due to high overhead
- VoIP capacity
- Mobility evaluation
- Latency for UP (<=10ms) and CP (<=100ms)
- Handover interruption times
- Link budget

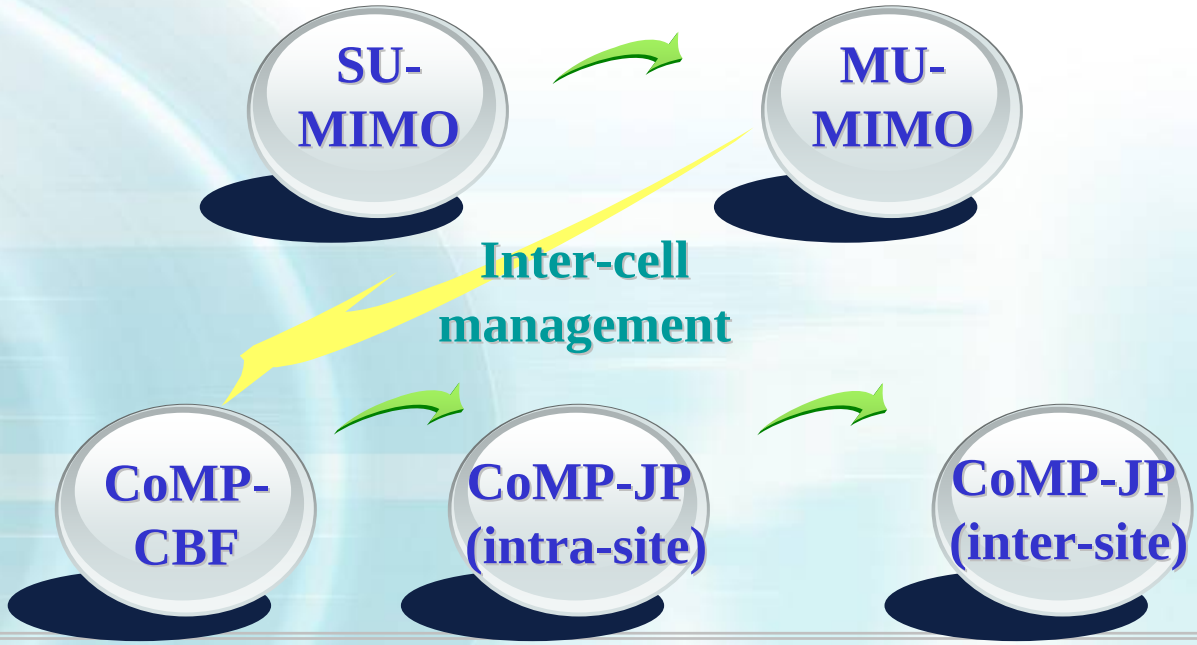
⟷ R8 enough

Some basic assumptions in ITU and their impacts

- Full buffer traffic
  - It is not a real traffic and system is overloaded
  - The throughput results are the upper bound
- Quasi-static simulator
  - Users are static
  - No modeling for UE moving and handover
- Real channel estimation
  - How real is the modeling?
  - Vendors have different implementation methods
- No control channel error
  - The required BLER for PDCCH is 1%
  - The control channel error's impact is FFS

Evolving Multi-antenna Techniques

- In most cases, LTE is an interference-limited system. SINR is restricted by the inter-cell interference (ICI).
- How to mitigate or even cancel the ICI is the key point to improve the system SINR.
- Rank adaptation and users pairing can make full use of high SINR thus can get high throughput.



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Introduction of MU-MIMO

MU-MIMO

- a typical feature for 3GPP LTE-A self-evaluation
- also evaluated in 802.16m self-evaluation
- Its performance outperforms ITU requirements.

Results of 3GPP LTE-A TDD Self-evaluation (Up to 2-user Pairing)

Scheme and antenna configuration	Scheme and antenna configuration	ITU Requirement (Ave./Edge)	Cell average [b/s/Hz/cell]			Cell edge [b/s/Hz]		
			L=1	L=2	L=3	L=1	L=2	L=3
InH	MU-MIMO 4 x 2 (C)	3 / 0.1	6.7	6.1	5.6	0.24	0.22	0.20
UMi	MU-MIMO 4 x 2 (C)	2.6 / 0.075	3.5	3.2	3.0	0.11	0.096	0.089
UMa	MU-MIMO 4 x 2 (C)	2.2 / 0.06	2.9	2.6	2.4	0.079	0.071	0.067
RMa	MU-MIMO 4 x 2 (C)	1.1 / 0.04	3.5	3.2	3.0	0.098	0.089	0.083

Key Points of MU-MIMO

Joint Precoding

- Joint precoding with BD or ZF is a very efficient way to depress inter-user interference.
- PMI + long term CSI based MU-MIMO is applicable for FDD/TDD.
- Short term CSI with channel reciprocity is utilized for TDD.

CSI estimation

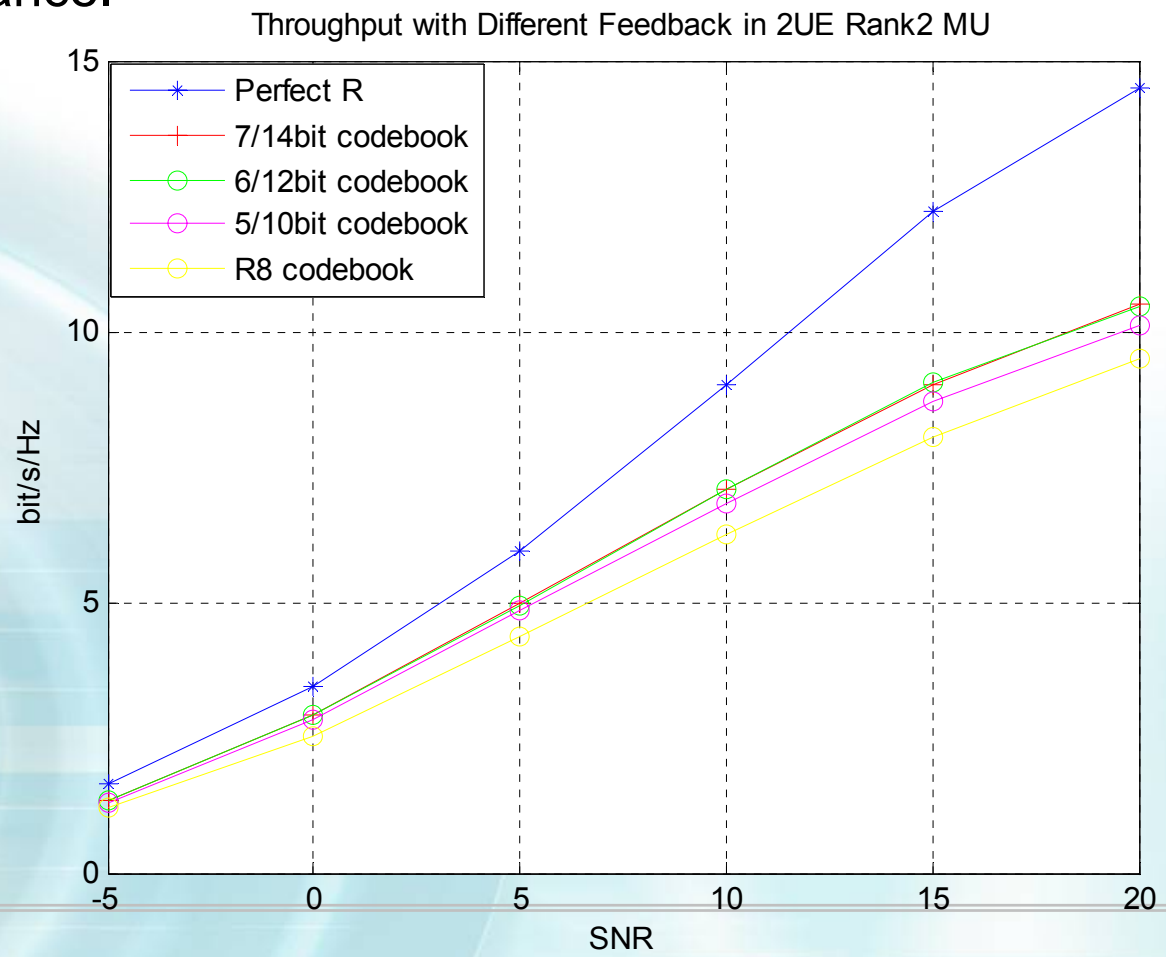
- Rel8 CQI feedback can be used as basic information.
- MCS adjustment based on multi-user CSI is needed for more accurate estimation.
- MCS can also be adjusted by ACK/NACK ratios.

Scheduler design

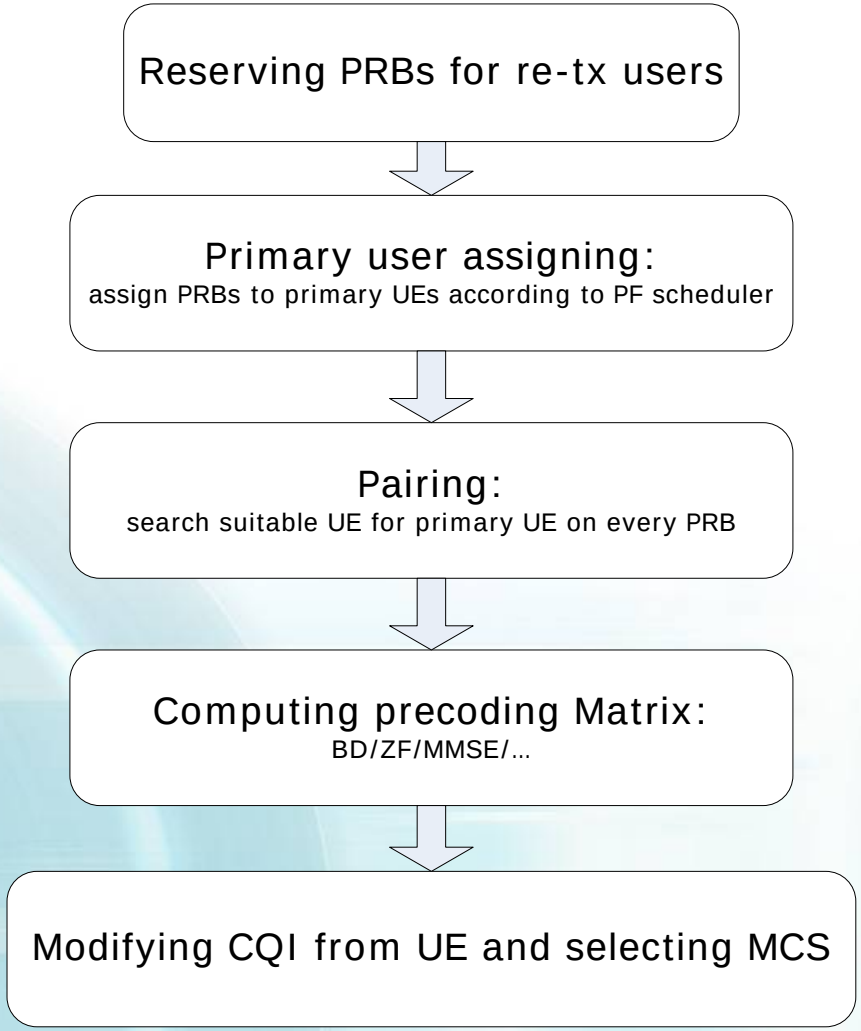
- Rank adaptation and MU/SU adaptation can avoid cell edge performance degradation.
- Users Pairing algorithm is very important to ensure high performance.

Impact of UE feedback

- Impact of UE feedback should be taken into account.
- In general, there is a tradeoff between feedback overhead and performance.



Example of Scheduler Processing



Example of Scheduler Details

SU/MU adaptation:

- Set a threshold of channel quality to switch between SU/MU, such as Geometry or CQI ;
- Primary user whose channel quality is under the threshold could not be paired with other users .

Pairing algorithm (based on Max Capacity Principle) :

- eNB obtains channel information H of each UE from Sounding RS ;
- Compute the capacity of SU on every PRB;
- Obtain the total capacity of Multi-users with pre-pairing other UEs with the primary UE on each PRB;
- If the maximum capacity of MU is over SU, both primary and corresponding paired UE are scheduled on the PRB, otherwise only primary UE is scheduled.

Example of Scheduler Details (cont'd)

Capacity Estimation:

$$C_{SU} = \log(1+SINR_{SU\_primaryUE})$$

$$C_{MU} = \log(1+SINR_{MU\_primaryUE}) + \log(1+SINR_{MU\_pairedUE})$$

Hereof,

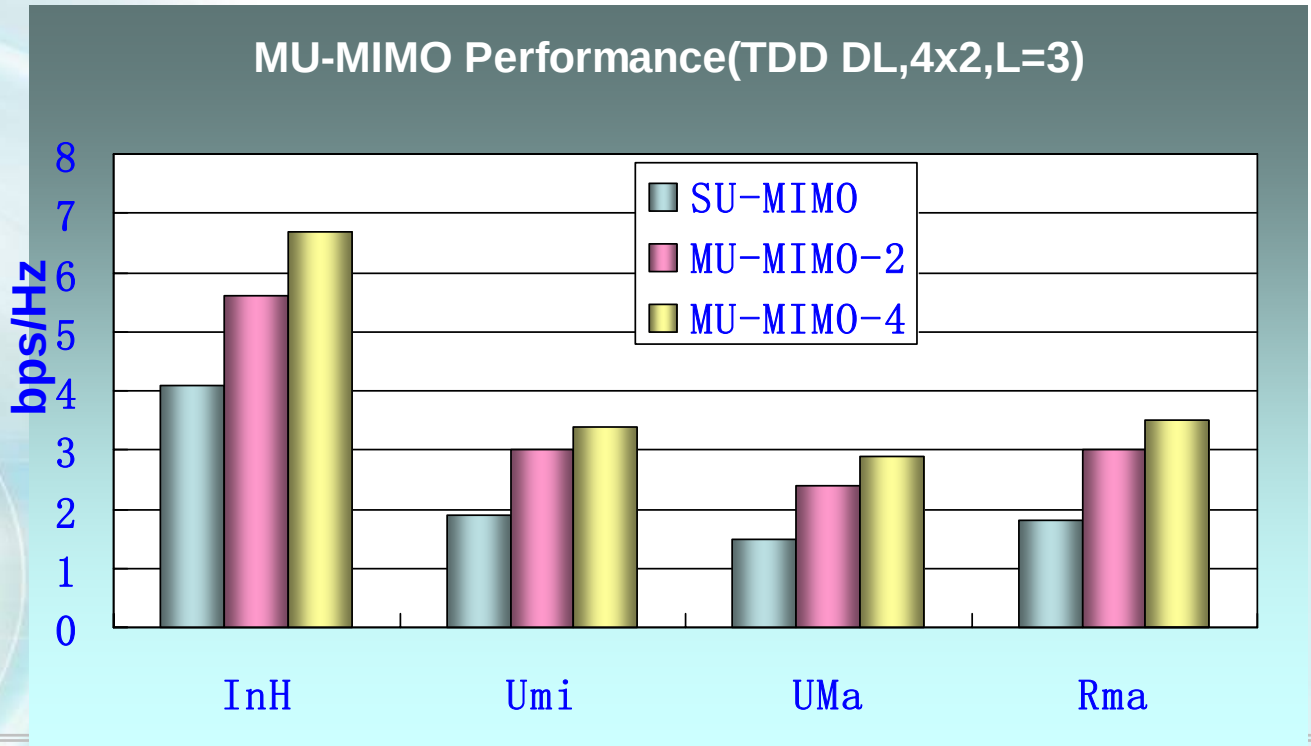
$SINR_{SU\_primaryUE}$ is computed based on H, CQI, and precoding matrix W_{SU} where W_{SU} is derived from SVD;

$SINR_{MU\_primaryUE}$ and $SINR_{MU\_pairedUE}$ are from H, CQI, and precoding matrix W_{MU} where W_{MU} is derived from W_{SU} of both primary and paired UEs according to ZF or BD algorithm.

MU-MIMO Performance

Cell Average Performance (LTE-A TDD)

- Current self-evaluation of MU-MIMO show 40-60% performance gain over LTE-R8 SU-MIMO;
- MU-MIMO up to 4-user paring can get further 15-20% gain;



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CoMP Concept & Categories

CoMP: Coordinated Multi-Point Access Network

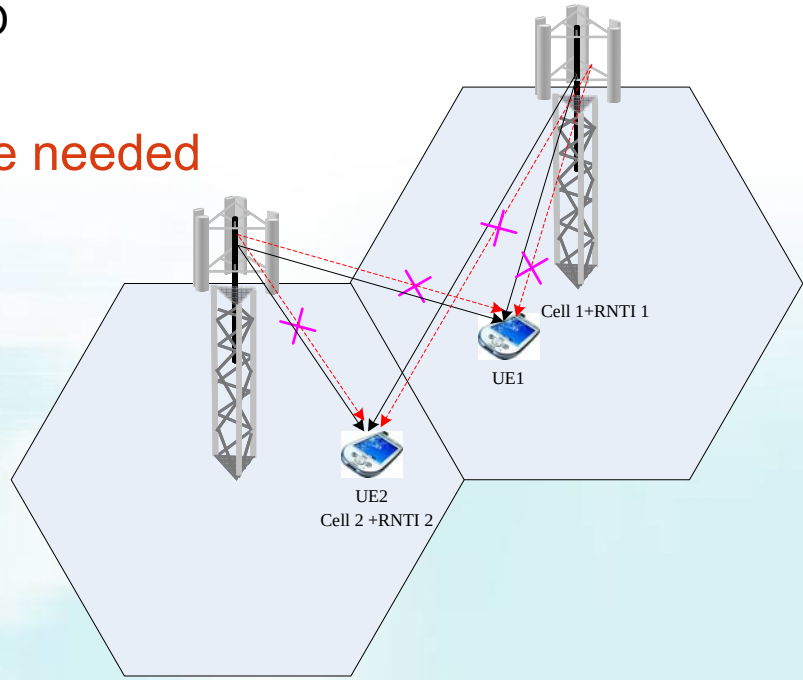
- **According to coordination nodes**
  - **Inter-eNB CoMP**
  - ***Intra-eNB CoMP***
- **According to number of coordinated users per cell**
  - **SU-CoMP**
  - ***MU-CoMP***
- **According to data availability at multiple points**
  - ***Joint processing:***
    - **Joint Transmission: PDSCH transmission from multiple points at a time**
    - **Dynamic cell selection: PDSCH transmission from one point at a time**
  - **CB/CS:**
    - **CBF: no tight scheduling limit**
    - **CBS: tight scheduling limit**

CoMP Joint Processing (JP)

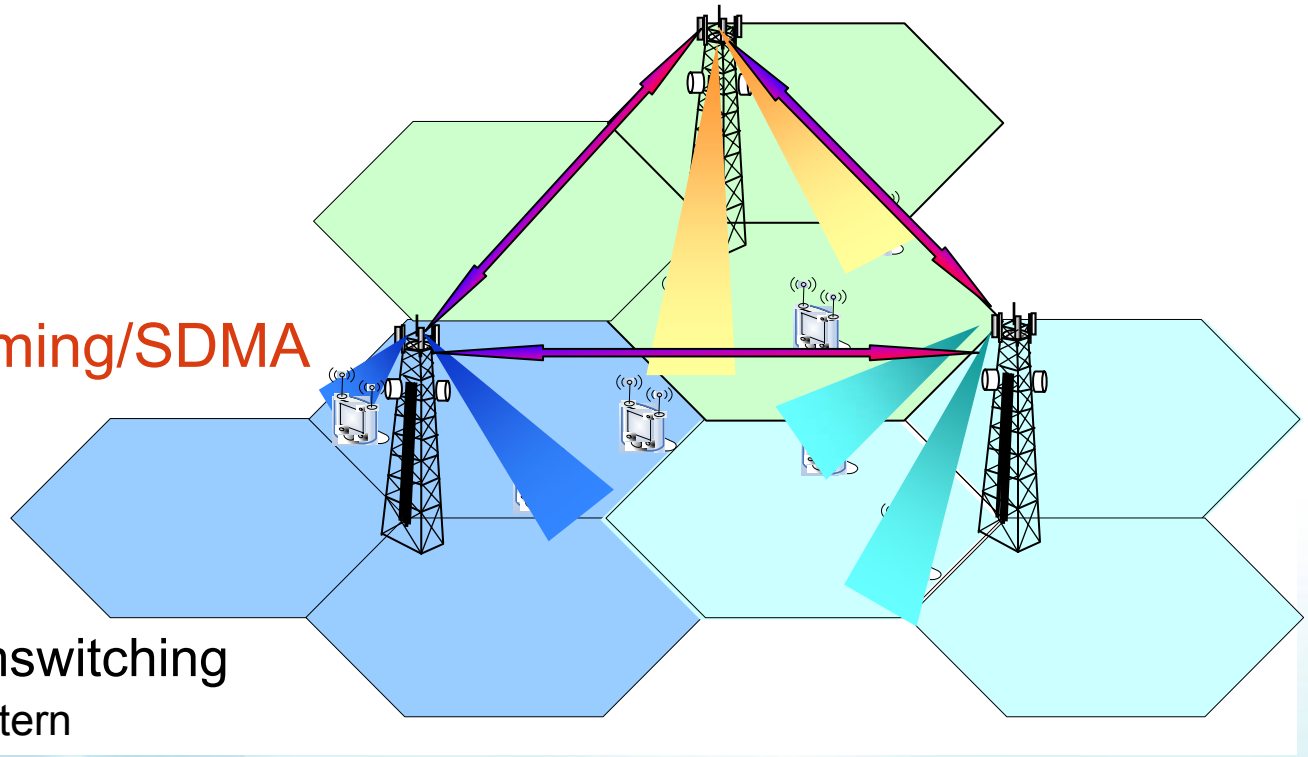
- Joint Transmission: PDSCH transmission from multiple points at a time
- Dynamic cell selection: PDSCH transmission from one point at a time

- UE specific DM-RS from multiple points simplifies CoMP transmission
  - PDSCH detection based on DM-RS, which minimizes the new signaling
  - Same DM-RS design as single cell MU-MIMO

- Multi-cell measurement and feedbacks are needed
  - Multi-cell CSI-RS multiplexing
  - Multi-cell feedback design
  - Channel reciprocity helps to reduce feedback overhead, esp. in TDD



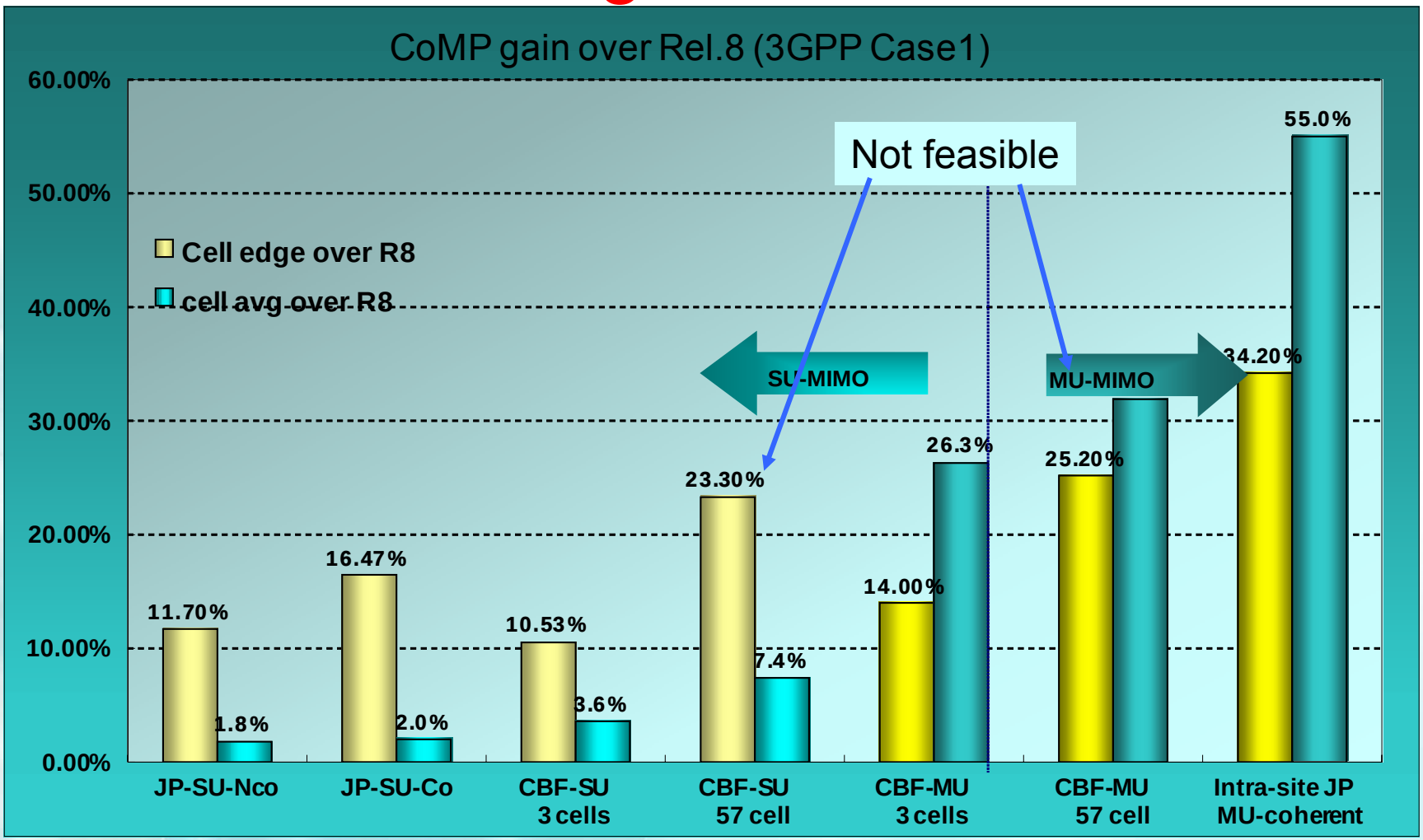
CoMP CB/CS



- Uncoord. Beamforming/SDMA

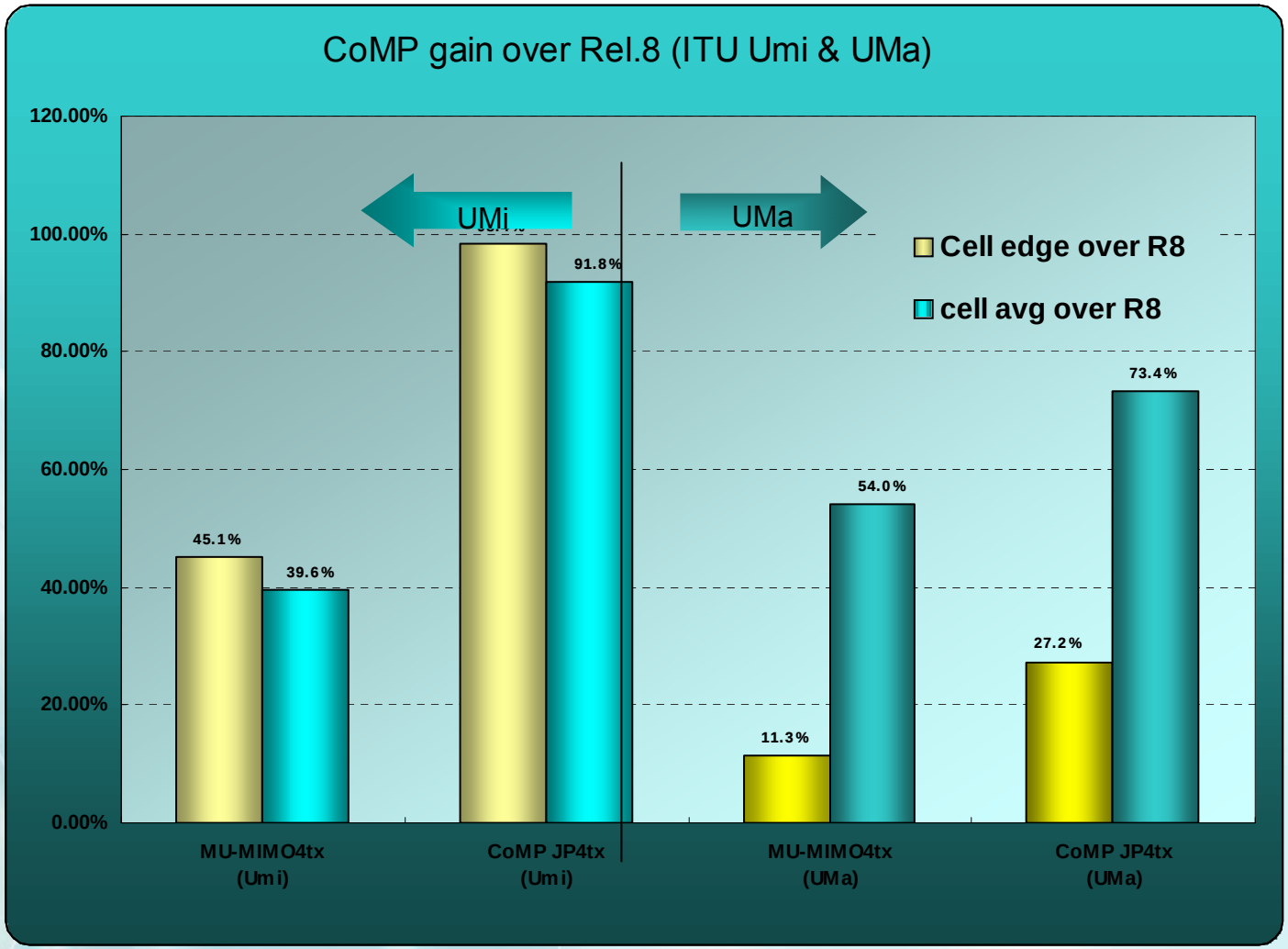
- CoMP CB/CS
  - Coordinated beamswitching
    - Periodic beam pattern
    - CQI based on periodicly precoded RS to avoid flashlight effect
    - Low impact on backhaul
  - Coordinated beamforming
    - More flexible scheduler than CBS
    - Require multiple cell CSI

DL CoMP Categories and Evaluation



- Attractive gain only by combining CoMP with MU-MIMO
- Intra-site CoMP JP is recommended for evaluation

Simulation results



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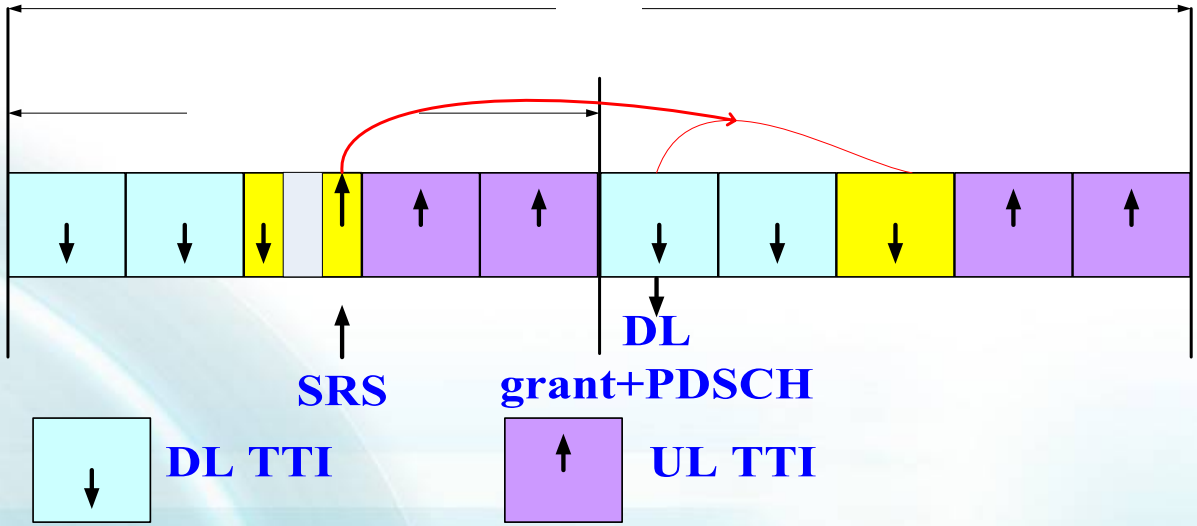
SRS modeling

- UL SRS is used to get the DL channel in TDD systems. Its performance depends on:
  - SRS delay and period



  - SRS estimation error
    - SRS power control: open-loop, P0 = -84dBm， alpha = 0.8

$$P_{\mathrm{SRS}}(i) = \min\{P_{\mathrm{MAX}}, 10\log_{10}(M_{\mathrm{SRS}}) + P_{\mathrm{O\_PUSCH}}(j) + \alpha \cdot PL\}$$

Half frame (5ms)

    - SRS SINR calculation

SINR calculation for SRS

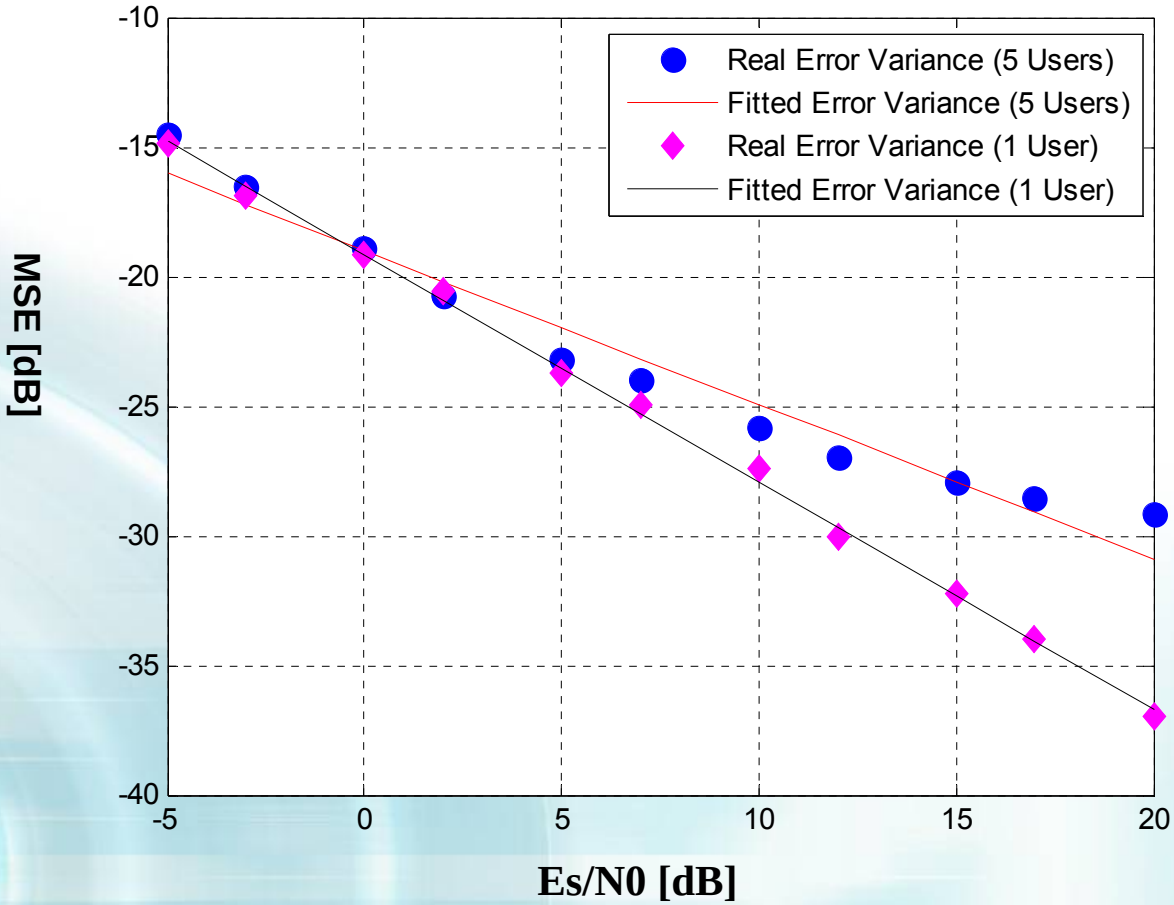
- Procedures of SRS modeling
  - The interference comes from the co-channel interference from UE sounding in other cells in the same symbol-subcarrier domain.
  - After getting the SINR, then the SRS error covariance according to this SINR value is obtained from the link level results.

$$\tilde{\mathbf{H}}_{k,l} = \mathbf{H}_{k,l} + \Delta\mathbf{H}_{k,l}$$

  - $\tilde{\mathbf{H}}_{k,l}$ is used by eNB to do EBB, or other actions.

Link Level Results

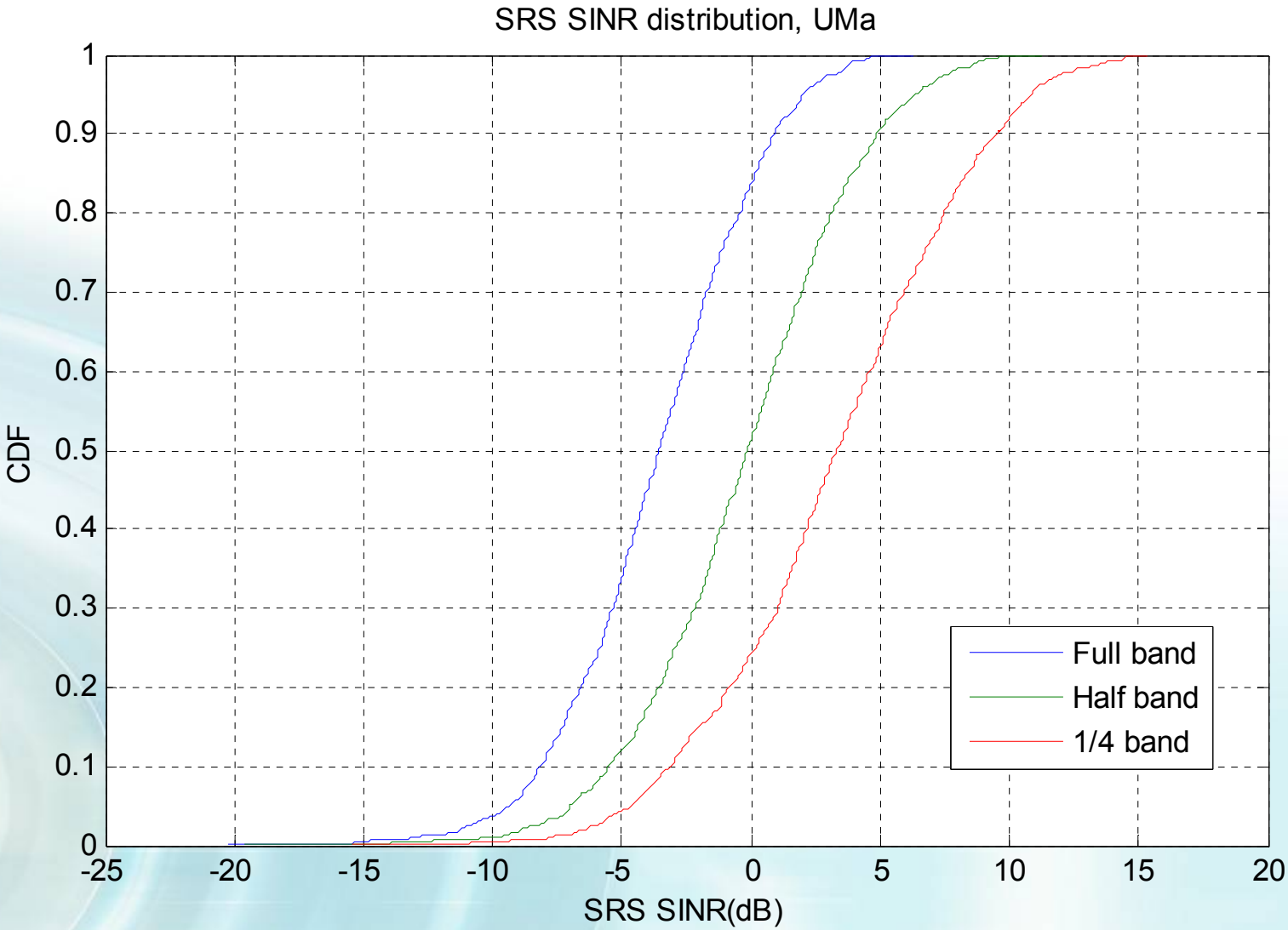
SRS, InH, 2D-MMSE



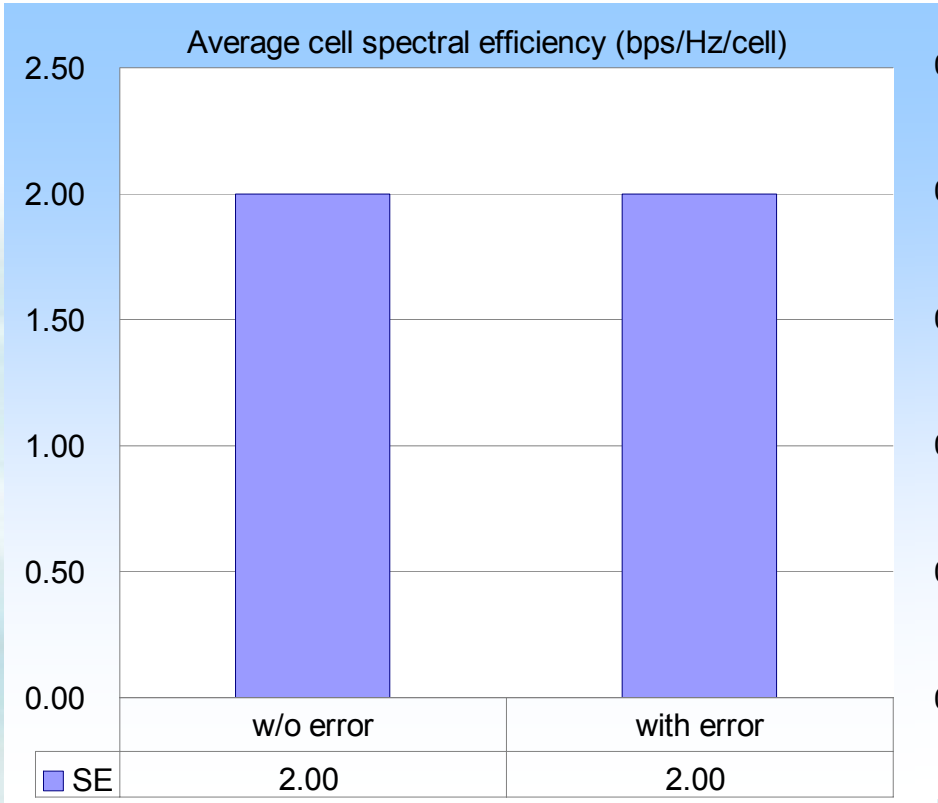
σ_E^2 (dB) = -18.9992 - 0.5946 SNR (dB)

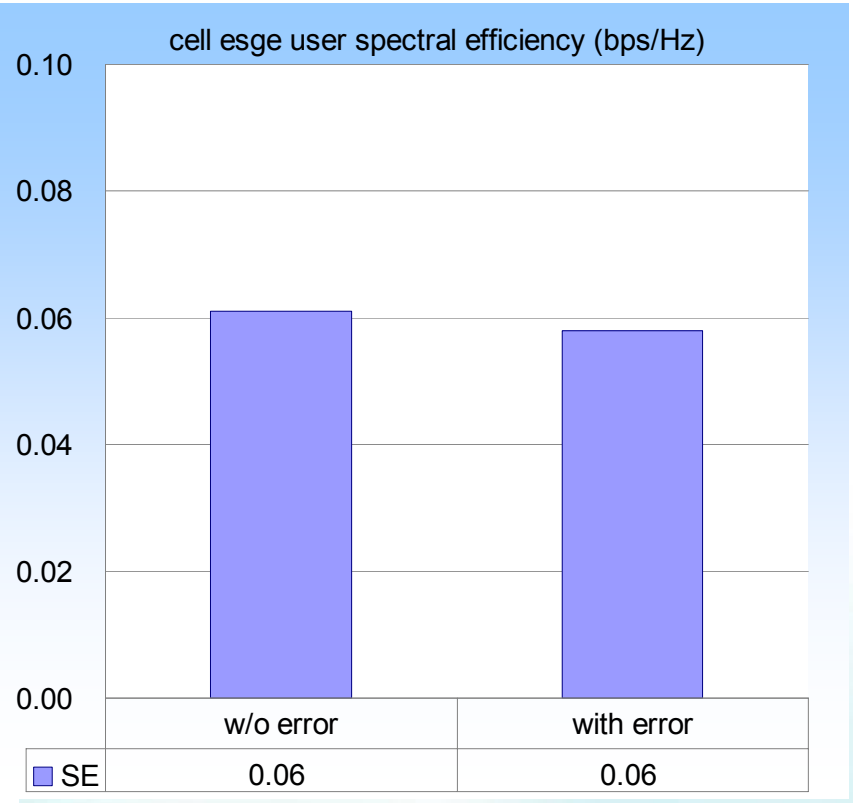
σ_E^2 (dB) = -19.1578 - 0.8766 SNR (dB)

SRS SINR Distribution



SRS impact on EBB 8x2 (UMi)





- **Assuming 2D-LMMSE for SRS channel estimation, the cell average throughput loss of UMi EBB is marginal and the cell edge performance loss is 5%.**

Conclusions of SRS modeling

- This model has been applied in ChEG LTE-A evaluation.
- The SRS error is negligible and the performance loss is marginal.

Please see [ITU-R WP5D 576] .

Summary

- ChEG focuses on MU-MIMO and CoMP evaluation.
  - MU-MIMO
    - SU/MU adaptation (up to 4 users pairing)
    - Rank adaptation (up to 2 ranks per user)
  - CoMP
    - Intra-site JP/CBF with MU-MIMO
- The sounding based DL transmission is recommended for MU-MIMO and CoMP in TDD.

Thanks!

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