



Systematic Data Repetition for Effective Cell edge Interference Management

Centre of Excellence in Wireless Technology
(CEWiT India)

Agenda Item:12.2
Discussion

Prevailing Scenario

- Requirements of the emerging broadband wireless standard *
 - Reuse 1 deployment
 - Uniform data rates across the cells
 - Optimization for fixed and nomadic applications

- Poor 'Low-SINR user' performance in reuse-1 networks
 - Severe co-channel interference (CCI)
 - Multiple CCI (more than two significant interferers)
 - Very low data rates at the cell edge
 - Soft FFR is not sufficient to serve these users
 - A significant number of them can bring down the system throughput

- **Effective interference management techniques needed**

* Consolidated view point of CEWiT, COAI (Cellular Operator Association of India) and BWCi (Broadband Wireless Consortium of India)

Legacy Interference Handling

- Conventional technique for handling interference are
 - FFR (tries to minimize interference and make it noise like)
 - Repeat information bits (eg. Rate 0.5, QPSK)
 - A baseline two receiver antenna can handle one interferer

Toy example with one receive antenna:

$$y_1 = h_1 x + g_{1i} x_i + n_1 \quad \text{Initial transmission}$$

$$y_2 = h_2 x + g_{2i} \tilde{x}_i + n_2 \quad \text{Re-transmission}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} x + \begin{bmatrix} g_{1i} x_i \\ g_{2i} \tilde{x}_i \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \quad \text{Equivalent expression}$$

Two equations in three variables, solution can not be clean

Legacy Interference Handling (ctd)

- Coherent combining assumes interference to have white noise behaviour
 - Helps to improve the S(I)NR, but does not permit interference mitigation
 - Bit level repetition is spectrally inefficient
- When interference user strength becomes comparable, then the structure of the interference can be exploited

Modified toy example:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ \cdot \end{bmatrix} x + \begin{bmatrix} g_{1i} \\ \cdot \end{bmatrix} x_i + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

Two equation in two variable, solution is possible

Scenario with Two Receive Antennas

- LTE baseline of 2 Rx antennas can handle 1 interferer

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} x + \sum_i \begin{bmatrix} g_{1i} \\ g_{2i} \end{bmatrix} x_i + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \quad \Rightarrow \quad \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \\ \cdot \\ \cdot \end{bmatrix} x + \sum_i \begin{bmatrix} g_{1i} \\ g_{2i} \\ \cdot \\ \cdot \end{bmatrix} x_i + \begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \end{bmatrix}$$

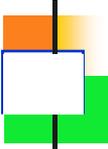
$h_1(f)$
 $h_1(f+L) = \phi(h_1(f))$

Use the OFDM property, adjacent RBs

$$h_1(f)\phi(x) \Rightarrow \phi(h_1(f))x$$

ϕ Can be a simple functions like phase shift and conjugation

- Create multiple copies of transmit data across cells for the MMSE receiver processing
 - Repeat symbols across cells in a coordinated manner
 - This simple modification can handle three significant interferers

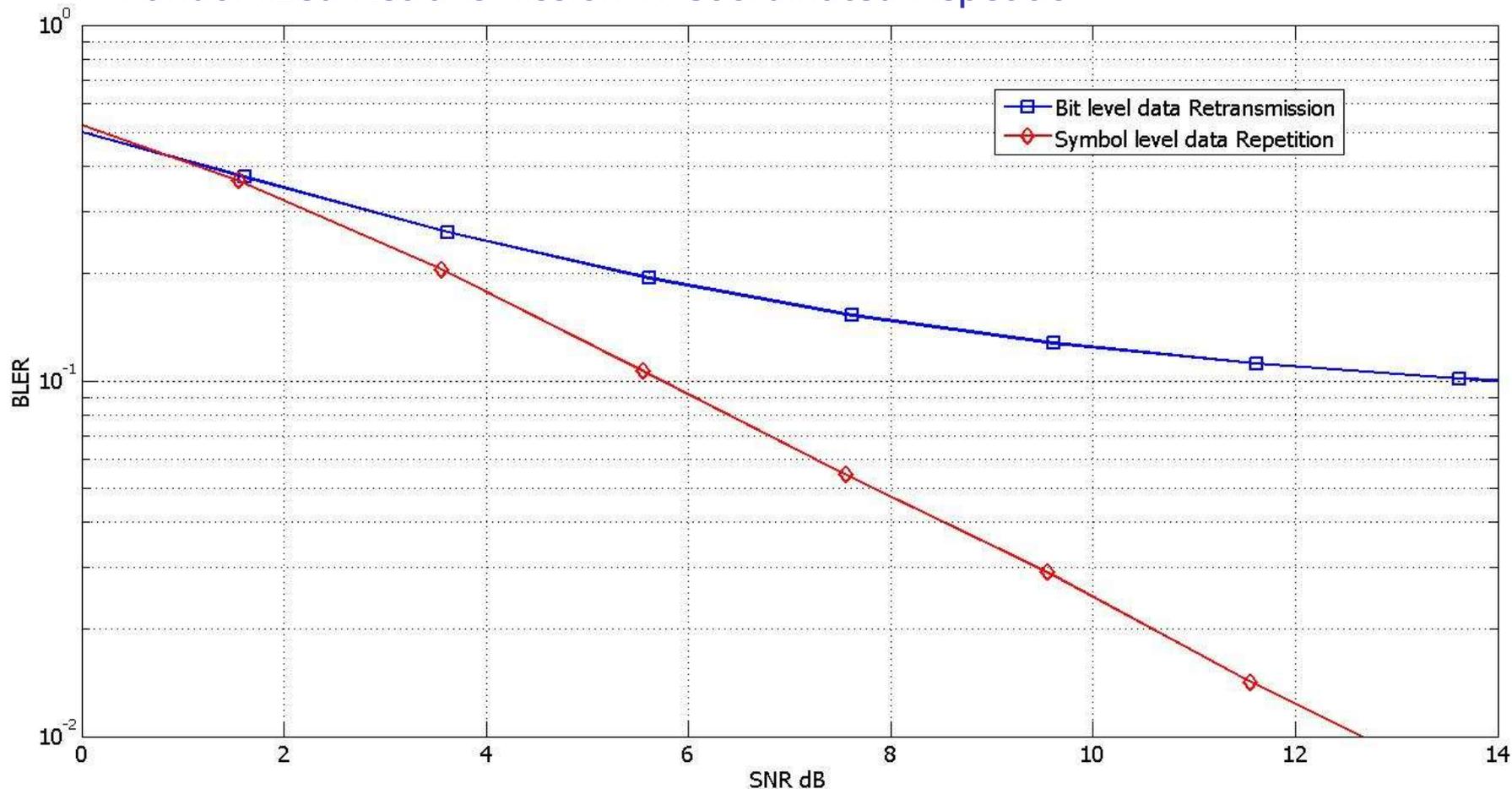


Simulation Setup

- Three interferers at $[0, -2, -4]$ dB S/I_i
- EPA channel model, 5 Hz Doppler
- 2 x 2 MIMO scheme
- MCS index 7 (rate ~ 0.533 , QPSK)
- No HARQ
- 10 MHz bandwidth and 2 GHz carrier frequency
- Other assumptions as per Rel-8 terminology

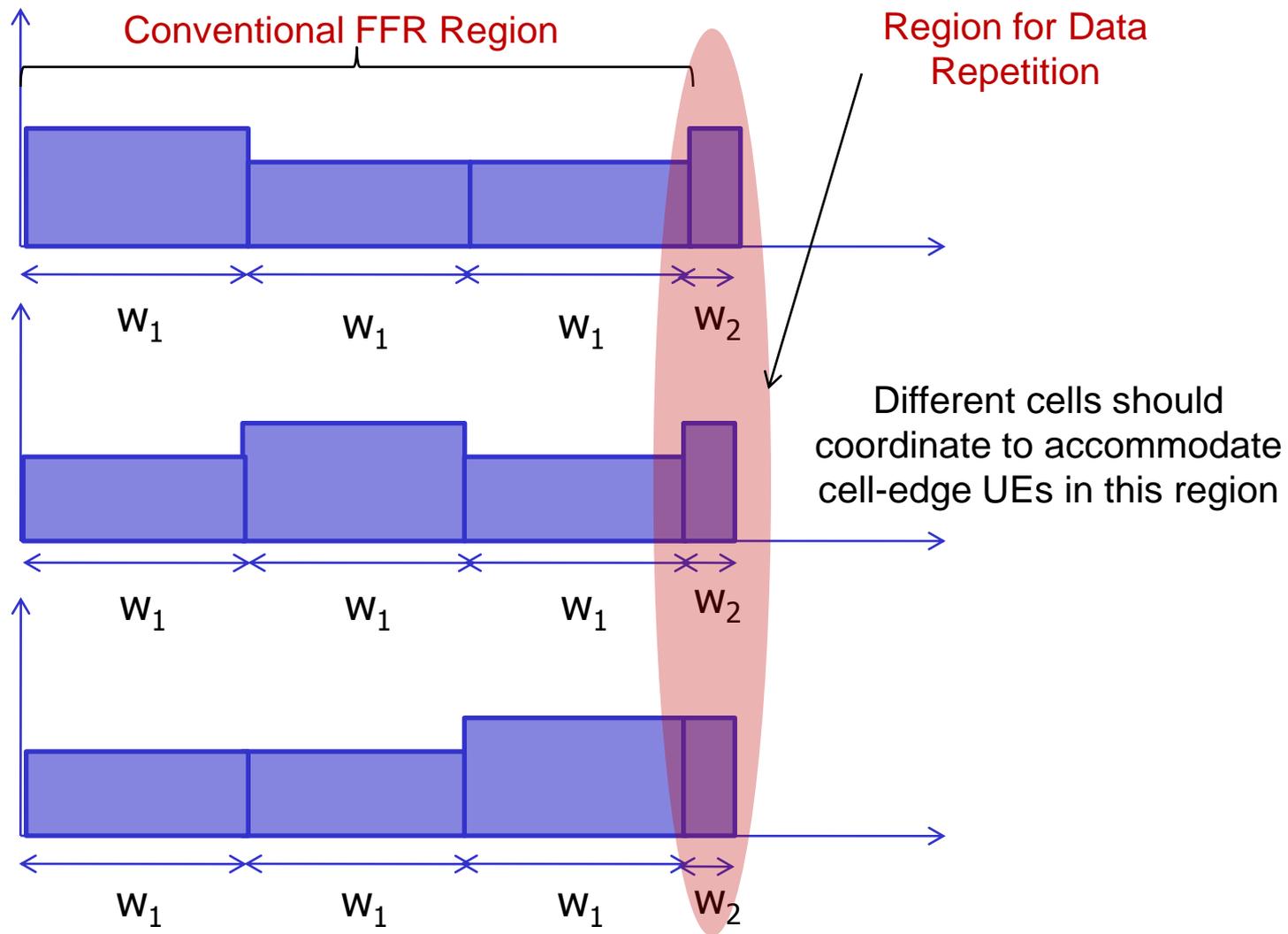
Simulation Performance

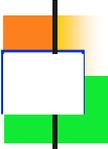
Randomized Retransmission v. Coordinated Repetition



SNR = Signal / (Rest of Interf. + Noise)

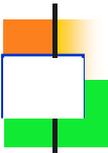
FFR Choice





Conclusions

- Complementing FFR, MMSE receiver processing makes efficient usage of the receiver antennas
 - Network level coordination to transmit similar MIMO schemes show merit
- Coordinated data repetition can improve the performance of very low SINR users
 - Cell edge users benefit by this approach
 - 5% point can be changed from the Rel-8 values



References

1. TR 36.913 v8.0.0, "Requirements for Further Advancements for E-UTRA (LTE-Advanced)"
2. R1-083931, "Downlink coordinated transmission – Impact on specification", Ericsson, 3GPP RAN1 #54bis, Prague, Czech Republic, Sept 29- Oct 3, 2008
3. 3GPP TS 36.211 "Evolved Universal Terrestrial Radio Access (E-UTRA) Physical channels and modulation", V8.4.0
4. R1-084482, "Low-Complexity Precoding for LTE-A Collaborative MIMO: A Signal Leakage Approach", Mitsubishi Electric, 3GPP RAN1 #55, Prague, Czech Republic, Nov. 2008
5. R1-050829, "Coordinated Symbol Repetition to Mitigate Downlink Inter Cell Interference", Panasonic, 3GPP RAN1 42, London, Sug-Sep 2005
6. REV-080050, CEWiT, "IMT Advanced Technical Requirements -- An India Perspective"
7. R1-081714, CEWiT, "IMT Advanced RAN1 Requirements - An India Perspective"

The GSM inference

- GSM systems deployed in reuse 1:3 mode
 - Interference is less, but typically one or two visible interferers
- UEs had (have) one antenna each
 - Can handle one parameter
 - Interference handling not possible
- GSM used BPSK and later MSK symbol alphabet ($x_i \in \mathfrak{R}$)

$$y = hx_0 + \sum_{i=1}^N g_i x_i + n$$

Detected value

$$y^* = h^* x_0 + \sum_{i=1}^N g_i^* x_i + n^*$$

Conjugate copy

- The second equation comes for free
- A MMSE receiver implementation handles one interferer effectively

MMSE Receiver Description

- Known fact: **With N receiver antennas, N-1 interferers can be handled**
 - MMSE receivers show very good performance

$$y = hx_0 + \sum_{i=1}^N g_i x_i + n$$

System relation

$$\hat{x}_0 = wy \quad w = R_{xy} R_{yy}^{-1}$$

MMSE relation and equalizer weight

- With a baseline 2 Rx antenna at UE, 1 interferer can be effectively handled
- Performance relies on:
 - How good the h estimate is
 - How good the R_{xy} estimate is