Inter-band Carrier Aggregation in Heterogeneous Networks: Design and Assessment

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Outline

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- System Model
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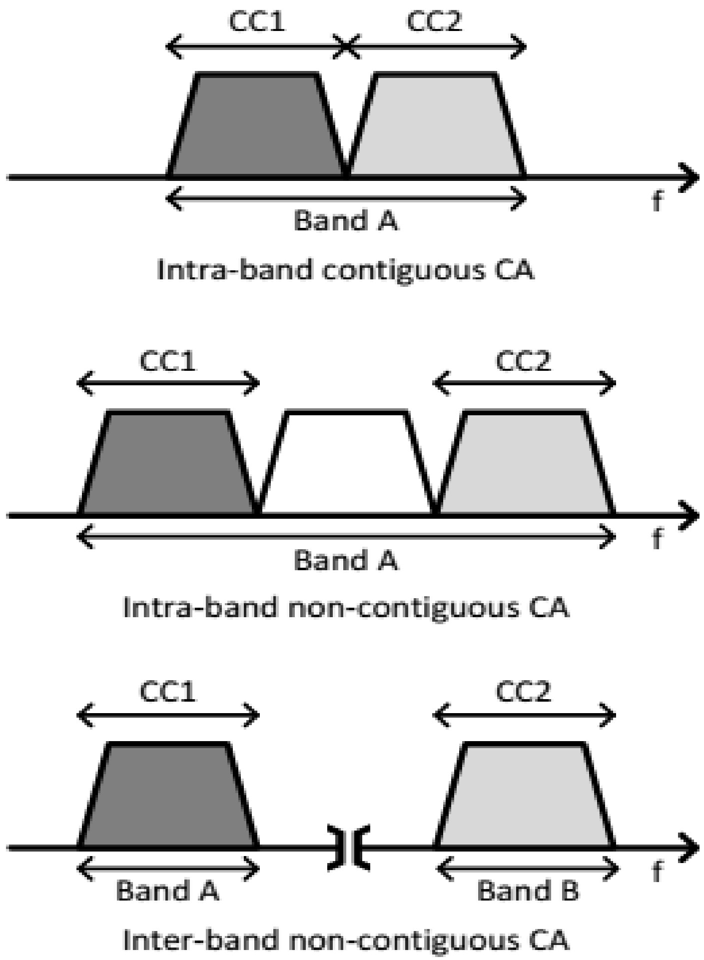
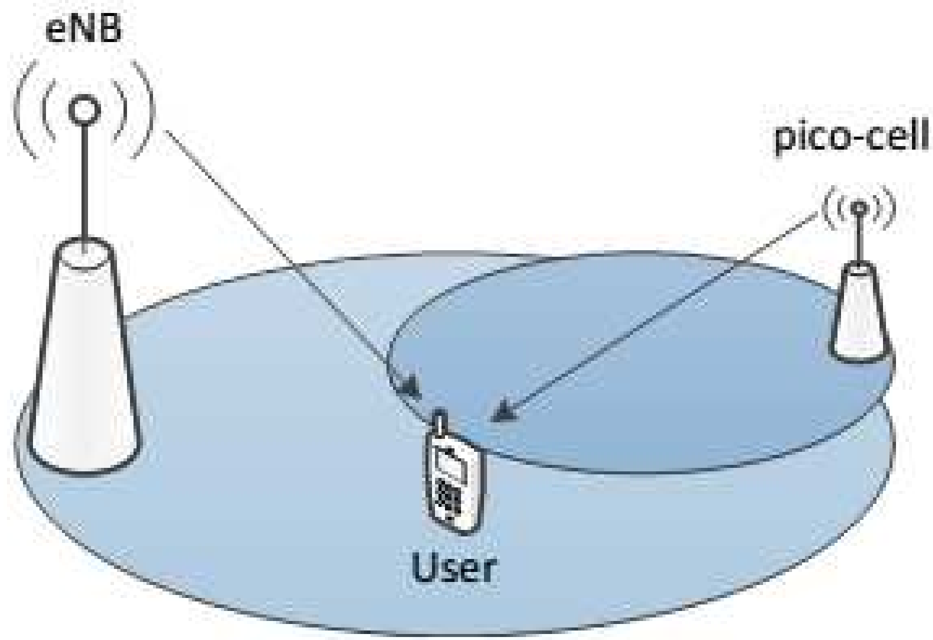
SOLDER

Introduction

- LTE-Advanced systems are expected to support high data rates after the Carrier Aggregation (CA) technology was initially introduced as part of Release 10.
- Various deployment scenarios for homogeneous and heterogeneous networks are supported by continuous and noncontiguous CA with proper utilization of different component carriers (CC)s.
- Additional advantages are offered by CA in terms of spectrum efficiency, deployment flexibility, backward compatibility, and more.

Carrier Aggregation Options in LTE-Advanced and SOLDER





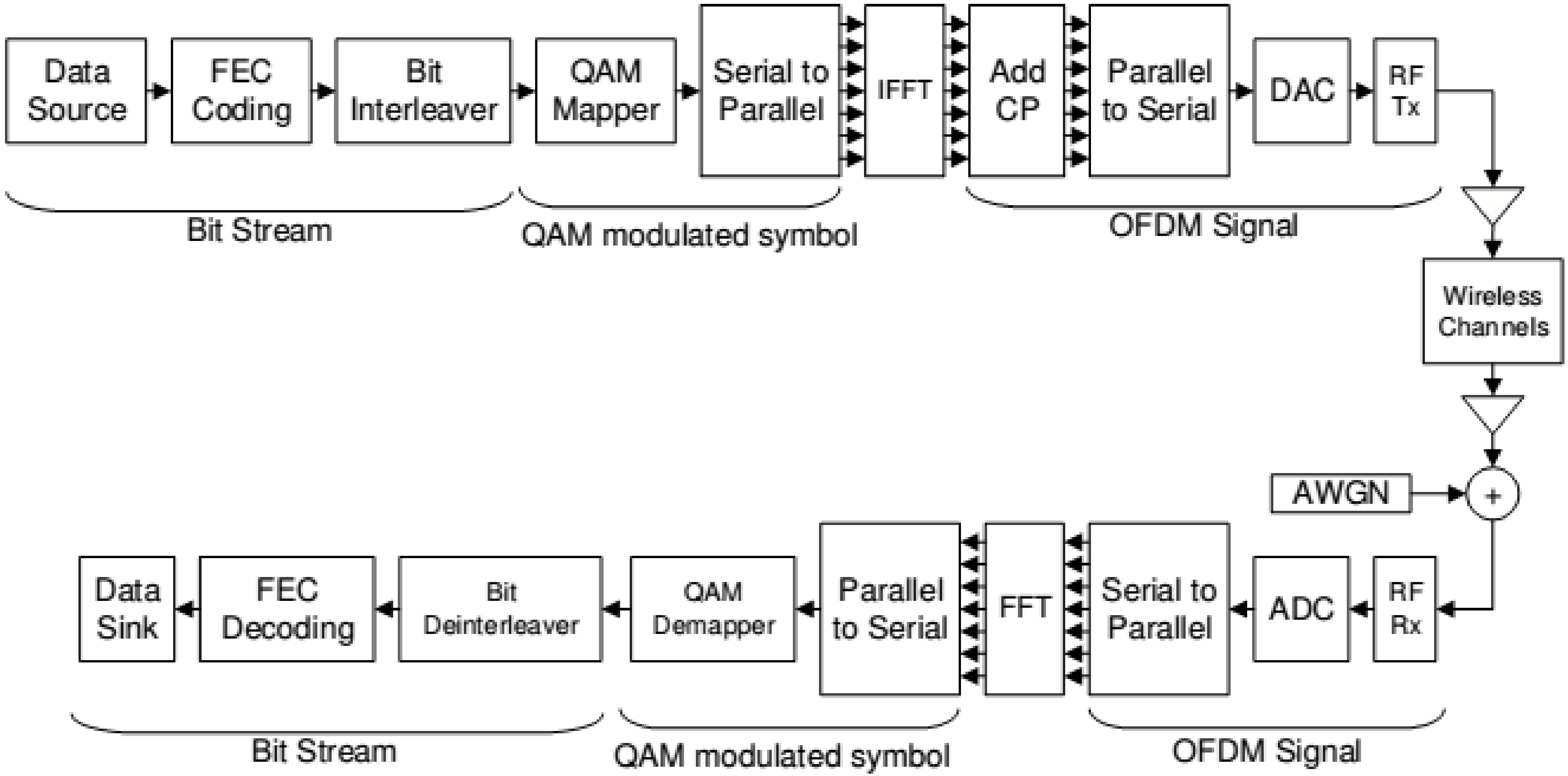
SOLDER: Carrier aggregation over HetBands: typical HetNets scenario with macro/pico cell

Carrier Aggregation in HetNets: HetBands aggregation

- *Deployment scenario 1*: Cells with carrier frequencies of F1 and F2 are overlaid with F1 and F2 in the same band. In this case, almost the same coverage is provided on both carriers due to the similar path loss within the same band.
- *Deployment scenario 2:* Cells with carrier frequencies F1 and F2 are overlaid, where F1 and F2 are in different bands. Unlike the scenario 1, the coverage of each frequency is different.
- *Deployment scenario 3*: Antennas in cells with frequency F2 are directed to the cell boundaries with frequency F1 to improve the cell edge data rate and throughput.
- *Deployment scenario 4*: Cells with frequency F1 provide macro coverage, and remote radio heads with frequency F2 are used to improve throughput at hot spots.
- *Deployment scenario 5*: Similar to deployment scenario 2. Frequency selective repeaters are additionally deployed.

System Model

Downlink physical layer block diagram of much closer to LTE-Advanced Release 12 system



OFDM parameters

Bandwidth (MHz)	1.4	3	5	10	15	20
Δf	15 KHz					
N	128	256	512	1024	1536	2048
N_{sc}	72	180	300	600	900	1200
N_{cp}	9	18	36	72	108	144
f_s (MHz)	1.92	3.84	7.68	15.36	23.04	30.72

More details on the system model

- Fundamental processes involved in the downlink transmission of the LTE-Advanced:
  - Modulation with one out of the possible schemes, namely QPSK, 16-QAM and 64-QAM
  - OFDM symbols are created and then converted from digital samples to an analog waveform
  - Turbo coding with a data rate equal to 1/3
  - Transmit and Butterworth D/A filters application
  - Up-conversion to the center f_c
- The reception process is straightforward, since it is just the reverse of that having taken place at the transmitter.
- Although CA supports up to five CCs, the current specifications include CA scenarios of only two CCs.

$$s_{CA}(t) = s_{tb1}(t)e^{j2\pi f_{c1}t} + s_{tb2}(t)e^{j2\pi f_{c2}t}$$

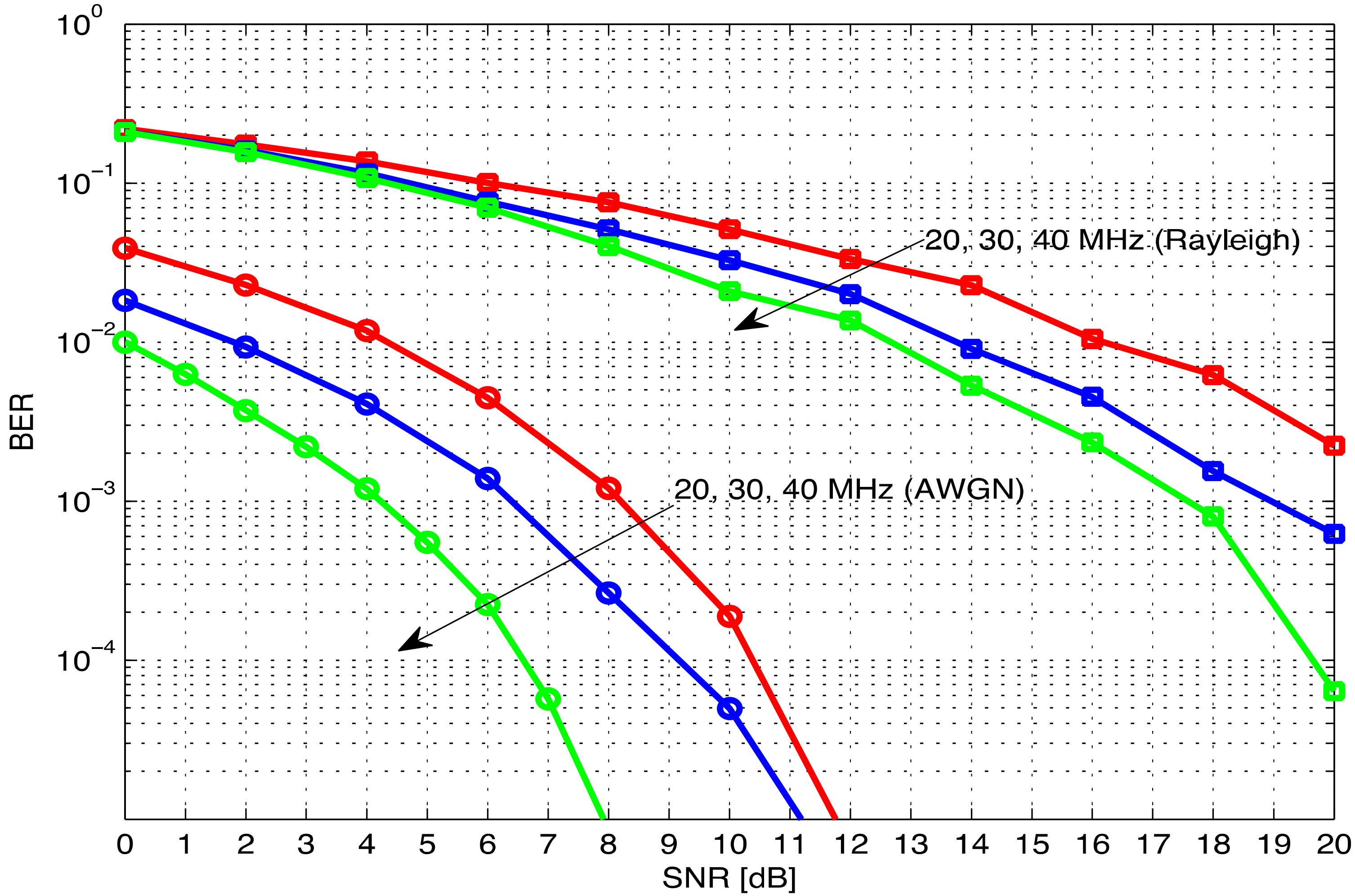
Implemented scenarios

- Based on the system model different CA options were simulated as specified in the latest 3GPP specifications:

E-UTRA CA Band	E-UTRA Frequency Band	f_{low}-f_{high} (MHz)	Bandwidth (MHz)
CA(1, 5)	1	2110 – 2170	10
	5	869 – 894	10
CA(3, 7)	3	1805 – 1880	10, 15 or 20
	7	2620 – 2690	10, 15 or 20

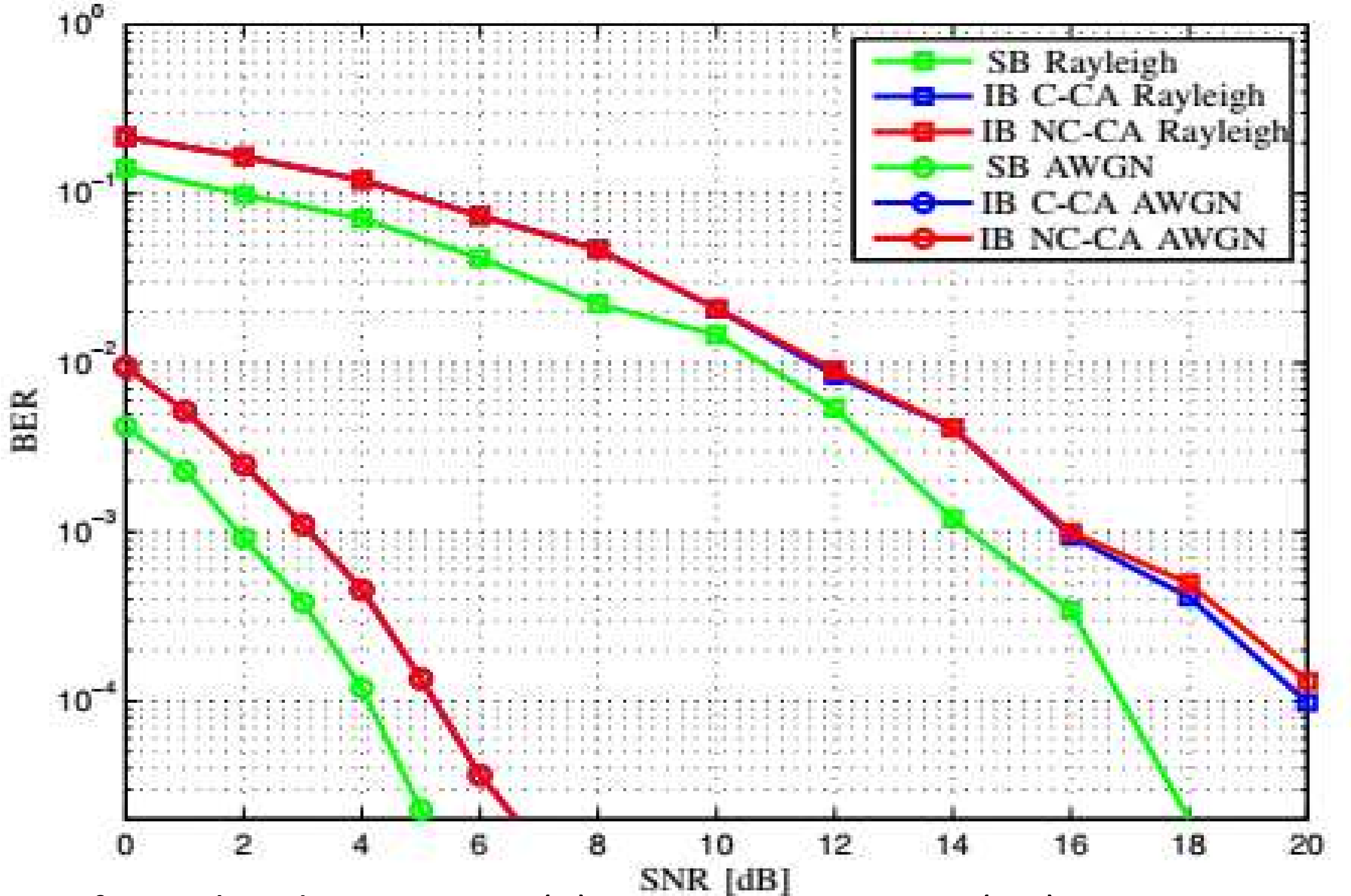
- Addionally:
  - Intra-band CA scenarios and new options utilizing bands in the unlicensed spectrum have been simulated.
  - CA of unlicensed bands at 5GHs is applied.
- All CA scenarios are simulated in terms of the BER for the two cases of a SISO flat fading Rayleigh and a pure AWGN channel.

Results (1)



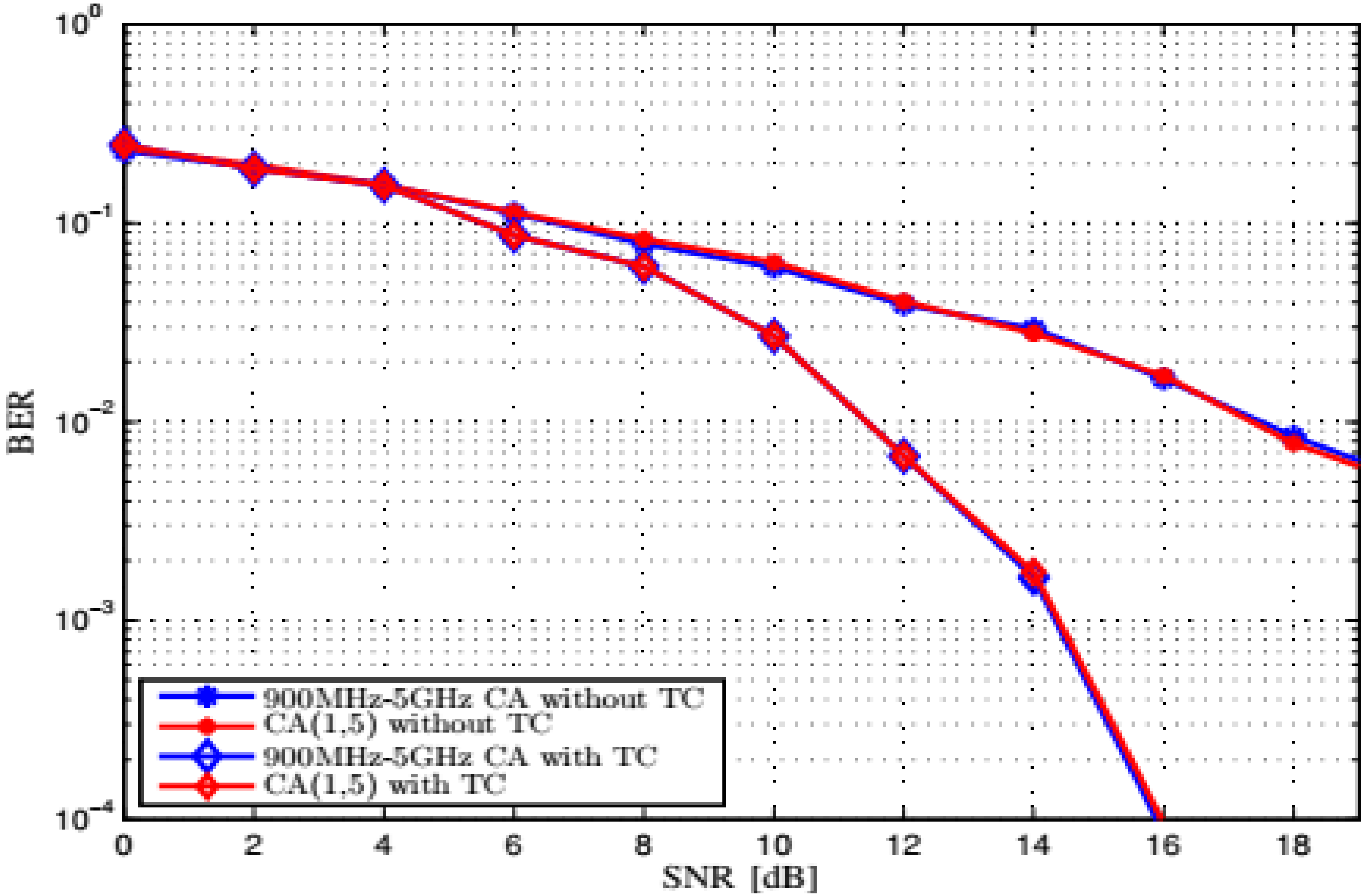
Performance of inter-band non-contiguous CA(3, 7) scenario with 20, 30 and 40 MHz total bandwidths over two extreme channel conditions.

Results (2)



Comparison of intra-band Contiguous (C)- or Non-Contiguous (NC)-CA using LTE-A Band 7 with 20 MHz total bandwidth.

Results (3)



Performance of two inter-band CA scenarios over dispersed bands; i) licensed CA(1, 5) and ii) unlicensed 900 MHz - 5 GHz, with or without Turbo Coding (TC) and total bandwidth in both cases equal to 20 MHz.

Conclusions

- Continuous or non-continuous within the same band, i.e. intra-band does not have significant performance impact.
- Inter-band can be applied transparently across the electromagnetic spectrum as well.
- Data service provided by a pico-cell carrier at 5 GHz aggregated with a CC at 900 MHz belonging to the cellular network, thus implementing the CA over Heterogeneous Bands (HetBand)s (SOLDER approach-1).
- Algorithm complexity including hardware implementation, relative cost and power consumption should be taken into account in the selection of the most advantageous CA scenario: Cognitive radio application is required to this end (SOLDER approach-2).

Thank you!

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