LTE Carrier Aggregation and Applicability Inter-eNodeB Carrier Aggregation

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ABSTRACT

The rapid growth in the levels of data traffic carried by mobile broadband networks in recent years has resulted in mobile operators deploying various technologies to improve the throughput provided for mobile data transmission. For example, operators are migrating mobile broadband users from 3G to 4G networks in countries where LTE and LTE-Advanced networks have been launched. However, customer demand and the need for a compelling service proposition are driving a need to provide continual improvement in data throughput and, in particular, achieve higher peak downlink speeds.

Carrier aggregation (CA), a key feature of LTE-Advanced (LTE-A), enables carriers at multiple frequencies to be used together to provide improved data rates for users of 4G networks. However, these increased data rates may come at the cost of exacerbating coverage and capacity problems, depending on which carriers are being aggregated.

Keywords

Carrier aggregation (CA), of LTE-Advanced (LTE-A), data throughput , Intra-band, Inter-band.

1. INTRODUCTION

Carrier aggregation is used in LTE-Advanced in order to increase the bandwidth and data rate by increasing end user throughput. It can used for FDD and TDD as well Figure1. Carrier Aggregation is the most important component in LTE-Advanced. CA is released in 3GPP Release 10.

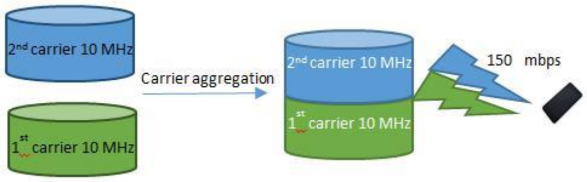

Figure 1. Carrier Aggregation

Carrier aggregation tests and deployment in Live network started from 2011. Data rate evolution in downlink with carrier aggregation is shown in Figure 2. Commercial LTE networks started with devices of Categories 3 and 4 supporting from 100 to 150 Mbps with continuous 20 MHz spectrum. The first version of carrier aggregation, during 2013, enabled 150 Mbps with 10 + 10 MHz allocation. The next phase with Category 6 devices has been commercially available since 2014, supporting 300 Mbps with 20 + 20 MHz. Category 9 will bring 450 Mbps with 60 MHz during 2015, and the evolution continues, with expected rates of 1 Gbps in the near future.

Figure 2. Data Rate Evolution in Downlink with CA

2. RF ASPECTS OF CA

There are a number of ways in which LTE carriers can be aggregated:

Intra-band: This form of carrier aggregation uses a single band. There are two main formats for this type of carrier aggregation – **contiguous** and **not- contiguous**.

Intra-band contiguous carrier aggregation is the carriers adjacent to each other. The aggregated channel can be considered by the terminal as a single enlarged channel from the RF point of view. In this case, only one transceiver is required within the terminal. Non-contiguous intra-band carrier aggregation is more complicated than the contiguous one as multi-carrier signal can't be treated as a single signal with one transceiver. This adds complexity for UE where space, power and cost are changes.

Inter-band non-contiguous: This form of carrier aggregation uses different bands. It will be of particular use because of the fragmentation of bands - some of which are only 10 MHz wide. For the UE it requires the use of multiple transceivers within the single item, with the usual impact on cost, performance and power. There are also additional complexities resulting from the requirements to reduce intermodulation and cross modulation from the two transceivers

The current standards allow for up to five 20 MHz carriers to be aggregated, although in practice two or three is likely to be the practical limit. These aggregated carriers can be transmitted in parallel to or from the same terminal, thereby enabling a much higher throughput to be obtained.

3. INTER-eNodeB CARRIER AGGREGATION

Standard and most popular carrier aggregation introduced 3GPP Release 10 enables to aggregate cells under same NodeB (using the same system module). More complex CA configurations (such like 2 carriers of 3 x 20 MHz cells with UL CoMP 4Rx) could not be used due to the HW limitations (system module). So deployment on separate eNBs is required.

Inter-eNB Carrier Aggregation between two co-located Macro eNBs enables to make advanced configurations that have to be deployed on separate eNBs, allowing for more flexibility in CA configuration. To have CA in 2 different EnodeB's physical connectivity is needed between the system modules ENodeB1 and ENodeB2. There should be 2 kinds of connectivity:

1. For signaling messages and bearer data transfers between the eNBs. In order to complete scheduling for all carriers within a subframe, the latency between the eNBs must be lower than 50 μs.

2. Synchronization information required to keep two eNBs in phase sync as required for CA. In order to meet the CA synchronization requirements, the maximum phase error must not be greater than +/- 50 ns.

The maximum phase error as defined above is a target value which ensures that the following maximum Timing Advance Error (TAE) between the radio interfaces can be met in the system configurations specified for carrier aggregation:

- TAE ≤ 260ns for inter band CA and non contiguous intra band CA
- TAE ≤ 130ns for intra band contiguous CA

Based on the mentioned requirements recommended to have max distance between ENodeb's 15 meter.

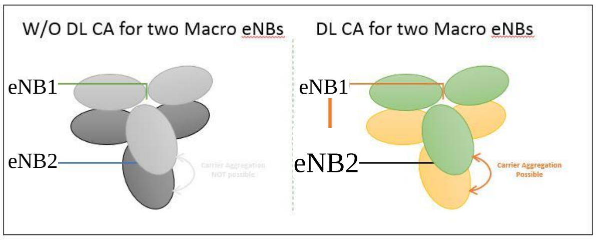

Figure 3. DL CA for two Macro eNBs

4. CARRIER AGGREGATION IN REAL NETWORK

Tests are performed in TEST BTS in order to have just one UE to be connected to the cell. Tems Investigation is used for throughput measurements. DL test is performed using UDP packets in order to reach max peack throughput.

The Primary Cell (PCell) is always active, whereas the Seconday Cell (SCell) is dynamically activated or deactivated. When a UE has an activated SCell and the DL channel quality on the SCell is above a specified threshold, DL data can be transmitted over both carriers. The amount of data sent on each carrier is proportional to the bandwidth and the DL channel quality of the carrier. Data splitting into multiple carriers only occurs if the data to be sent exceeds a specified threshold. If the amount of data sent does not exceed this threshold, transmission only occurs on the carrier that could potentially send more data given the constraints of carrier bandwidth and DL channel quality on the carrier.

Figures 4 and 5 show the test results.

Shown DL throughput when the user was connected to separate cells and to both cells. Thus we can see that during the test with CA we have about 2 times more DL throughput.

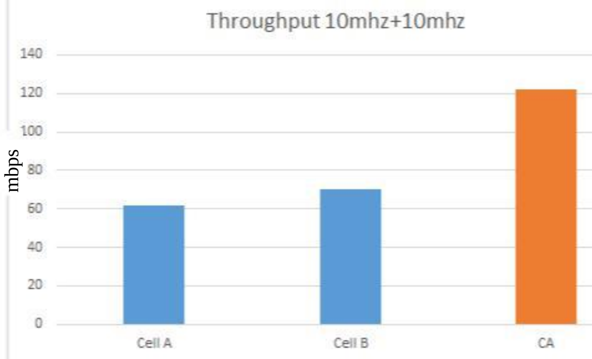

Figure 4. Downlink Throughput

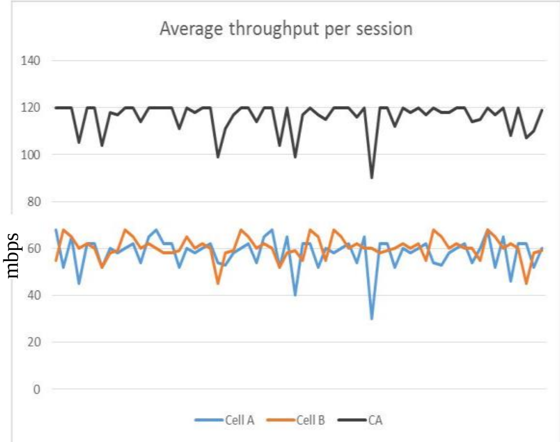

Figure 5. Average Throughput per Session

5. CONCLUSION

Inter-Band with 2 component carriers aggregated in the downlink is one of the most demanded combinations today.

Test results confirm that using CA

- Data transmitted on two bands simultaneously to a single UE
- Increased DL throughput across the coverage area
- Improved scattered spectrum efficiency
- Brings Higher capacity

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