LTE-A Carrier Aggregation Enhancements in Release 11

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Summary

LTE-Advanced standardisation in Release 10 was completed some time ago and vendors are busy implementing the latest features. In a previous 3GPP newsletter [1] we introduced the various Release 11 work and study items. By now Release 11 is well advanced and first change requests to the specifications will be agreed upon at the next RAN plenary in September 2012.

This newsletter provides an overview about Release 11 enhancements defined for one of the most important LTE-Advanced features – Carrier Aggregation. Core of the described enhancements are the support of Carrier Aggregation in Heterogeneous Networks with non-collocated cell sites.

Release 10 – Carrier Aggregation

One of the most important features for the mobile communication industry in 3GPP LTE-Advanced Release 10 is Carrier Aggregation (CA). In CA multiple up- or downlink LTE carriers in contiguous or non-contiguous frequency bands can be bundled (Figure 1).

Each of the component carriers itself will be backwards compatible to accommodate Release 8,9 UEs providing signals for synchronisation and transmitting system information via the broadcast channel.

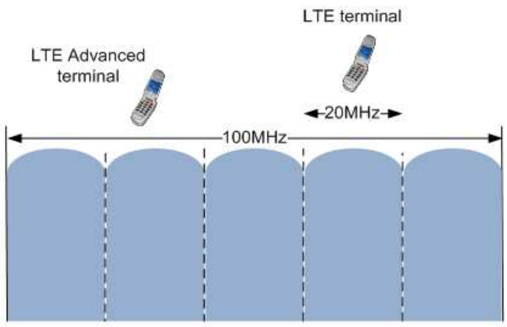

Figure 1: Carrier Aggregation

By mean of cross carrier scheduling (Figure 2) users can be dynamically scheduled on the different component carriers. This means a UE might receive a PDCCH control channel on one carrier with a resource allocation for another carrier. For this a new information element was added to the downlink control information that is called Carrier Indicator Field (CIF).

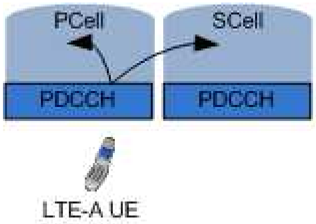

Figure 2: Cross Carrier Scheduling

With 3 bits CIF up to 5 carriers are being signalled in Release 10. The serving carrier where the UE gets its system information from is called Primary Cell (PCell) while every other configured carrier is a Secondary Cell (SCell).

A Release 8 UE is only able to be connected to a single, backward compatible carrier at a time and will thus not benefit from Carrier Aggregation enhancements. If the UE shall use another carrier, a time consuming and signalling intensive handover procedure is required to switch between the carriers. Thus CA can be used only for LTE-A terminals to increase the peak data rates as well as for fast load balancing.

In Release 10, the uplink CA deployment is limited to intra-band Carrier Aggregation, which means that the different carriers are part of the same frequency band as shown in Figure 1. Consequently carriers have similar radio characteristics (at least in terms of path loss and shadowing), which simplifies switching on/off carriers without the use of extensive measurements, but reduces diversity on the other side. This can be seen by both frequencies having the same coverage in Figure 3 [2].

Surely UE implementation complexity is significantly reduced in this scenario since the UE will get along with a single RF chain of broader bandwidth.

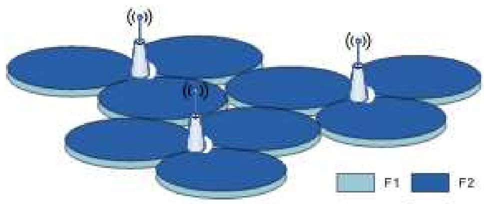

Figure 3: Co-located same frequency band

CA Release 11 – Carrier Aggregation

Release 11 CA will also support inter-band Carrier Aggregation where the component carriers are located in different frequency bands. This should prove to be very beneficial for operators having LTE frequencies in different bands.

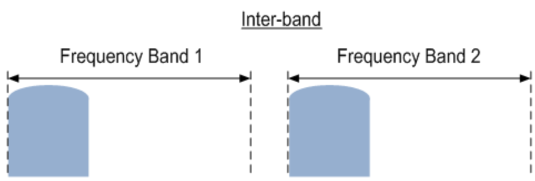

Figure 4: Inter- band Carrier Aggregation

RF terminal complexity is a major issue for supporting inter-band Carrier Aggregation and it will take considerable time until respective terminals with various band combinations become available.

Nevertheless new band combinations will be introduced for every upcoming 3GPP release.

The scheduler in a scenario, as illustrated in Figure 4, can make use of the different coverage and different propagation conditions. F1 with a lower frequency can provide coverage and mobility whereas F2 with the high frequency can provide high throughput in a limited coverage area.

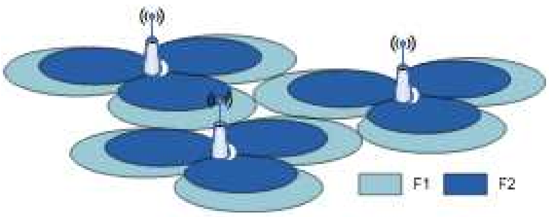

Figure 4: Co-located, different frequency band

LTE in general supports a synchronized uplink by means of the uplink Timing Advance (TA) procedure. A detail of CA Release 10 is that only a single uplink Timing Advance value is supported for all component carriers. This means that the base station transceivers for different carriers should be at the same location to avoid different propagation delay. The use of remote radio heads, distributed antennas and repeater is thus limited. The signal should be received within the Cyclic Prefix length for a correct reception by a regular UE.

Heterogeneous Networks with small cell base stations are seen as a key enabler for performance increase in today's networks. Therefore, Release 11 will support Carrier Aggregation with multiple uplink Timing Advances and other enhancements to support non-collocated cells, e.g. multiple uplink power control instances or improved sounding reference symbols. One of the key scenarios is the extensive use of Remote Radio Heads connected via fibre to a central baseband unit as shown in Figure 5.

Another variation of this scenario would be that macro and small cells both use the same frequencies F1 and F2 in parallel. In this case inter-cell interference coordination will be required, potentially using another Release 10 feature called Enhanced Inter-cell Interference Coordination by using Almost Blank Subframes (ABS).

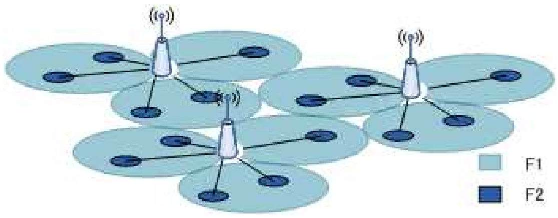

Figure 5: LTE-A HetNet using Remote Radio Heads

Multiple Timing Advance

As outlined above, the use of multiple timing advances is required for the support of non-collocated cells with Carrier Aggregation. Assuming synchronization to the macro cell's PCell is already obtained, the UE next has to synchronize to the SCell of the other site. Therefore the PCell eNB will request a RACH on SCell immediately after SCell activation (see Figure 6). The RACH request is being sent by PDCCH signalling from the PCell.

Enhanced MAC Control Elements are used to signal multiple Timing Advance values by using previously reserved fields in the header.

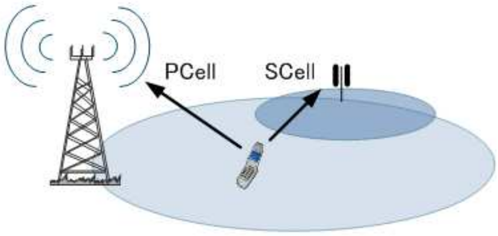

Figure 6: Multiple Timing Advance Transmission

In case several carriers require the same timing advance, these carriers will be grouped in so called timing advance groups with the same timing advance. This more complex scenario is shown in Figure 7.

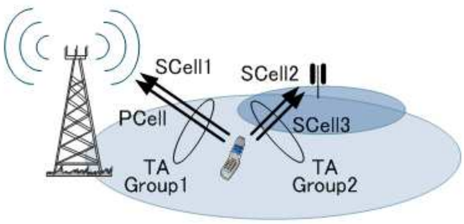

Figure 7: Timing Advance Groups

The Timing Advanced Groups will be configured by eNB Radio Resource Control signalling. This will reduce the overall complexity and signalling overhead for multiple TAs in case carrier aggregation is being used at each transmission point. For each Timing Advance Group a reference carrier for synchronization will be configured as timing reference.

In case of required support of HetNet scenarios the support of 2 Timing Advanced might become a baseline implementation for future LTE-A terminal. This could go along with a UE supporting 2x2 uplink MIMO transmission, where also two RF transmit chains will be required.

References

[1] NOMOR 3GPP Newsletter, "LTE Release 11 Work and Study Items", November 2011

[2] 3GPP TS 36.300 V10.5.0 Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 10)

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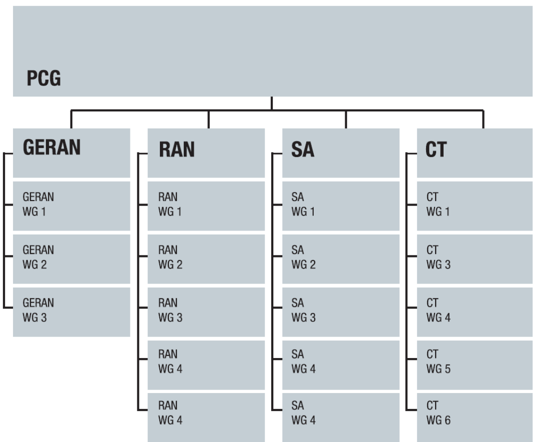

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- Analyse the feasibility of concepts for standardisation,
- Active contributions to standard activities,
- Evaluation of own and other contributions,
- Preparation of release roadmaps,
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- Intra- and intercell interference modeling for OFDMA, SC-FDMA and WCDMA
- 2D and 3D antenna pattern and multi-antenna beam forming
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- Single user-, multi-user MIMO with open and closed loop feedback
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