

Carrier Aggregation

Feature Description

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Contents

| | | |
|----------|--|-----------|
| 1 | Carrier Aggregation Overview | 1 |
| 2 | Dependencies of Carrier Aggregation | 5 |
| 3 | Feature Operation | 7 |
| 3.1 | Bandwidths Supported by Carrier Aggregation | 7 |
| 3.2 | Inter-Band Aggregation | 7 |
| 3.3 | Intra-Band Aggregation | 7 |
| 3.4 | Secondary Cell Configuration | 8 |
| 3.5 | Secondary Cell Deconfiguration | 9 |
| 3.6 | Dynamic Secondary Cell Activation and Deactivation | 9 |
| 3.7 | Downlink Data Transmission on Multiple Carriers | 11 |
| 3.8 | Limiting the Number of CA Users | 11 |
| 3.9 | Enhanced Carrier Aggregation Features | 12 |
| 4 | Parameters for Carrier Aggregation | 13 |
| 5 | Network Impact | 14 |
| 5.1 | Capacity and Throughput | 14 |
| 5.2 | Mobility | 14 |
| 6 | Performance | 15 |
| 6.1 | KPIs | 15 |
| 6.2 | Counters | 15 |
| 6.3 | Events | 16 |
| 7 | Activate Carrier Aggregation | 19 |
| 8 | Deactivate Carrier Aggregation | 20 |
| | Appendix A: Feature Change History | 21 |
| | Appendix A.a: Support for 3 MHz Channel Bandwidth to Carrier Aggregation | 21 |
| | Appendix A.b: CA Performance Optimization | 22 |
| | Appendix A.c: Optimization of UE CA Band Combination Report by Using requestedFrequencyBands | 23 |
| | Appendix A.d: 17.Q4: Dynamic SCell Selection for Carrier Aggregation Enhancements | 24 |



Appendix A.e: Support for a Mix of Different Special Subframe Pattern
and Non-Zero Frame Start Offset Values



1 Carrier Aggregation Overview

| | |
|-------------------------|---|
| Access Type: | LTE |
| Feature Identity: | FAJ 121 3046 |
| Value Package Name: | Carrier Aggregation |
| Value Package Identity: | FAJ 801 0405 |
| Node Type: | Baseband Radio Node DU Radio Node |
| Licensing: | Licensed feature. One license per node. |

Summary

The benefit of the Carrier Aggregation feature is that it enables data to be simultaneously transmitted on two bands to a single UE. The main benefits of Carrier Aggregation are the following:

- Increased downlink speed across the coverage area
- More efficient use of scattered spectrum
- Higher capacity

The Carrier Aggregation feature supports the following characteristics:

- Up to four downlink component carriers
- For 3 MHz, up to two downlink component carriers
- Statically configured secondary component carrier
- Up to two uplink component carriers
- Mixed Transmission Mode supported between carriers
- Same downlink and uplink subframe configuration for two aggregated TDD carriers

Note: If the Cross-DU Carrier Aggregation Support feature is enabled, then different special subframe patterns are allowed for a PCell and SCell that are spread over two DUs.

- Dynamic activation or deactivation of secondary component carrier
- No cross-carrier scheduling



- Inter-band aggregation
- Contiguous intra-band carrier aggregation between TDD carriers
- Non-contiguous intra-band carrier aggregation
- Intra- and Inter-LTE Mobility
- FDD only: for 3 MHz carrier bandwidth

Note: Carrier Aggregation is not supported in 3 MHz for Elastic RAN, or Inter-eNodeB CA features.

Figure 1 shows the UE configuration supported by Carrier Aggregation. For a UE that supports 3GPP release 8, 9, or both, each carrier configuration appears as an LTE release 8 carrier, whereas a UE capable of Carrier Aggregation can exploit the total aggregated bandwidth for up to two downlink carrier configurations. For more details about Carrier Aggregation configuration and setup of secondary carriers, refer to *3GPP TS 36.331*.

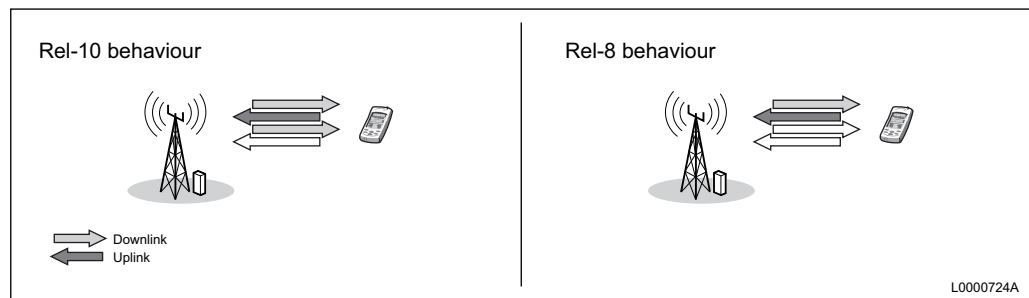


Figure 1 UE Configurations Supported by Carrier Aggregation. The Left-Hand Figure Shows the Asymmetric Two-Downlink and One-Uplink Case. The Right-Hand Figure Shows the Legacy Case.

A UE configured for carrier aggregation has one PCell and one SCell. The PCell is the cell where the UE is connected, has established the RRC connection, and is operating on the primary frequency. The SCell operates on a secondary frequency and can be configured once the RRC connection is established.



Note: If Cell Sleep Mode feature is active, it can affect the Carrier Aggregation feature. If, for example, all SCell candidates are capacity cells that have sleep mode enabled, the carrier aggregation capability is disabled when all capacity cells enter sleep mode. Also, if the PCell is a capacity cell with sleep mode enabled, the CA capability of a UE ends as the UE moves out of the cell when the cell enters sleep mode.

Intra-Cell Handover to Additional Band is an enhancement to the Multiple Frequency Band Indicators feature. When activated it increases the availability of Carrier Aggregation for UEs not supporting Carrier Aggregation on the primary band, but on the MFBI additional band. More information can be found in [Multiple Frequency Band Indicators](#).

Frequency Band Indicator Priority Rel-12 is another enhancement to the Multiple Frequency Band Indicators feature. When activated, it increases the availability of Carrier Aggregation for UEs supporting band prioritization in two cases. One case is when there are possible CA combinations on the additional band, but not on the primary band, and the other is when there are more possible CA combinations on the additional band. More information can be found in [Multiple Frequency Band Indicators](#).

Additional Information

More information about this feature and related topics can be found in the following documentation:

- [3GPP TS 36.331](#)
- [3GPP TS 36.321](#)
- [3GPP TS 36.213](#)
- [3GPP TS 36.101](#)
- FDD only: Supplemental Downlink for Carrier Aggregation
- Dynamic SCell Selection for Carrier Aggregation
- 3CC DL Carrier Aggregation Extension
- 4CC DL Carrier Aggregation Extension
- 5CC DL Carrier Aggregation Extension
- Cross-DU Carrier Aggregation Support
- Carrier Aggregation FDD-TDD
- FDD only: Enhanced PDCCH Link Adaptation



- Multiple Frequency Band Indicators
- Uplink Carrier Aggregation
- Elastic RAN
- Configurable SCell Priority



2 Dependencies of Carrier Aggregation

Table 1 Feature Dependencies

| Feature | Relationship | Description |
|--|--------------|--|
| Uplink Carrier Aggregation(FAJ 121 4425) | Prerequisite | Feature Carrier Aggregation is a prerequisite for the feature Uplink Carrier Aggregation. |
| Elastic RAN(FAJ 121 4608) | Prerequisite | Feature Carrier Aggregation is a prerequisite for the feature Elastic RAN |
| Scheduler(part of LTE Basic) | Related | Feature Carrier Aggregation affects the RAN feature Scheduler. |
| Enhanced PDCCH Link Adaptation(FAJ 121 3051) | Related | TDD only: Feature Carrier Aggregation affects the RAN feature Enhanced PDCCH Link Adaptation |
| Mission-Critical Push-to-Talk (FAJ 121 4929) | Related | When the Mission-Critical Push-to-Talk feature is active, this feature treats mission-critical bearers like it treats VoLTE bearers (QCI 1). |

Hardware

No special hardware requirement is expected for this feature.

Limitations

No limitations for this feature.

Network Requirements

This is a licensed feature. This means that for the feature to be operational, a valid license key must be installed and the feature must be explicitly activated by setting a MOM attribute.

The following must also be fulfilled at feature activation:

- The attribute `sCellCandidate` must be set to ALLOWED, which means that aggregation is allowed between the `EUtranCellFDD` or `EUtranCellTDD` and the `EUtranCellRelation` cell. Only one `EUtranCellRelation` per `EUtranCellFDD` or `EUtranCellTDD` can have attribute `sCellCandidate` set to ALLOWED.
- The PCell must have a relationship to its own frequency.



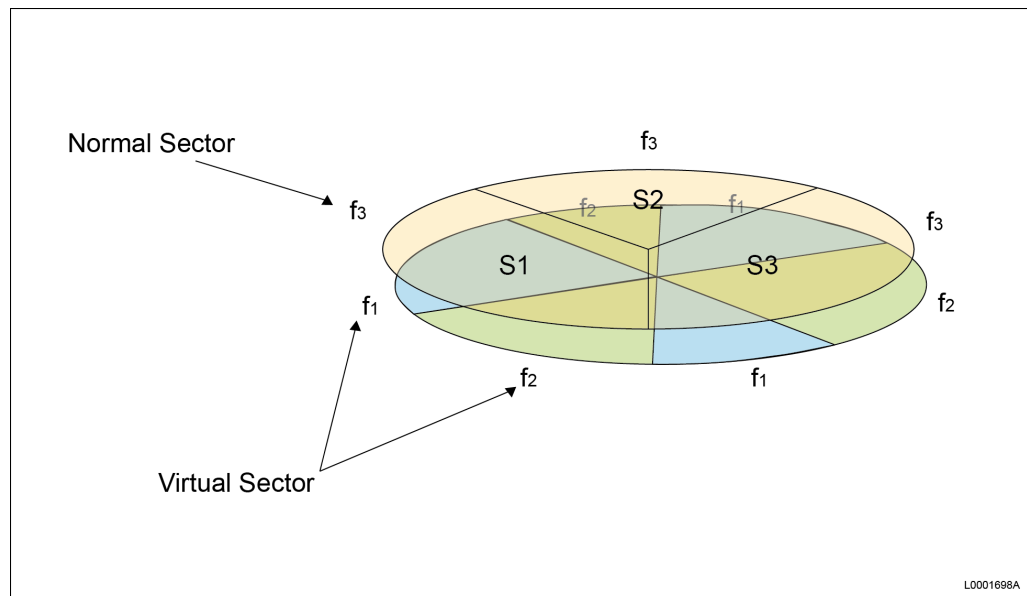
- The UE must support Carrier Aggregation, release 10 or later, in order to benefit from it.

Affected Features

Feature Carrier Aggregation is a prerequisite for the features Uplink Carrier Aggregation and Elastic RAN.

Be aware that in the following cases there are compatibility issues between Carrier Aggregation and Virtual Sectors:

- When Carrier Aggregation is activated after Virtual Sectors, the SCell candidate relations must be set to the overlapping virtual sectors.
- When Carrier Aggregation is activated before Virtual Sectors, although Carrier Aggregation cannot work, the Carrier Aggregation configuration between these virtual sectors can be kept anyway. The license for Virtual Sectors can be turned off to use Carrier Aggregation again.
- Carrier Aggregation cannot work between virtual sectors, but Carrier Aggregation is still possible between a virtual sector and a normal sector. For an example see figure below.



There are three carriers per radio. One carrier (f3) covers the full physical sector and the other two carriers (f1 and f2) cover the virtual sectors.

Figure 2 Compatible Configuration for Carrier Aggregation or Inter-Frequency Load Balancing



3 Feature Operation

This section describes the Carrier Aggregation feature in more detail, including network configuration requirements and operation flows.

3.1 Bandwidths Supported by Carrier Aggregation

Bandwidth support for Carrier Aggregation can be up to an aggregated bandwidth of 40 MHz. For specific bandwidth combinations per band combination, see *3GPP TS 36.101*.

3.2 Inter-Band Aggregation

The Carrier Aggregation feature supports inter-band aggregation, that is, carriers on different frequency bands, as shown in [Figure 3](#).

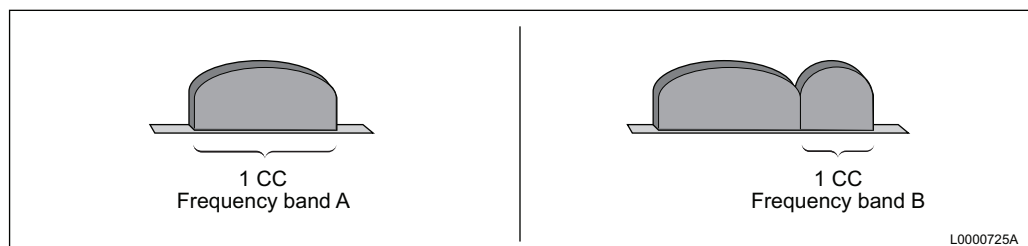


Figure 3 Inter-Band Carrier Aggregation

3.3 Intra-Band Aggregation

The Carrier Aggregation feature supports intra-band aggregation, that is, carriers on the same frequency band.

3.3.1 Contiguous Intra-Band Carrier Aggregation

For contiguous intra-band carrier aggregation, the carriers are located next to one another in the same band and are allocated with a defined nominal channel spacing between their middle frequencies.

If channel spacing is equal to or less than nominal channel spacing, the eNodeB considers carriers for contiguous intra-band carrier aggregation. If channel spacing is larger than nominal spacing, the eNodeB considers the carriers for non-contiguous carrier aggregation. Nominal channel spacing is defined in *3GPP TS 36.101*.

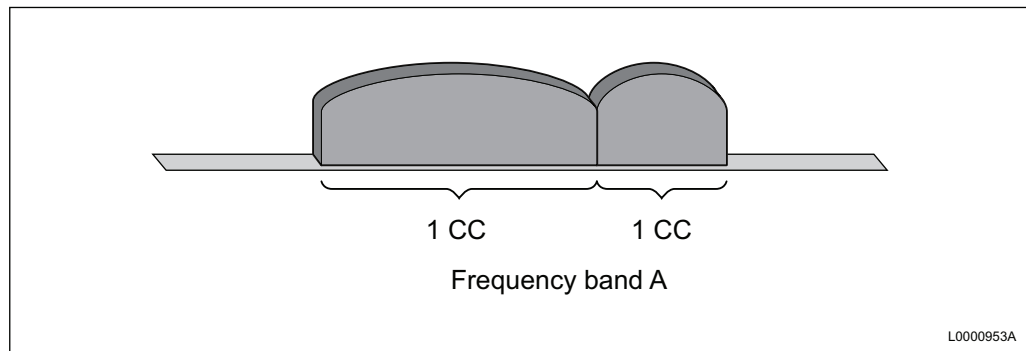


Figure 4 Contiguous Intra-Band Carrier Aggregation

3.3.2 Non-Contiguous Intra-Band Carrier Aggregation

For non-contiguous carrier aggregation, the carriers are located within the same band with some spectrum of uncoordinated operation between them, for example spectrum owned by another operator.

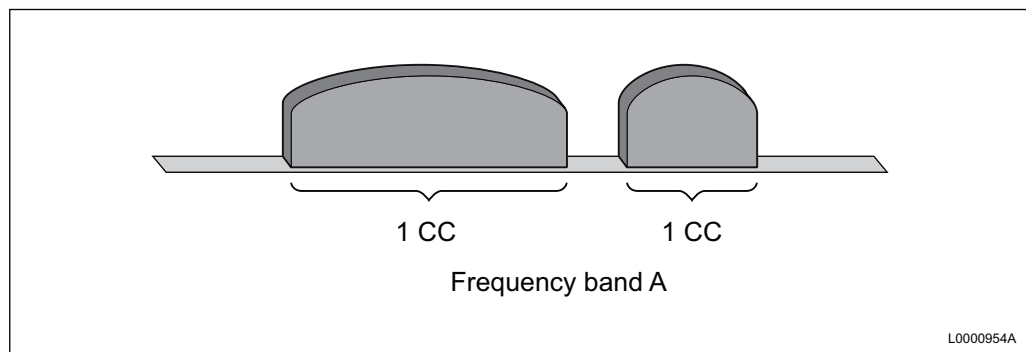


Figure 5 Non-Contiguous Intra-Band Carrier Aggregation

3.4 Secondary Cell Configuration

The operator decides which cells can be aggregated, by manually configuring cells for a specific `EUtranCellFDD` or `EUtranCellTDD` PCell, and another `EUtranCellFDD` or `EUtranCellTDD` that can be used as a secondary cell (SCell) for the carrier aggregation UE. Attribute `sCellCandidate` for the SCell must be set to enable successful configuration by UEs capable of Carrier Aggregation.

Note: Configurations with `EUtranCellTDD` PCell are not applicable for Inter-eNodeB Carrier Aggregation.

At attach during reestablishment and incoming handover for either inter- or intra-frequency, the eNodeB checks the CA license, the CA neighbor cell configuration, that is, the SCell candidate, as well as the UE capability. If all the conditions are fulfilled, the CA UE is configured with one downlink SCell in the



same RRCConnectionReconfiguration message required for the attach or outgoing handover reconfiguration to complete.

When the VoLTE Optimized Carrier Aggregation feature is enabled and the MOM attribute `EUtranCellFDD.sCellHandlingAtVolteCall` or `TDD.sCellHandlingAtVolteCall` is set to `DECONF_SCELLS`, all SCells which were deconfigured when a voice bearer (VoLTE or PTT) was established are reconfigured for the UE when the voice bearer is released.

3.5 Secondary Cell Deconfiguration

The SCell is always deconfigured at incoming handover.

When the VoLTE Optimized Carrier Aggregation feature is enabled and the MOM attribute `EUtranCellFDD.sCellHandlingAtVolteCall` or `TDD.sCellHandlingAtVolteCall` is set to `DECONF_SCELLS`, all SCells which have been configured for the UE and measurements related to CA and SCells are deconfigured during an active voice bearer service (VoLTE or PTT).

3.6 Dynamic Secondary Cell Activation and Deactivation

To facilitate UE battery saving, the Carrier Aggregation feature supports SCell dynamic activation and deactivation.

DL transmissions on an SCell are only possible if it is activated. If it is deactivated although still configured, no transmissions are possible on that carrier. The UE does not monitor the deactivated component carrier. This results in UE battery saving.

Dynamic activation and deactivation ensures that the SCell is only activated when there is DL data demand that could benefit from transmitting on more than just one carrier. Furthermore, the activated SCell is only used for DL transmissions if the SCell DL channel quality is above a certain threshold. The SCell is deactivated either if the DL data demand drops to such an extent that it can be handled through only one component carrier, or when the DL channel quality of the activated SCell stays below a threshold for a certain time.

To avoid a ping-pong effect of activation or deactivation, a timer is started whenever a state change from deactivated to activated or from activated to deactivated is triggered. No new state change is allowed until the timer expires.

— RELATED INFORMATION —

[4. Parameters for Carrier Aggregation on page 13](#)



3.6.1 Secondary Cell Activation or Deactivation Triggers

The following conditions must be met so that SCell activation or deactivation can take place:

Note: The UE's configured SCell can only be activated when the associated cell is unlocked.

- Need-based: Allow activation or deactivation of the SCell based on the amount of data available in the Radio Link Control (RLC) buffer.
- Coverage-based: Allow deactivation of the SCell based on poor channel quality.

Note: SCells are activated as soon as possible without checking activation conditions when UE is initially configured with one or more SCells. An activated SCell is only used for transmission if it has good channel quality.

- Prohibit Timer: To avoid a ping-pong effect, allow activation or deactivation of the SCell if the timer is not running. The prohibit timer must be started whenever either activation or deactivation is triggered. No new activation or deactivation can be triggered while the timer is running.

3.6.2 Secondary Cell Activation

An SCell can be activated after successful configuration by means of an RRC Reconfiguration if the trigger conditions are met. See [Secondary Cell Activation or Deactivation Triggers](#) on page 10.

SCell activation is achieved through the transmission of an Activation-Deactivation Medium Access Control (MAC) Control Element (CE) with the SCell index bit set to one.

Once activated, the UE is polled for SCell channel status information. DL data transmissions are allowed on the SCell if the SCell channel quality is sufficient.

3.6.3 Secondary Cell Deactivation

The SCell is only deactivated if one of the conditions from [Secondary Cell Activation or Deactivation Triggers](#) on page 10 are met, while the prohibit timer is not running. Additional triggers are described below.

In FDD, when the Enhanced PDCCH Link Adaptation feature is enabled and the UE is configured with a QCI 1 bearer, any configured secondary cells will become deactivated. When the QCI 1 bearer is removed, the SCell may become activated again. However, if attribute `CarrierAggregationFunction.pdcchEnhancedLaForVoLTE` is set to TRUE, the following applies for the SCell:



- UEs receive PDSCH transmissions for the subframes when there is no VoLTE packet within the eNodeB.
- UEs receive no PDSCH transmission for the subframes from the time interval that a VoLTE packet arrives in the eNodeB and until it departs the eNodeB.

Note: When the Mission-Critical Push-to-Talk feature is activated, all processes and criteria in this feature operation regarding QCI 1 also apply to QCIs with the `serviceType` value PTT.

In TDD, Enhanced PDCCH Link Adaptation does not apply to UEs which are configured with Carrier Aggregation.

With the Carrier Aggregation, LTE Broadcast, and Autoconfiguration of LTE Broadcast Subframes licenses enabled, the features can be used simultaneously. However, UEs with SCell configured at the time of any eMBMS service change in this cell will have their SCell deactivated for the duration of current UEs connection.

Locking the physical cell associated with the SCell also triggers deactivation of the SCell.

SCell deactivation is achieved through the transmission of an Activation-Deactivation MAC Control Element with the SCell index bit set to zero. As at activation, the MAC CE is piggy-backed on PCell data and repeated multiple times. The eNodeB considers the SCell as deactivated when the first HARQ ACK detection parameter is received after the burst occurred that contained the Activation-Deactivation MAC CE.

3.7 Downlink Data Transmission on Multiple Carriers

The PCell is always active, whereas the SCells are dynamically activated or deactivated. When a UE has activated SCells and the DL channel quality on SCells is above a specified threshold, DL data can be transmitted over multiple carriers. The amount of data sent on each carrier is proportional to the bandwidth and the DL channel quality of the carrier. Data splitting onto 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.

3.8 Limiting the Number of CA Users

A UE configured with an SCell consumes twice as many resources as a UE that only has a PCell, yet it is still counted as one connected UE from a connected UE license perspective. There are two ways to limit the extra resources consumed by SCells:

- Limit the total number of SCells configured on the eNodeB via `caUsageLimit`, regardless of the number of connected UEs



- Stop configuring new SCells when the total resource usage on a DU or Baseband, the total number of connected UEs + the total number of configured SCells, exceeds $\text{Maximum RRC Connected Users} * (100 - \text{caPreemptionThreshold}) / 100$. By stopping the configuration of new SCells and natural UE attrition, the number of SCells configured on the eNodeB is indirectly regulated

The Maximum RRC Connected Users is a DU or Baseband hardware capacity limit which can be found in the capacity section of the Network Impact Report depending on the DU or Baseband type.

These two mechanisms work independently of each other. For example, the eNodeB stops configuring SCells if the number of connected UEs is high, even though the SCells configured are still below `caUsageLimit`. Using the correct `caPreemptionThreshold` setting, there is a high probability that the licensed connected user number can be reached at high loading without limiting the number of CA users at low loading.

3.9 Enhanced Carrier Aggregation Features

The following features offer additional benefits on top of the Carrier Aggregation feature and require additional licenses to operate. For more information, see the respective feature description.

- FDD only: Supplemental Downlink for Carrier Aggregation
- Dynamic SCell Selection for Carrier Aggregation
- Configurable SCell Priority
- 3CC DL Carrier Aggregation Extension
- 4CC DL Carrier Aggregation Extension
- 5CC DL Carrier Aggregation Extension
- Cross-DU Carrier Aggregation Support
- Carrier Aggregation FDD-TDD
- Uplink Carrier Aggregation
- Elastic RAN



4 Parameters for Carrier Aggregation

Feature Configuration Parameters

- `CarrierAggregationFunction.sCellActDeactDataThres`
- `CarrierAggregationFunction.sCellActDeactDataThresHyst`
- `CarrierAggregationFunction.sCellActProhibitTimer`
- `CarrierAggregationFunction.sCellDeactProhibitTimer`
- `CarrierAggregationFunction.sCellScheduleSinrThres`
- `CarrierAggregationFunction.caPreemptionThreshold`
- `CarrierAggregationFunction.caRateAdjustCoeff`
- `CarrierAggregationFunction.caUsageLimit`
- `CarrierAggregationFunction.pdcchEnhancedLaForVolte`
- `EUtranCellFDD.noOfChannelSelectionSets`
- `EUtranCellTDD.noOfChannelSelectionSets`
- `EUtranCellFDD.channelSelectionSetSize`
- `EUtranCellRelation.sCellCandidate`
- `EUtranCellFDD.SCellHandlingAtVolteCall`
- `EUtranCellTDD.SCellHandlingAtVolteCall`

Affected Parameters

The implementation of this feature affects no parameters.



5 Network Impact

This section describes how the Carrier Aggregation feature impacts the network functions and capabilities.

5.1 Capacity and Throughput

Each Carrier Aggregation UE with one configured SCell consumes the memory of two connected users in the system. As a result, the maximum total number of RRC_CONNECTED users decreases by the number of Carrier Aggregation UEs connected.

5.2 Mobility

There are no changes to mobility from the previous releases. Mobility is based on PCell coverage. Refer to *3GPP TS 36.331*:

- Event A1: Serving values improve to a higher level than threshold level.
- Event A2: Serving values improve to a higher level than threshold level.
- Event A3: Neighbor offset values improve to a higher level than PCell values.
- Event A5: PCell values deteriorate to a lower level than threshold1 values and neighbor values improve to a higher level than threshold 2 values
- Event B1: Inter-RAT neighbor values improve to a higher level than threshold values.
- Event B2: PCell values deteriorate to a lower level than threshold1 and inter RAT neighbor values improve to a higher level than threshold 2 values.

PCell values always change at handover. In the new PCell, the old SCell is removed and a new SCell is configured even if the SCell is the same. All this is handled in the same RRCConnectionReconfiguration message at the handover event.



6 Performance

This section describes performance indicators, counters, and events associated with the Carrier Aggregation feature.

6.1 KPIs

The following Key Performance Indicators (KPI) are associated with this feature:

- Downlink Latency, Downlink Latency per QC
- Average DL PDCP UE Throughput for Carrier Aggregation
- Average UL PDCP UE Throughput for Carrier Aggregation
- DL PDCP UE Throughput Distribution
- UL PDCP UE Throughput Distribution
- Mean DL UE PDCP Throughput
- Mean UL UE PDCP Throughput

For more information about KPIs, see [Key Performance Indicators](#).

6.2 Counters

The following counters in MO Class `EUtranCellFDD` and `EUtranCellTDD` are associated with the Carrier Aggregation feature:

- `pmCaCapableDlSum`
- `pmCaCapableDlSamp`
- `pmCaConfiguredDlSum`
- `pmCaConfiguredDlSamp`
- `pmCaActivatedDlSum`
- `pmCaScheduledDlSum`
- `pmRadioThpVolDlSCell`
- `pmRadioThpVolDl`
- `pmPdcPvolDlDrbCa`



- pmPdcPVolD1DrbLastTTICa
- pmUeThpTimeD1Ca
- pmUeThpVolU1Ca
- pmUeThpTimeU1Ca
- pmUeThp2D1Distr
- pmUeThp2U1Distr

More information about counters can be found in Managed Object Model (MOM).

6.3 Events

Table 2 list the events associated with the Carrier Aggregation feature.

Table 2 Events

| Event | Event Parameter | Description |
|--------------------------------------|--|--|
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_PER_SCELL_MAC_DTX_D L_QPSK | The total number of times a downlink HARQ feedback was not received from a UE for a Transport Block where QPSK and DTX are considered to be the reason. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier, PCell. |
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_PER_SCELL_MAC_DTX_D L_16QAM | The total number of times an uplink grant was given for HARQ transmission in the uplink direction with 16QAM, where DTX is considered to be the reason for no reception of HARQ in uplink in the eNodeB. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_PER_SCELL_MAC_DTX_D L_64QAM | The total number of times an uplink grant was given for HARQ transmission in the uplink direction with 64QAM where DTX is considered to be the reason for no reception of HARQ in uplink in the eNodeB. Only the secondary component carrier traffic the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_SCELL_HARQ_DL_NACK_ QPSK | The total number of unsuccessful HARQ transmissions in the downlink direction using a QPSK modulation. Failure is based on the HARQ NACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_SCELL_HARQ_DL_NACK_ 16QAM | The total number of unsuccessful HARQ transmissions in the downlink direction using a 16QAM modulation. |



| Event | Event Parameter | Description |
|----------------------------------|--------------------------------------|--|
| | | Failure is based on the HARQ NACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_HARQ_DL_NACK_64QAM | The total number of unsuccessful HARQ transmissions in the downlink direction using a 64QAM modulation. Failure is based on the HARQ NACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_HARQ_DL_ACK_QPSK | The total number of successful HARQ transmissions in the downlink direction using a QPSK modulation. Success is based on the HARQ ACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_HARQ_DL_ACK_16QAM | The total number of successful HARQ transmissions in the downlink direction using a 16QAM modulation. Success is based on the HARQ ACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_HARQ_DL_ACK_64QAM | The total number of successful HARQ transmissions in the downlink direction using a 64QAM modulation. Success is based on the HARQ ACK from the UE. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_PER_SCELL_DL_MAC_DELAY | The aggregated time for the downlink delay measurement in the MAC layer with one sample per MAC SDU. The time recorded for each sample is the time measured between RLC PDU packet reception until the packet is received by the UE or the HARQ transmission failure value on this MAC SDU. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_RADIOHTP_VOL_DL | The total successfully transferred data volume on the DL MAC level. Only the secondary component carrier traffic, the SCell data is included, that is the UE uses another cell as its primary component carrier PCell. The total successfully transferred data volume on MAC level in the downlink C276. This counter includes possible padding bits. Only the secondary component carrier traffic, the SCell is included, that is. the UE has another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFIC_REPORT | EVENT_PARAM_SCELL_RADIOHTP_RES_DL | The total amount of physical resources used for transmission in the downlink. All transmissions |



| Event | Event Parameter | Description |
|--------------------------------------|--|---|
| | | whether successful or unsuccessful are counted. Only the secondary component carrier traffic, the SCell is included, that is the UE uses another cell as its primary component carrier PCell. |
| INTERNAL_PER_CELL_TRAFFI C_REPORT | EVENT_PARAM_PER_SCELL_SCHED_ACT IVITY_UE_DL | The sum of the contributions from each UE in the cell of the number of ms where SRB/DRB data was scheduled in the DL for secondary component carrier traffic. the SCell, that is the UE uses another cell as its primary component carrier PCell. |

For a full list with detailed information about PM events, see the list files in the **List Files** library folder.



7 Activate Carrier Aggregation

Prerequisites

- The license key is installed in the node.
- Continuous Cell Trace Recording (CCTR) is activated since at least one week. This ensures there is troubleshooting data available if something goes wrong.

Steps

1. Set the attribute `featureState` to `ACTIVATED` in the applicable MO instance, depending on node type:

| Node Type | License Control MO |
|---------------------|--|
| DU Radio Node | <code>OptionalFeatureLicense=CarrierAggregation</code> |
| Baseband-based Node | <code>FeatureState=CXC4011476</code> |

2. Perform cell lock/unlock immediately after activation.

After This Task

Let the CCTR be active for one week, for continued collection of troubleshooting data.



8 Deactivate Carrier Aggregation

Prerequisites

- Continuous Cell Trace Recording (CCTR) is activated since at least one week. This ensures there is troubleshooting data available if something goes wrong.

Steps

1. Set the attribute `featureState` to DEACTIVATED in the applicable MO instance, depending on node type:

| Node Type | License Control MO |
|----------------|---|
| DU Radio Node | OptionalFeatureLicense=CarrierAggregation |
| Baseband-based | FeatureState=CXC4011476 |

2. Perform cell lock/unlock immediately after deactivation.

After This Task

Let the CCTR be active for one week, for continued collection of troubleshooting data.



Appendix A: Feature Change History

This section lists changes that affected this feature and the impact it had on network.

Appendix A.a: Support for 3 MHz Channel Bandwidth to Carrier Aggregation

| | |
|--------------------|--|
| Access Type: | LTE |
| Hardware Platform: | DUS 31, DUS 41, Baseband 5212, Baseband 5216, Baseband 6318, Baseband 6620 and Baseband 6630 |
| Licensing: | Carrier Aggregation, FAJ 121 3046 |

The enhancement to the Carrier Aggregation feature introduces support for 3 MHz carrier aggregation in FDD cells with up to two component carriers for both downlink and uplink directions. This facilitates more efficient use of the scattered 3 MHz spectrum, and increases downlink and uplink average UE throughput. More information can be found in [Carrier Aggregation](#).

Capacity and Performance

No impact.

Operation

The following MOM attribute is modified:

Table 3 Modified MOM Attributes

| MO Class | Attribute | Description |
|---------------|---------------------------|---|
| EUtranCellFDD | noOfChannelSelection Sets | The following dependency is removed: cells with channel bandwidth less than 5 MHz do not reserve channel selection PUCCH resources. |

Interfaces

No impact.

Other Network Elements

No impact.



Appendix A.b: CA Performance Optimization

| | |
|--------------------|--|
| Access Type: | LTE |
| Hardware Platform: | All DU products |
| Licensing: | Carrier Aggregation FAJ 121 3046 Dynamic SCell Selection FAJ 121 3063 |

This enhancement provides carrier aggregation performance optimization, and enhances Carrier Aggregation related features and Dynamic SCell Selection feature. Internal parameters related to the Dynamic SCell Selection feature are set to enabled by default.

Capacity and Performance

No impact.

Operation

New pmCounters

- `pmPdcPVo1D1DrbCa`: The total volume (PDCP SDU) on Data Radio Bearers. For KPI CA DL PDCP UE Throughput
- `pmPdcPVo1D1DrbLastTTICa`: The total volume (PDCP SDU) on Data Radio Bearers of carrier aggregation UE. For KPI CA DL PDCP UE Throughput
- `pmUeThpTimeD1Ca`: The effective DL transport time of carrier aggregation UE comprises those periods from when the first part of the PDCP SDU of the DL buffer was transmitted on Uu until the buffer is emptied, excluding the TTI emptying the buffer. For KPI CA DL PDCP UE Throughput.
- `pmUeThpVo1U1Ca`: The UL DRB volume used for UL carrier aggregation UE throughput. For KPI CA UL PDCP UE Throughput.
- `pmUeThpTimeU1Ca`: The UL volume transfer time used for UL carrier aggregation UE Throughput. For KPI CA UL PDCP UE Throughput.
- `pmUeThp2D1Distr`: Distribution of the DL UE throughput. As KPI Downlink UE PDCP Throughput Distribution.
- `pmUeThp2U1Distr`: Distribution of the UL UE throughput. As KPI Uplink UE PDCP Throughput Distribution.

Interfaces

No impact.



Other Network Elements

No impact.

Appendix A.c: Optimization of UE CA Band Combination Report by Using requestedFrequencyBands

| | |
|--------------------|-----------------------------------|
| Access Type: | LTE |
| Hardware Platform: | All |
| Licensing: | Carrier Aggregation, FAJ 121 3046 |

If a UE supports more than 128 band combinations for Carrier Aggregation, it will drop some when reporting supported band combinations, depending on implementation. This could result in suboptimal SCell selection by the eNB that varies unpredictably from UE to UE.

In the UECapabilityEnquiry message, the eNB now populates the parameter requestedFrequencyBands and takes advantage of the Rel-11 functionality requestedFrequencyBands. This way the UE has access to an additional 256 combinations to communicate its capabilities.

UEs supporting this functionality only report UE supported band combinations out of the bands listed in the parameter. This will reduce the risk of dropping band combinations and reduce the risk of a suboptimal SCell selection in the eNB.

UEs not supporting the functionality will continue to report all supported band combinations.

Capacity and Performance

In a network with many possible band combinations, a larger portion of the UEs will be able to do complete reporting of their supported bands. This enables the assignment of an optimal band combination for Carrier Aggregation and it can lead to increased UE throughput.

With the ability to exchange up to 384 band combinations, the UE Capability Information messages can become larger. Messages exceeding the supported size are discarded, reducing accessibility. Disabling this feature restricts the UE to 128 combinations, and provides a way to limit the message size.

Operation

No impact.

Interfaces

No impact.



Other Network Elements

No impact.

Appendix A.d: 17.Q4: Dynamic SCell Selection for Carrier Aggregation Enhancements

This feature enhancement handles the shutting down of capacity cells triggered by Cell Sleep Mode (CSM) or any system-initiated soft lock functionality. This feature triggers SCell deconfiguration on CA stuck UEs which do not report any configured measurement report when SCell is disabled. This improves Carrier Aggregation (CA).

Feature Name: Dynamic SCell Selection for Carrier Aggregation

Feature Identity: FAJ 121 3063 R4

Value Package Name: Carrier Aggregation

Value Package Identity: FAJ 801 0405 R9

Node Type: Baseband Radio Node, DU Radio Node

Access Type: LTE

This feature enhancement handles the shutting down of capacity cells triggered by Cell Sleep Mode (CSM) or any system-initiated soft lock functionality. This feature triggers SCell deconfiguration on CA stuck UEs which do not report any configured measurement report when SCell is disabled. This improves Carrier Aggregation (CA).

Capacity and Performance

No impact.

Operation

The following pmCounter is updated:

Table 4 Updated pmCounters

| pmCounter | Description |
|---------------------|---|
| pmCaDeconfiguredOoc | Accumulated when the SCell deconfiguration is initiated because of poor coverage in the SCell. It includes either receiving A2 measurement or time-out for no measurement report. |

The following pmEvents are updated:



Table 5 Updated pmEvents

| pmEvent | Description |
|---|--|
| INTERNAL_EVENT_UE_T R_RRC_SCELL_DECONF IGURED | Generated when the SCell is deconfigured because no measurement report is received from the UE when the SCell is disabled. |
| INTERNAL_EVENT _RRC_SCELL_DECONF IGURED | |

Interfaces

No impact.

Hardware

No special hardware requirements.

Other Network Elements

No impact.

Appendix A.e: Support for a Mix of Different Special Subframe Pattern and Non-Zero Frame Start Offset Values

This enhancement provides a solution for non-zero `EUTranCellTDD.frameStartOffset` on TDD cells in TDD-TDD Elastic RAN carrier aggregation.

| | |
|-------------------------|-----------------|
| Feature Name: | Elastic RAN |
| Feature Identity: | FAJ 121 4608 R |
| Value Package Name: | Elastic RAN |
| Value Package Identity: | FAJ 801 0568 R4 |
| Node Type: | Baseband |
| Access Type: | LTE |

This enhancement provides a solution for non-zero `EUTranCellTDD.frameStartOffset` on TDD cells in TDD-TDD Elastic RAN carrier aggregation if all TDD cells involved have the same non-zero `EUTranCellTDD.frameStartOffset` value. Different `specialSubframePattern` values between Pcell and Ecell are supported.

Capacity and Performance

No impact.



Operation

No impact.

Interfaces

No impact.

Hardware

Baseband 5216, Baseband 6630

Other Network Elements

No impact.