ERICSSON

# Carrier Aggregation-Aware IFLB

## Feature Description

173/221 04-LZA 701 6014/1 Uen T4B

# Contents

# 1 Carrier Aggregation-Aware IFLB Overview

| | |
|---|---|
| Access Type: | LTE |
| Feature Identity: | FAJ 121 3075 |
| Value Package Name: | Advanced Carrier Aggregation |
| Value Package Identity: | FAJ 801 0564 |
| Node Type: | Baseband Radio Node<br>DU Radio Node |
| Licensing: | Licensed feature. One license per node. |


## Summary

The Carrier Aggregation-Aware IFLB feature aims to improve average system throughput by efficient distribution of Carrier Aggregation-capable UEs to cells where the carrier aggregation capability can be utilized, or utilized in a better way. This leads to better throughput for Carrier Aggregation-capable UEs.


## Additional Information

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

- *3GPP TS 36.300 rev 11.11, Overall description, Stage 2*
- *3GPP TS 36.331, Radio Resource Control (RRC), Protocol Specification*
- *3GPP TS 36.423, X2 Application Protocol (X2AP)*
- Automated Cell Capacity Estimation
- Best Neighbor Relations for Intra-LTE Load Management
- Best Neighbor Relations for WCDMA IRAT Offload
- Coverage-Triggered Inter-Frequency Handover
- Coverage-Triggered Inter-Frequency Session Continuity
- Dynamic GBR Admission Control
- Idle Mode Support
- Inter-Frequency Offload
- Inter-RAT Offload to WCDMA

- Radio Bearer Service
- Service Triggered Mobility
- Shared LTE RAN
- Service Specific Load Management
- Inter-Frequency Load Balancing
- Subscriber Triggered Mobility
- Limited-Uplink-Aware IFLB
- Multiple Frequency Band Indicators
- Inter-eNodeB Carrier Aggregation
- Elastic RAN

# 2 Dependencies of Carrier Aggregation-Aware IFLB

## Features

Table 1 Feature Dependencies

| Feature | Relationship | Description |
|---|---|---|
| Inter-Frequency Load Balancing (FAJ 121 3009) | Prerequisite | To use the Carrier Aggregation-Aware IFLB feature, the Inter-Frequency Load Balancing feature must be active. |
| Carrier Aggregation (FAJ 121 3046) | Related | The purpose of the Carrier Aggregation-Aware IFLB feature is to increase system utilization of Carrier Aggregation. |
| Subscriber Triggered Mobility (FAJ 121 1788) | Related | |
| Limited-Uplink-Aware IFLB (FAJ 121 4406) | Related | The Limited-Uplink-Aware IFLB feature adds the limited uplink awareness to the load balancing, to avoid moving UEs to a cell with uplink congestion. |
| Multiple Frequency Band Indicators (FAJ 121 3054) | Related | The Multiple Frequency Band Indicators feature adds awareness of additional bands to UE evaluation in Carrier Aggregation Triggered Redirection. |
| Inter-eNodeB Carrier Aggregation (FAJ 121 4469) | Related | The Inter-eNodeB Carrier Aggregation feature provides possibility for Carrier Aggregation-Aware IFLB to include ESCell in aggregated subscription capacity evaluation. |
| Elastic RAN (FAJ 121 4608) | Related | The Elastic RAN feature provides possibility for Carrier Aggregation-Aware IFLB to include ESCell in aggregated subscription capacity evaluation. |
| Inter-Frequency Load Balancing (FAJ 121 3009) | Affected | The Carrier Aggregation-Aware IFLB feature affects how Inter-frequency Load Balancing selects UE for a load balancing action. |

## Hardware

No special hardware requirement is expected for this feature.

## Limitations

No limitations for this feature.

## Network Requirements

No Network Requirements for this feature.

## Affected System Functions

Table 2 Affected System Functions

| Function | Description |
|---|---|
| Inter-frequency measurements | The number of inter-frequency measurements increases when the Carrier Aggregation-Aware IFLB feature is activated. The increase depends on the number of UEs that are considered to gain in carrier aggregation utilization by a relocation. |
| Inter-frequency handover | The number of inter-frequency handovers increases when the Carrier Aggregation-Aware IFLB feature is activated. The increase depends on the number of UEs that are considered to gain in carrier aggregation utilization by a relocation. |

# 3 Carrier Aggregation-Aware IFLB Operation

### Feature Operation Sequence Diagram

The Carrier Aggregation-Aware IFLB feature is based on the Inter-Frequency Load Balancing feature. The purpose is to improve load balancing by taking carrier aggregation-capable UEs into account. The main functions of Carrier Aggregation-Aware IFLB are the following:

**CATR** During Initial Context Setup, a UE is evaluated for its carrier aggregation utilization potential in the source cell and the available load balancing target cells. If a better target cell is found, the UE is configured to measure the corresponding frequency.

**Extended criteria for UE selection during Inter-Frequency Load Balancing**
During Inter-Frequency Load Balancing UE selection criteria are evaluated to choose a certain UE for load balancing. The Carrier Aggregation-Aware IFLB feature is part of this evaluation. Its purpose is to make sure that a carrier aggregation-capable UE is only subject to load balancing if a target cell with better aggregated subscription capacity is found.

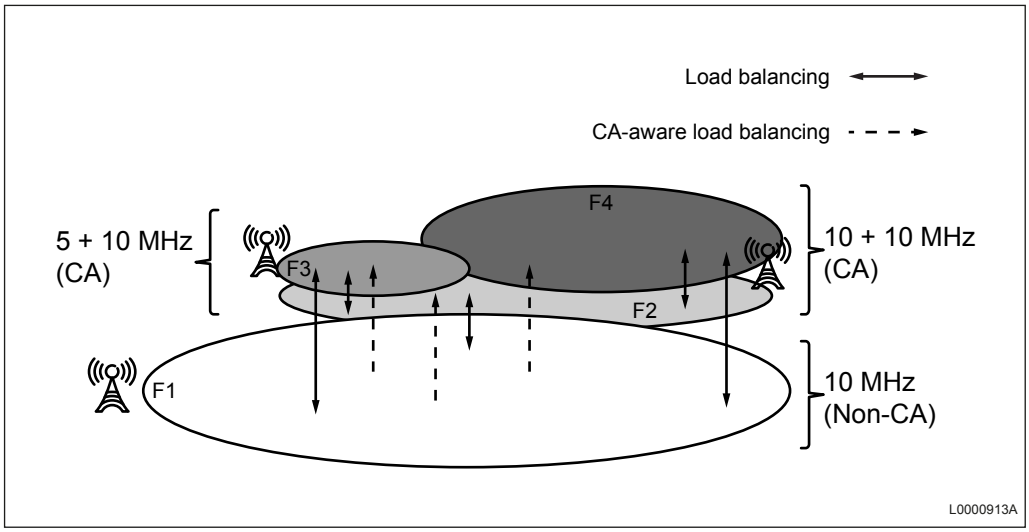



Figure 1 Principal UE Movement Due to Inter-Frequency Load Balancing and Carrier Aggregation-Aware IFLB

### Process Steps

1. The Carrier Aggregation-Aware IFLB orders the carrier aggregation-capable UEs to hand over after initial context setup (CATR).

2. The Carrier Aggregation-Aware IFLB carries out load balancing by reassigning the carrier aggregation-capable UEs to carrier aggregation-capable cells.

   Load balancing is possible in both directions between all cells, but Carrier Aggregation-Aware IFLB only happens if the carrier aggregation utilization potential for the UE increases.

— RELATED INFORMATION —

3.1 Carrier Aggregation Triggered Redirection Operation on page 6

## 3.1 Carrier Aggregation Triggered Redirection Operation

### Process Steps

The cell evaluation process is performed at initial context setup. The following steps are performed to find a desired target cell:

1. Selects frequencies available for CATR, which means frequencies for which the The Carrier Aggregation-Aware IFLB `EUtranFreqRelation.caTriggeredRedirectionActive`
2. For selected frequencies, all cells are selected that are available for load balancing. This can be configured by setting the `EUtranCellRelation.loadBalancing` attribute of the desired cell relations to `ALLOWED` or `IFO_AND_IFLB`.
3. All cells are selected that fulfill the following:
   - The CarrierThe target cell subscription ratio is lower than `LoadBalancingFunction.lbCaThreshold`. (Criterion 1)
   - The difference between the target cell subscription ratio and the source cell subscription ratio is lower than the value of the `LoadBalancingFunction.lbDiffCaOffset` attribute. This means that it is allowed to overload the target cell with the value of the `LoadBalancingFunction.lbDiffCaOffset` attribute compared to the source cell. (Criterion 2)
   - All remaining cells are evaluated for best carrier aggregation combination. A target cell is only qualified if the aggregated subscription capacity is `LoadBalancingFunction.lbCaCapHysteresis` % better than the aggregated subscription capacity for the source cell. (Criterion 3)

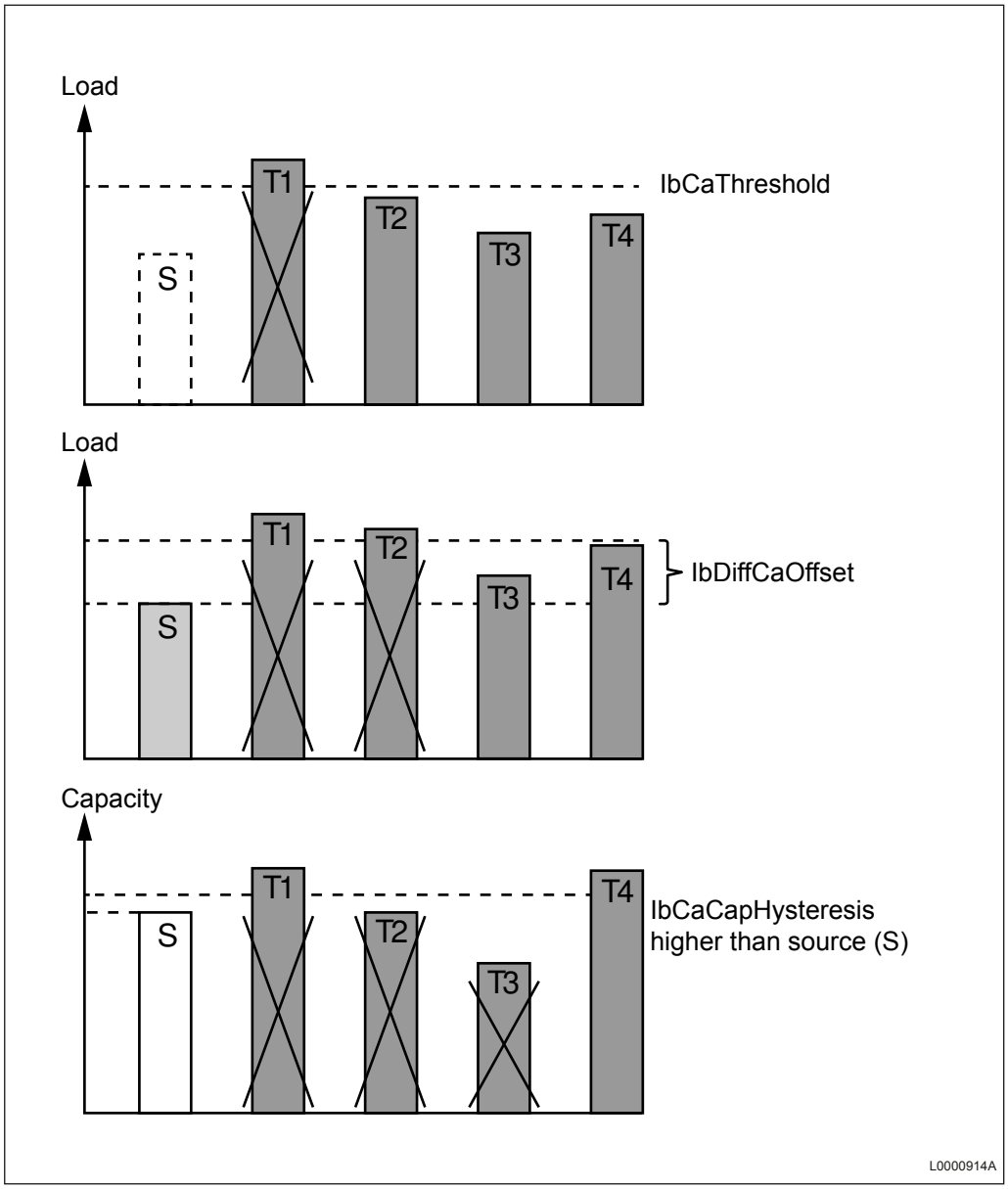
**Note:** Intra-Cell Handover to Additional Band is an enhancement to the Multiple Frequency Band Indicators feature. When MFBI is active, the evaluation described above considers the possibility to move UEs to the additional band.

4. The Carrier Aggregation-Aware IFLB selects the frequency for the best target cell and orders the UE to start A5 measurement for that frequency. Measurement configuration is included in the first `RRC connection reconfiguration` message sent to the UE.

5. If the UE responds with a measurement report and the reported cell still fulfills the required conditions, a handover is triggered.

### Feature Operation Sequence Diagram

Figure 2 High-Level Example of Evaluations Performed by CATR




1. Criterion 1 excludes target cell T1 as a candidate for CATR, since load is higher than `lbCaThreshold`.
2. Criterion 2 excludes target cell T2 as a candidate for CATR, since load difference is too high.
3. Criterion 3 excludes T3 as a candidate for CATR, since carrier aggregation capacity is lower than the source and hysteresis values combined.

—— RELATED INFORMATION ——

3. Carrier Aggregation-Aware IFLB Operation on page 5

## 3.2 Process Steps for Load Balancing UE Selection

In addition to the normal criteria for UE selection in the load balancing UE selection process, there are additional steps performed for carrier aggregation-capable UEs.

### Process Steps

1. For a carrier aggregation-capable UE to be selected for load balancing action, at least one of the following criteria must be fulfilled:

   - The subscription ratio in the source cell is higher than `LoadBalancingFunction.lbCaThreshold` together with `LoadBalancingFunction.lbCaCapHysteresis`. (Criterion 1)
   - `LoadBalancingFunction.lbDiffCaOffset` together with the load difference between the source and target cell is higher than `LoadBalancingFunction.lbCaCapHysteresis`. (Criterion 2)
   - A target cell on the frequency has a better, or slightly worse, aggregated subscription capacity than the aggregated subscription capacity of the source cell. This means that a target cell is only qualified if its aggregated capacity increased by `LoadBalancingFunction.lbCaCapHysteresis` % is greater than the aggregated capacity of the source cell. (Criterion 3)

2. If the UE responds with a measurement report and the reported cell still fulfills the required conditions, a handover is triggered.

   For further description of the UE selection procedure, see Inter-frequency Load Balancing.

**Note:** Carrier aggregation-aware IFLB towards a target cell is inhibited for a UE if parameter for the concerned target carrier frequency `loadBalancingAllowed` field of the `RATFreqPrio.FreqPrioEUTRA` attribute is set to `FALSE` for matching UE SPID. Otherwise, if set to `TRUE` or no matching UE SPID, the carrier aggregation-aware IFLB towards a target cell for the UE is allowed. Subscriber Triggered Mobility provides details on the support of SPID use.

# 4 Network Impact of Carrier Aggregation-Aware IFLB

## Capacity and Performance

The Carrier Aggregation-Aware IFLB feature distributes the UE population to achieve good utilization of the Carrier Aggregation feature.

The feature relies on UE inter-frequency measurements to identify UEs suitable for redirection. The RRC signaling associated with inter-frequency measurements and the handover-related signaling can increase and the resources are shared between the Inter-Frequency Load Balancing, Inter-Frequency Offload, Inter-RAT Offload to WCDMA, and Carrier Aggregation-Aware IFLB features.

## Mobility

The Carrier Aggregation-Aware IFLB feature redistributes users in connected mode between inter-frequency cells by inter-frequency handover. The number of inter-frequency handovers increases with this feature. The handover is performed under good radio conditions.

## Interfaces

No impact is expected from this feature.

## Other Network Elements

No impact is expected from this feature.

# 5 Parameters of Carrier Aggregation-Aware IFLB

### Feature Configuration Parameters

The following attributes are introduced by the feature:

- `LoadBalancingFunction.lbCaThreshold`
- `LoadBalancingFunction.lbCaCapHysteresis`
- `LoadBalancingFunction.lbDiffCaOffset`
- `EUtranFreqRelation.caTriggeredRedirectionActive`
- `EUtranFreqRelationUnlicensed.caTriggeredRedirectionActive`
- `ExternalENodeBFunction.eSCellCapacityScaling`

### Affected Parameters

The implementation of this feature affects no parameters.

### Parameters Affecting the Carrier Aggregation-Aware IFLB Feature

The following attributes affect the feature:

- `EUtranCellRelation.loadBalancing`
- `EUtranCellRelationUnlicensed.loadBalancing`
- `EUtranCellFDD.cellSubscriptionCapacity`
- `EUtranCellTDD.cellSubscriptionCapacity`
- `QciProfilePredefined.qciSubscriptionQuanta`
- `QciProfileOperatorDefined.qciSubscriptionQuanta`
- `LoadBalancingFunction.lbThreshold`
- `LoadBalancingFunction.lbCeiling`
- `ReportConfigEUtraInterFreqLb.a5Threshold1Rsrp`
- `ReportConfigEUtraInterFreqLb.a5Threshold2Rsrp`

- ReportConfigEUtraInterFreqLb.a5Threshold2Rsrq
- ReportConfigEUtraInterFreqLb.hysteresisA5

# 6 Performance of Carrier Aggregation-Aware IFLB

## KPIs

The main Key Performance Indicators (KPIs) associated with the feature are the following:

— Mobility success rate

— Downlink Throughput

## Counters

Table 3 Counters

| Counter | Description |
|---|---|
| EUtranCellRelation.pmHoPrepAttLteInterFCaRedirect<br>EUtranCellRelationUnlicensed.pmHoPrepAttLteInterFCaRedirect | Records the number of attempted inter-frequency handover preparations towards the related cell, due to carrier aggregation-triggered redirection performed during Initial UE connection setup, when the Carrier Aggregation-Aware IFLB feature is used. |
| EUtranCellRelation.pmHoPrepSuccLteInterFCaRedirect<br>EUtranCellRelationUnlicensed.pmHoPrepSuccLteInterFCaRedirect | Records the number of successful inter-frequency handover preparations towards the related cell, attempted due to CATR performed during initial UE connection setup, when the Carrier Aggregation-Aware IFLB feature is used. |
| EUtranCellRelation.pmHoExecAttLteInterFCaRedirect<br>EUtranCellRelationUnlicensed.pmHoExecAttLteInterFCaRedirect | Records the number of attempted inter-frequency handover executions towards the related cell, due to CATR performed during initial UE connection setup, when the Carrier Aggregation-Aware IFLB feature is used. |
| EUtranCellRelation.pmHoExecSuccLteInterFCaRedirect<br>EUtranCellRelationUnlicensed.pmHoExecSuccLteInterFCaRedirect | Records the number of successful inter-frequency handover executions towards the related cell, attempted due to CATR performed during initial UE connection setup, when the Carrier Aggregation-Aware IFLB feature is used. |
| EUtranFreqRelation.pmCaRedirectMeasuredUe<br>EUtranFreqRelationUnlicensed.pmCaRedirectMeasuredUe | Records the number of UEs selected for measurements that qualify for CATR towards cells on the related frequency, when the Carrier Aggregation-Aware IFLB feature is used. The counter is used as a parameter to calculate the load balancing measurement success rate for the related cells. |
| EUtranFreqRelation.pmCaRedirectMeasRepUe<br>EUtranFreqRelationUnlicensed.pmCaRedirectMeasRepUe | Records Number of UEs that report the related E-UTRAN cell as the strongest cell in connection with carrier aggregation-triggered redirection, when feature Carrier Aggregation-Aware IFLB is used. |
| EUtranCellRelation.pmCaRedirectQualifiedUe<br>EUtranCellRelationUnlicensed.pmCaRedirectQualifiedUe | Records the number of UEs that report the related cell as the cell with highest RSRP in connection with CATR, when the Carrier Aggregation-Aware IFLB feature is used. |
| EUtranCellRelation.pmHoPrepAttNonMob<br>EUtranCellRelationUnlicensed.pmHoPrepAttNonMob | The number of attempts to start outgoing intra-LTE handover preparation due to non-mobility reasons. |
| EUtranCellRelationUnlicensed.pmHoPrepSuccNonMob | The number of successful outgoing intra-LTE handover preparations due to non-mobility reasons. |

| Counter | Description |
|---|---|
| EUtranCellRelation.pmHoPrepSuccNonMob | |
| EUtranCellRelationUnlicensed.pmHoExeAttNonMob<br>EUtranCellRelation.pmHoExeAttNonMob | The number of attempts to start outgoing intra-LTE handover executions towards the related cell due to non-mobility reasons. |
| EUtranCellRelationUnlicensed.pmHoExeSuccNonMob<br>EUtranCellRelation.pmHoExeSuccNonMob | The number of successful outgoing intra-LTE handovers performed due to non-mobility reasons. |

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

## Events

Table 4 Events

| Event | Event Parameter | Description |
|---|---|---|
| INTERNAL_EVENT_UE_LB_MEAS | EVENT_PARAM_FREQ | Target frequency. |
| | EVENT_PARAM_TRIGGERING_FUNCTION | Indicates the function that has triggered the UE measurement and so the measurement report:<br>—Load balancing<br>—CATR<br>—BNR for load balancing |
| | EVENT_PARAM_UE_CA_CAPABLE | Indicates whether the UE selected for load balancing related measurements is carrier aggregation-capable. |
| | EVENT_PARAM_NEIGHBOR_CGI | CGI of neighbor target cells for which UE fulfilled event A5 criteria. |
| | EVENT_PARAM_TRAVERSED_UES | Number of UEs checked and discarded before choosing this UE for load balancing related measurements. |
| INTERNAL_EVENT_UE_LB_QUAL | EVENT_PARAM_NEIGHBOR_CGI | CGI of neighbor target cells for which UE fulfilled event A5 criteria. |
| | EVENT_PARAM_HO_SOURCE_OR_TARGET_TYPE | Indicates the RAT of the source for incoming handover, for target for outgoing handover cell. |
| | EVENT_PARAM_LB_CANCELLED_REASON | Indicates the reason for not proceeding with a load balancing or CATR action when a measurement report is received from the UE:<br>—Carrier aggregation criteria not met<br>—Reported cell is not a valid load balancing target<br>—Reported cell is a valid target, but the amount of load balancing is already satisfied for the cell<br>—Service Specific Load Management related restrictions |

| Event | Event Parameter | Description |
|---|---|---|
| | | — RSRQ of target cell is less than configured threshold<br>— UE has signalled interest in MBMS on serving frequency<br>— UE has an ongoing VoIP call and does not support SRVCC |
| | EVENT_PARAM_TRIGGERING_FUNCTION | Indicates the function that triggered the UE measurement and so the measurement report:<br>— Load balancing<br>— CATR<br>— BNR for load balancing |

More information about events can be found in Manage Lists.

# 7 Activate Carrier Aggregation-Aware IFLB

### 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 | `OptionalFeatureLicense=CarrierAggregationAwareIFLB` |
| Baseband-based Node | `FeatureState=CXC4011666` |

### After This Task

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

# 8 Deactivate Carrier Aggregation-Aware IFLB

### 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=CarrierAggregationAwareIFLB` |
| Baseband-based | `FeatureState=CXC4011666` |

### After This Task

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

# 9 Engineering Guidelines for Carrier Aggregation-Aware IFLB

### Activate CA Triggered Redirection for Each Frequency

The following steps must be performed at the time of feature activation:

1. Set `EUtranFreqRelation.caTriggeredRedirectionActive` parameter to `TRUE` in the MO instance representing the frequency relation where Carrier Aggregation-Aware IFLB is desired. It allows CATR.
2. Set `EUtranCellRelation.loadBalancing` to `ALLOWED` on one or more MO instances representing cell relations belonging to this frequency relation. It allows Load Balancing.

For a UE to be subject to CATR, conditions configured by Service Specific Load Management and Shared LTE RAN handover restrictions, are also evaluated.

**Note:** Since UE measurement for CATR is configured during UE setup, not all bearers are fully set up. This means Service Specific Load Management conditions for these bearers cannot be evaluated. However, this evaluation is performed before a handover is triggered.

### Other Engineering Guidelines

The Carrier Aggregation-Aware IFLB feature adds conditions for UE evaluation for load balancing and evaluates the UE for CATR. The `LoadBalancingFunction.lbCaThreshold` attribute is used to determine the absolute subscription ratio threshold used to exclude target cell T1 as a candidate for CATR (Criterion 1) for both CATR and for UE selection evaluation during load balancing.

To keep an even traffic load balance between all cells, set `LoadBalancingFunction.lbDiffCaOffset` to a value that is an acceptable imbalance. This means that CATR performs handovers when there is an imbalance up to the value of `LoadBalancingFunction.lbDiffCaOffset`. It also means that UEs are not selected for load balancing if they are on the cell with the best carrier aggregation utilization potential, as long as the load difference is less than `LoadBalancingFunction.lbDiffCaOffset`. If the load difference rises above `LoadBalancingFunction.lbDiffCaOffset`, the UE is selected for load balancing regardless of whether the target cell offers better aggregated subscription capacity than the source cell.

In the evaluation of the best carrier aggregation utilization potential for a UE, the aggregated capacity of the PCell and one or more SCells is calculated for source and candidate target cells. Even combinations without any SCells are considered valid, which means that carrier aggregation-capable UEs will be subject to

evaluation even if there are no SCell candidates configured for a certain target cell. The `LoadBalancingFunction.lbCaCapHysteresis` attribute is used to qualify target cells so that they offer a clear benefit over the source cell in terms of aggregated capacity. If the source or target PCells have an ESCell, the cell subscription capacity of the ESCell can be scaled down by using `ExternalENodeBFunction.eSCellCapacityScaling` attribute. The attribute is used to decrease carrier aggregation attraction of an ESCell belonging to an indicated eNodeB.

**Note:** When the Limited-Uplink-Aware IFLB feature and Automated Cell Capacity Estimation feature are activated, the aggregated subscription capacity calculation is changed. For more information, see the document Limited-Uplink-Aware IFLB.

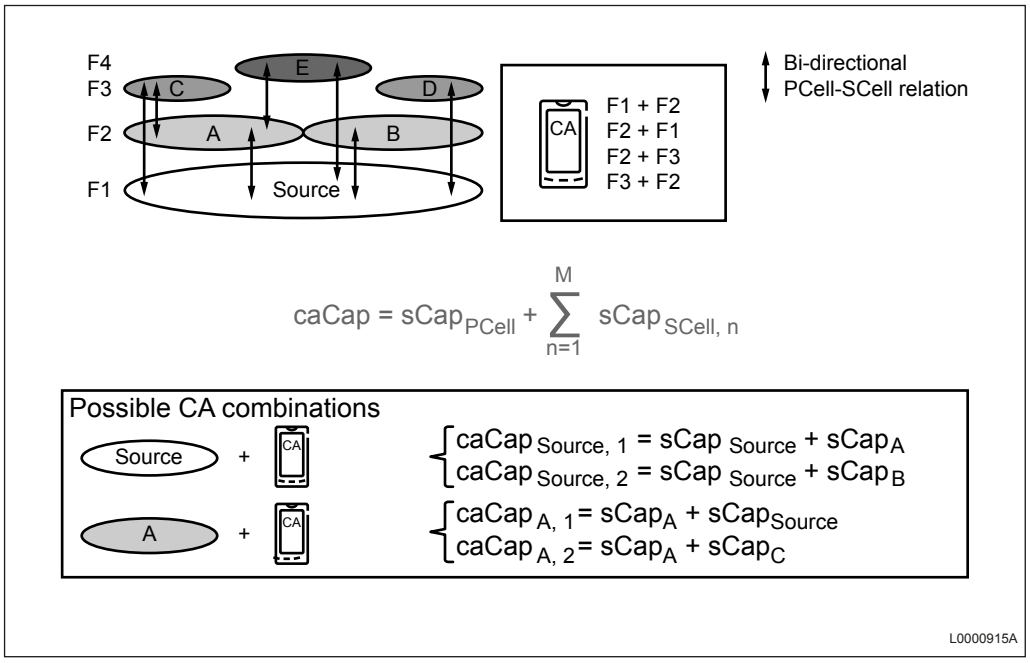
The `EUtranCellRelation.esCellCaConfigurationAvail` attribute is configured by the Inter-eNodeB Carrier Aggregation feature or Elastic RAN feature and is used for indicating the state of an ESCell. To identify the available ESCell, the `EUtranCellRelation.esCellCaConfigurationAvail` attribute must be set to one of the following values:

**ENABLED** Used for Inter-eNodeB Carrier Aggregation feature.

**ENABLED_IENB** Used for Inter-eNodeB Carrier Aggregation feature.

**ENABLED_ERAN** Used for Elastic RAN feature.

For more information, see Inter-eNodeB Carrier Aggregation and Elastic RAN documents.



The purpose of the aggregated subscription capacity calculation is to find the target cell that offers the best aggregated subscription capacity for the UE. To do so, network configuration is matched with the CA capabilities of the UE.

The aggregated subscription capacity is calculated based on the available PCell-SCell combinations, where the following conditions are true:

— Two possible carrier aggregation combinations use the source cell as PCell and can be chosen by the UE.

— The UE does not support any carrier aggregation band combination that includes frequency F4. Therefore no valid carrier aggregation combinations exist with cells on F4.

— The UE is handed over to target cell A if $caCap_{A,2}$ yields the highest aggregated subscription capacity. This occurs through CATR or LB.

Figure 4 Example of How to Calculate the Aggregated Subscription Capacity