

LTE1804 Downlink Carrier Aggregation 3CC 60 MHz

LTE2168 Additional carrier aggregation band combinations II

LTE2200 Additional carrier aggregation band combinations III

LTE2167 Additional Carrier Aggregation band combinations 3CC I

Please always check [the latest version](#) of this NEI slides!

LTE1804 Downlink Carrier Aggregation 3CC 60 MHz

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Introduction



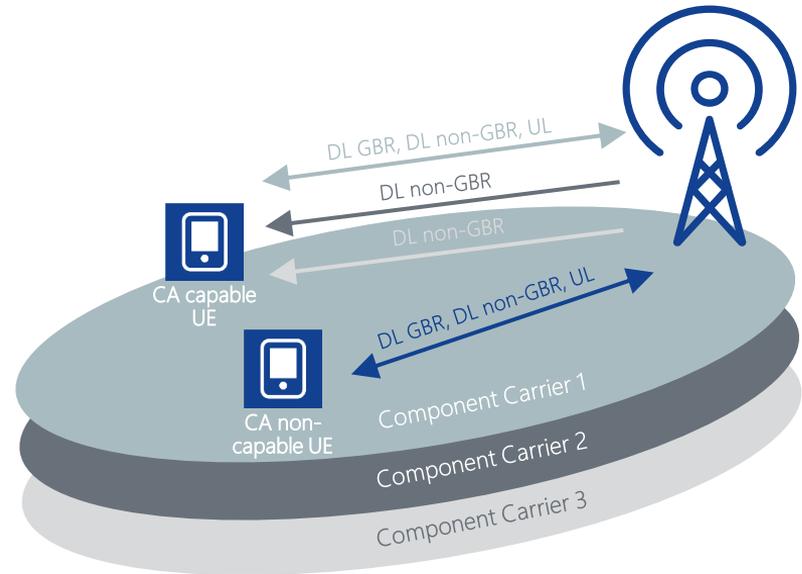
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Introduction

The idea behind LTE1804 DL Carrier Aggregation 3CC 60 MHz (1/2)

CA principles:

- Every cell called Component Carrier (CC) is logically combined with additional cells serving the same site sector
- Primary Cell (PCell) serves both UL and DL traffic (GBR and non-GBR)
- Secondary Cells (SCells) serve DL non-GBR traffic only
- If configured so, every carrier can play a PCell role
- All cells handle CA and non-CA UEs simultaneously

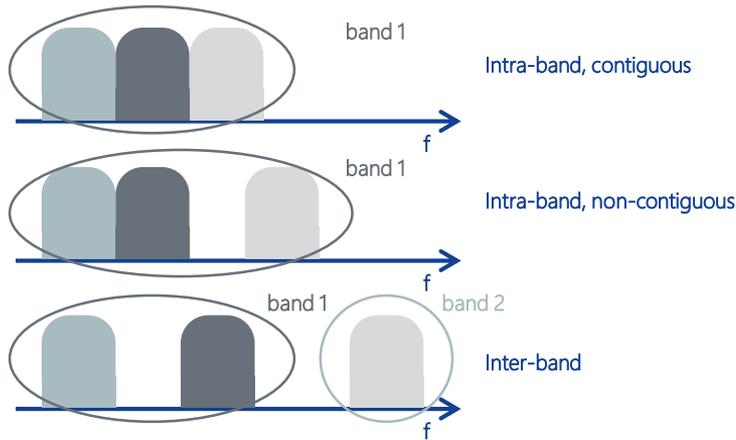


Introduction

The idea behind LTE1804 DL Carrier Aggregation 3CC 60 MHz (2/2)

DL CA 3CC 60 MHz principles:

- Enables aggregation of three CC
- Contiguous and non-contiguous intra-band and inter-band CA supported



Intra-band contiguity in terms of CA:

- Band contiguity in terms of CA is given by the formula considering channel bandwidth
- Two metrics are used to define band contiguity in terms of CA:
 - relative center frequency difference between cells, ΔF_C
 - nominal channel spacing, *nominalSpacing*
- Two cases are possible:
 - $\Delta F_C \leq \text{nominalSpacing}$ → contiguous intra-band CA
 - $\Delta F_C > \text{nominalSpacing}$ → non-contiguous intra-band CA

Introduction

Supported band combinations

Supported band combinations

LTE1803

Operating band			Note*	Frequency band		
1	3	5	0	2100	1800	850
1	3	8	0 and 2	2100	1800	900
1	5	7	1	2100	850	2600
1	18	28	0	2100	850	700
2	2	5	Band 2, NC, 0	1900	1900	850
2	2	12	Band 2, NC, 0	1900	1900	700
2	2	29	Band 2, C, 0	1900	1900	700
2	4	4	Band 4, NC, 0	1900	1700	1700
2	4	5	0	1900	1700	850
2	4	12	0	1900	1700	700
2	5	30	0	1900	850	2

¹ LTERLCR-9010

This CR adds BCS1 for CA band combination – **band 3 + band 3 + band 8**. CR introduces also several new CA band combinations:

- **band 3 + band 7 + band 28** (15MHz +20 MHz +10 MHz respectively)
- **band 3 +band 3 (BCS1)**. This new band combination is required for the fallback 3CC->2CC of the 3CC band combination **band 3 + band 3 + band 8 (BCS1)**
- **band 5 + band 7 (BCS1)**. This new band combination is required for the fallback 3CC->2CC of the 3CC band combination **band 1 + band 5 +band 7 (BCS1)**

Operating band			Note*	Frequency band		
2	12	30	0	1900	700	2300
2	29	30	0	1900	700	2300
3	3	7	0	1800	1800	2600
3	3	8	0 and 1	1800	1800	900
3	7	20	0	1800	2600	800
3	7	28	N/A	1800	2600	700
4	4	5	Band 4, NC, 0	1700	1700	850
4	4	12	Band 4, NC, 0	1700	1700	700
4	5	30	0	1700	850	2300
4	12	30	0	1700	700	2300
4	29	30	0	1700	700	2300

* numbers indicate the bandwidth combination set (BCS) supported, C – contiguous, NC – non-contiguous

Introduction

Band combinations supported by LTE2168 - Additional carrier aggregation band combinations II

Band combinations supported by LTE2168 - Additional Carrier Aggregation band combinations II

Operating band		Note*	Frequency band	
1	5	1	2100	850
1	8	2	2100	900
2	2	NC and C	1900	1900
2	12	0	1900	700
2	30	0	1900	2300
3	5	2	1800	850
3	8	2	1800	900
3	20	1	1800	800

Operating band		Note*	Frequency band	
4	5	0 and 1	1700	850
4	30	0	1700	2300
5	30	0	850	2300
7	7	1, C	2600	2600
7	20	1	2600	800
7	8	0	2600	900
12	30	0	700	2300
18	28	0	850	700



Officially supported configurations from RL70 onwards

* numbers indicate the bandwidth combination set (BCS) supported, C – contiguous, NC – non-contiguous

Introduction

Band combinations supported by LTE2200 - Additional Carrier Aggregation band combinations III

Band combinations supported by LTE2200 - Additional Carrier Aggregation band combinations III

Operating band		Note*	Frequency band	
1	11	0	2100	1500
1	20	0	2100	800
2	2	C	1900	1900
2	13	0 and 1	1900	700
2	28	0	1900	700
3	7	1	1800	2600
3	8	3	1800	900
4	13	0 and 1	1700	700
4	28	0	1700	700
5	17	0	850	700

Operating band		Note*	Frequency band	
5	25	0	850	1900
5	29	0	850	700
7	8	1	2600	900
7	28	1	2600	700
8	11	0	900	1500
8	28	0	900	700
12	12	B	700	700
25	25	0 and 1, NC	1900	1900
25	26	0, 1 and 2	1900	850

* numbers indicate the bandwidth combination set (BCS) supported, C – contiguous, NC – non-contiguous, B - contiguous (total bandwidth ≤ 20MHz)

¹ CA band combination (introduced by **LTERLCR-6799**) not covered by 3GPP 36.101 v13.2.1, but defined in 3GPP work items and it will be included in further releases

² CA band combination introduced by **LTERLCR-10069**

Introduction

Band combinations supported by LTE2167 - Additional Carrier Aggregation band combinations 3CC I

Band combinations supported by LTE2167 - Additional Carrier Aggregation band combinations 3CC I

Operating band			Note*	Frequency band			
1	3	7	0	2100	1800	2600	1
1	3	20	0	2100	1800	800	
1	3	28	0	2100	1800	700	
1	7	28	0	2100	2600	700	
1	8	11	0	2100	900	1500	2
1	8	28	0	2100	900	700	**
2	2	13	Band 2, NC, 0	1900	1900	700	
2	4	13	0	1900	1700	700	
2	4	29	0	1900	1700	700	
2	5	29	0	1900	850	700	

Operating band			Note*	Frequency band			
2	12	12	0, Band 12, C	1900	700	700	
3	7	7	0, Band 7, C	1800	2600	2600	
3	7	8	0 and 1	1800	2600	700	
3	7	28	0	1800	2600	700	
3	8	28	0	1800	900	700	**
4	4	7	Band 4, NC, 0	1700	1700	2600	
4	4	13	Band 4, NC, 0	1700	1700	700	
4	5	12	0	1700	850	700	
4	12	12	0, Band 12, B	1700	700	700	

* numbers indicate the bandwidth combination set (BCS) supported, C – contiguous, NC – non-contiguous, B - contiguous (total bandwidth ≤ 20MHz)

** CA band combinations not covered by 3GPP 36.101 v13.2.1, but defined in 3GPP work items and they will be included in further releases

1 CA band combination introduced by **LTERLCR-7669**

2 CA band combination introduced by **LTERLCR-10069**

Introduction

Supported bandwidth and eNB antenna combinations

Supported bandwidth combinations

Bandwidth [MHz]			Bandwidth [MHz]		
5	5	5	10	10	10
5	5	10	10	10	15
5	5	15	10	10	20
5	5	20	10	15	15
5	10	10	10	15	20
5	10	15	10	20	20
5	10	20	15	15	15
5	15	15	15	15	20
5	15	20	15	20	20
5	20	20	20	20	20

LTE1803

Supported eNB antenna combinations

Antenna configuration		
2TX/2RX	2TX/2RX	2TX/2RX
2TX/2RX	2TX/2RX	4TX/4RX
2TX/4RX	4TX/4RX	4TX/4RX
4TX/4RX	4TX/4RX	4TX/4RX

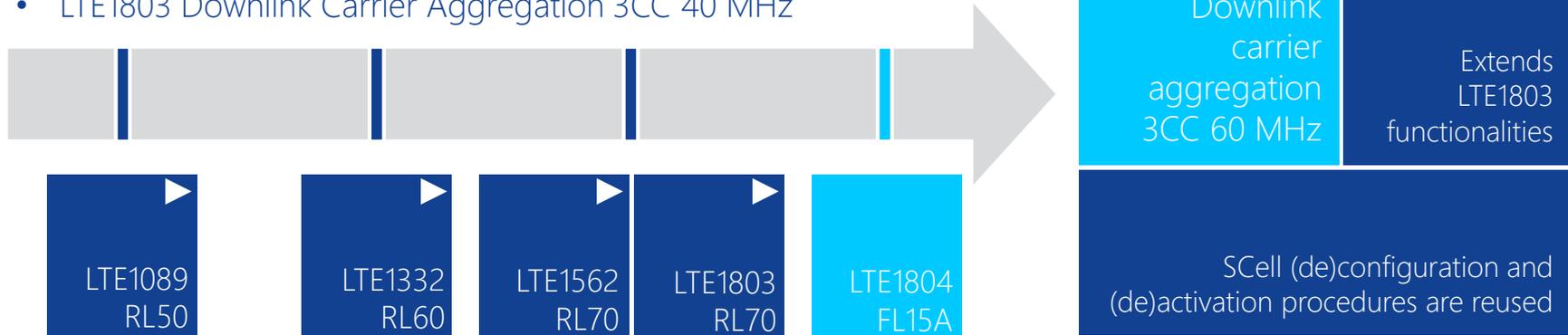
LTE1803

Introduction

Development timeline of related features

Related features:

- LTE1089 DL Carrier Aggregation
- LTE1332 DL Carrier Aggregation 40 MHz
- LTE1562 Carrier Aggregation for multi-carrier eNBs
- LTE1803 Downlink Carrier Aggregation 3CC 40 MHz



Introduction

With and without the LTE1804 DL Carrier Aggregation 3CC 60 MHz (1/2)

- Maximum aggregated bandwidth of 40 MHz
- Maximum throughput of 287.7 Mbps
- Fragmented spectrum tailored

2CC CA

- Maximum aggregated bandwidth of 40 MHz
- Maximum throughput of 283.0 Mbps

3CC CA in LTE1803

- Maximum aggregated bandwidth of 60 MHz
- Maximum throughput of 431.1 Mbps
- Fragmented spectrum tailored

3CC CA in LTE1804

Introduction

With and without the LTE1804 DL Carrier Aggregation 3CC 60 MHz (2/2)

- Only one (20+10+10) MHz bandwidth combination supported
- Joint activation of SCells
- CA limitations in case of fragmented spectrum owned
- Limitation of CA UEs number

3CC CA in LTE1803

- Maximum aggregated bandwidth of 60 MHz
- Additional several band and bandwidth combinations supported
- Stepwise SCell (de)activation
- Contiguous and non-contiguous intra-band and inter-band 3CC CA
- Increased number of UEs with SCell(s) configured
- PUCCH Format 3 ACK/NACK and periodic CSI multiplexing

3CC CA in LTE1804

Interdependencies



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Interdependencies

Activation prerequisites

prerequisites

LTE1089 Downlink Carrier Aggregation

LTE1332 Downlink Carrier Aggregation 40 MHz

LTE1562 Carrier Aggregation for multi-carrier eNBs

LTE1803 DL Carrier Aggregation 3CC 40 MHz

- The same activation flag `LNBTS-actDLCAggr` is used in order to enable all of the features



LTE1804

LNBTS-
actDLCAggr =
true

Interdependencies

Activation exclusions

exclusions

LTE117 Cell bandwidth 1.4 MHz
LTE116 Cell bandwidth 3 MHz

excluded from interworking
with any CA feature

LTE1382 Cell Resource Groups

This dependency does not impact interworking
with 2CC scenarios (LTE1089, LTE1332 and
LTE1562)

excluded from interworking
with
DL CA 3CC only
(DL CA 2CC features not
affected)

Interdependencies

Activation limitations

limitations

LTE1542 FDD Supercell

- Supercell-Supercell and Supercell-normal cell aggregations may impact the CA efficiency/performance due to coverage mismatch effect and hence CA relations (CAREL objects) must be carefully planned.

LTE907 TTI Bundling

- UE which is configured with TTI bundling cannot be configured with any SCell – but features can run in BTS in parallel

LTE1406 Extended VoLTE talk time

- LTE1406 triggers (voice bearer is setup via the E-RAB Setup Request Procedure) will deconfigure two SCells and voice bearer release might cause configuration of two SCells for 3-cell CA candidate UE

Interdependencies

Activation extensions (1/2)

extensions

LTE2006 Flexible SCell selection

- LTE1804 can benefit of the new functionalities introduced by LTE2006. When a UE is identified as a 2-cell CA candidate/3-cell CA candidate, Radio Admission Control (RAC) or Bearer Management (BM) needs to consider all SCell candidates on each applicable frequency layer.

LTE1534 Multiple Frequency Band Indicator

- The eNB considers mapped bands when checking whether the UE supports the band combination for three cell carrier aggregation. Mapped EARFCN is used for the SCell(s) in communication to the UE if native EARFCN is not supported by the UE. Note: mapped EARFCN can be used for the PCell if it is done at the Initial Context Setup.

Interdependencies

Activation extensions (2/2)

extensions

LTE1951 Automatic Configuration support for CA for multi-carrier eNBs

- NetAct SON feature automatically proposes configuration needed for Carrier Aggregation for multi-carrier eNBs. Without LTE1951 feature proper PCell/SCells pairing has to be assured manually on cell-by-cell basis.

LTE585 Smart DRX

- Cooperation of LTE1803 with DRX functionality is supported with some certain dependencies in active time handling. The same active time applies to all activated serving cells.

Interdependencies

Interworking improvements

interworking
improvements

LTE1042 Nominal Bit Rate

- Cooperation between LTE1042 and CA features is improved with LTE1804.

LTE13 Rate capping

- Interworking with LTE13 for two active SCells was introduced already with LTE1803. However, due to higher bandwidths of Serving Cells used in LTE1804, it is more likely that LTE13 will kick in with LTE1804 deployed.

Technical Details

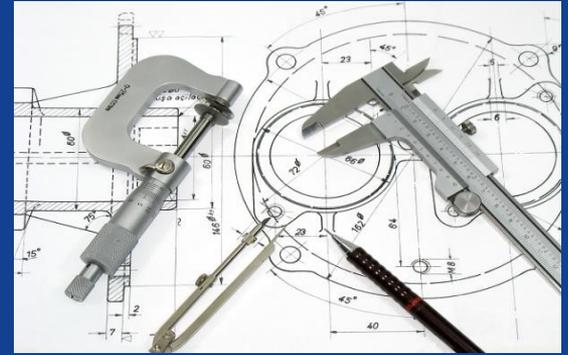


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Dependency table for LTE1804 and LTE2168

Sales information

BSW/ASW ASW

FDD LTE	RL release	eNodeB	NetAct
Release/version	FDD-LTE 15A	FL15A	NetAct 15.5

TDD LTE	RL release	eNodeB	NetAct
Release/version	NA	NA	NA

Flexi Zone Micro (FZM)	RL release	eNodeB	NetAct
Release/version	NA	NA	NA

HW & IOT	HW requirements	MME	SAE GW	UE	Specified by 3GPP
-	FSMF	For CA with UE aggregated bandwidth higher than 20 MHz, FlexiNS 4.0/Flexi NG 3.2 is a must in order to fully benefit from the functionality		3GPP Release 11 or higher	3GPP Release 10/11

Technical Details

Dependency table for LTE2167 and LTE2200

Sales information

BSW/ASW	ASW
---------	-----

FDD LTE	RL release	eNodeB	NetAct
Release/version	FDD-LTE 16	FL16	NetAct 16.2

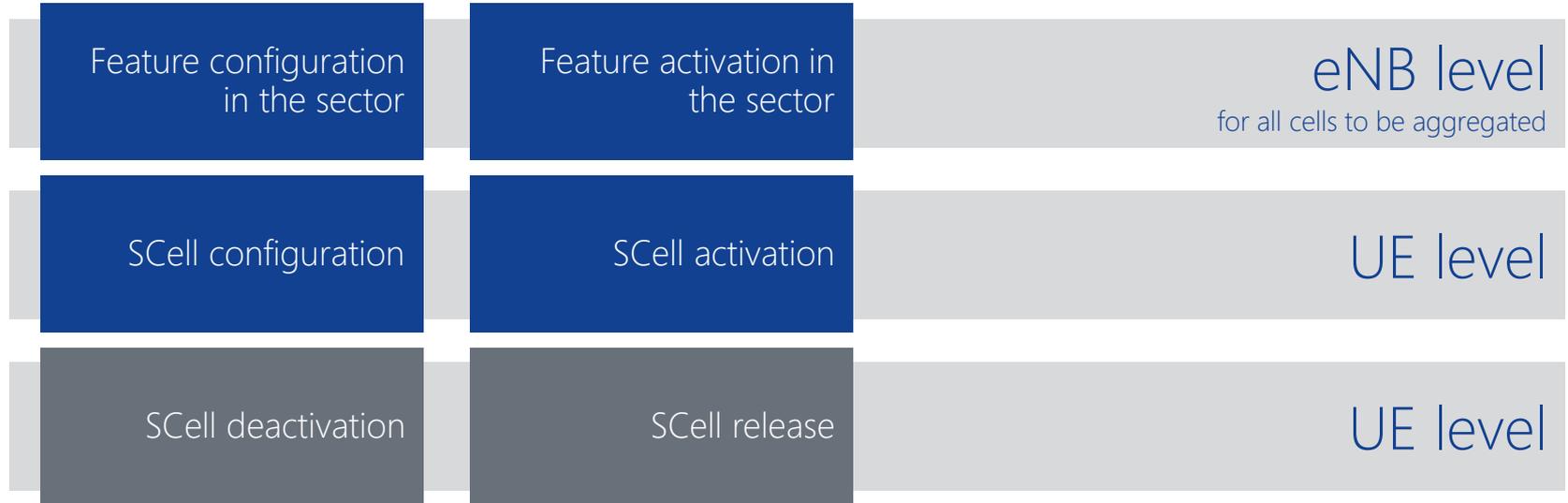
TDD LTE	RL release	eNodeB	NetAct
Release/version	NA	NA	NA

Flexi Zone Micro (FZM)	RL release	eNodeB	NetAct
Release/version	NA	NA	NA

HW & IOT	HW requirements	MME	SAE GW	UE	Specified by 3GPP
-	FSMF	For CA with UE aggregated bandwidth higher than 20 MHz, FlexiNS 4.0/Flexi NG 3.2 is a must in order to fully benefit from the functionality		3GPP Release 12	3GPP Release 13

Technical Details

Activation and deactivation process

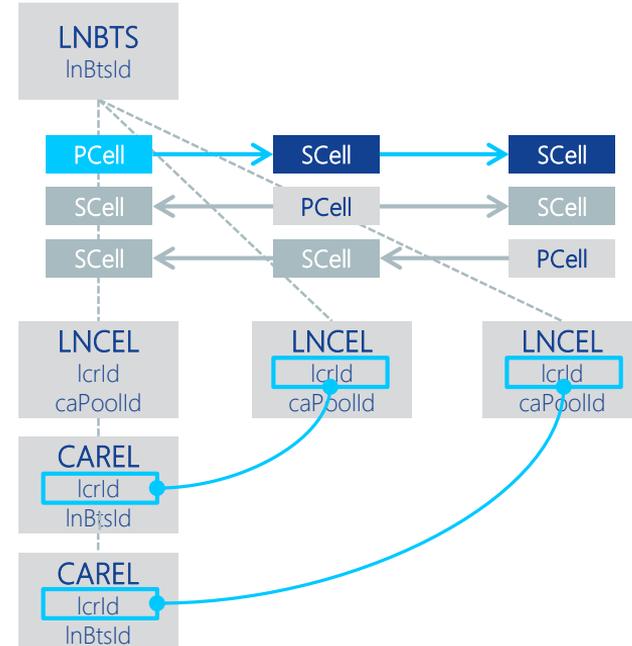


Technical Details

eNB level – feature configuration (1/2)

CA Relation (CAREL) objects:

- Creating a relation between cells is based on CAREL objects dependent on LNCEL with PCell role
- For 3CC CA two CAREL under LNCEL objects are required
- Relation between cells can be multidirectional – each cell can be both PCell or SCell

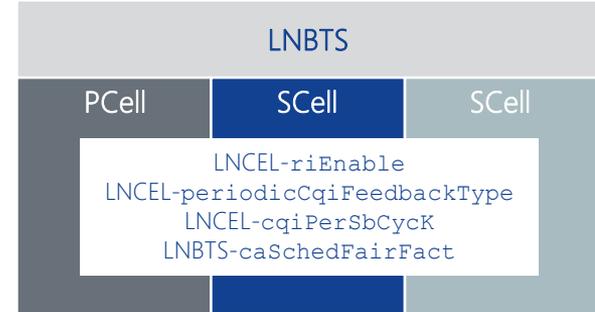


Technical Details

eNB level – feature configuration (2/2)

Aligned parameters setting for PCell and SCells:

- `LNCEL-riEnable` (Rank indication reporting enable)
- `LNCEL-periodicCqiFeedbackType` (Periodic CQI feedback type)
- `LNCEL-cqiPerSbCycK` (Periodic CQI subbands cycles)
- `LN BTS-caSchedFairFact` (Carrier Aggregation scheduling fairness control factor)



Other conditions:

- `LNCEL-deltaPucchShift` (Delta cyclic shift for PUCCH) ≤ 2
- `LNCEL-n1PucchAn` (ACK/NACK offset) = 10 or ≥ 72
- `LNCEL-maxNumSce11s` (Maximum number of SCells for DL CA) = 2

Technical Details

UE level – UE capabilities check (1/3)

- UE `accessStratumRelease` IE is `rel10` or higher
- At least one 2CC band combination can be extracted from IE:
 - `UE-EUTRA-Capability`
 - `UE-EUTRA-Capability-v1020-IEs`
 - `rf-Parameters-v1020`
 - `supportedBandCombination-r10`

CA capable UE

- At least one 3CC band combination can be extracted from IE:
 - `UE-EUTRA-Capability`
 - `UE-EUTRA-Capability-v1020-IEs`
 - `rf-Parameters-v1020`
 - `supportedBandCombination-r10`
- `Ca-BandwidthClassDL-r10` is set to `a` or `c`

3CC CA capable UE

Technical Details

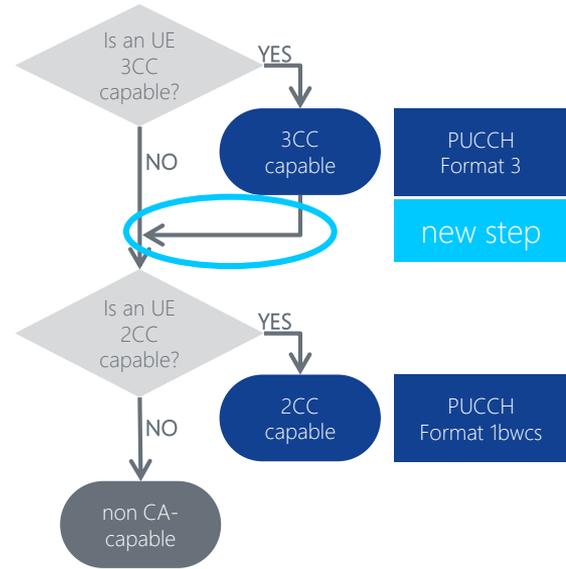
UE level – UE capabilities check (2/3)

CA capable UE:

- UE recognized as 3CC CA capable is checked for 2CC CA capabilities as well
- 3CC CA capable UE can be 2CC CA capable at the same time - this enables adding single SCell for 3-cell CA candidate

CA candidate:

- 3CC CA capable UE is 3-cell CA candidate if there is at least one band combination for 3CC CA that is supported both by the UE and the eNB

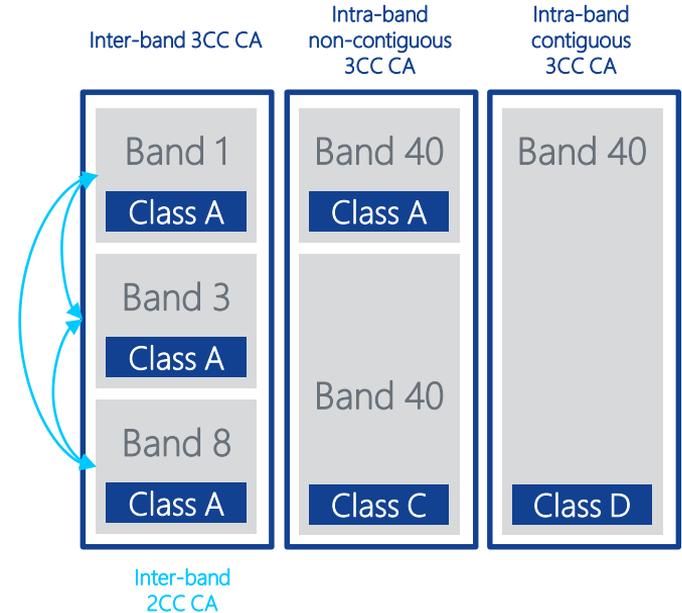


Technical Details

UE level – UE capabilities check (3/3)

Supported bandwidth combinations:

- UE signals supported BW combinations in the IE
`supportedBandCombinationExt-r10`
> `supportedBandwidthCombinationSet-r10`
- If the IE is:
 - not present - UE supports bandwidth combination set 0
 - present - each bit indicates a set of bandwidth combinations supported by UE (value of 0 is still possible)
- New parameter `LNBTs-enableBwCombCheck` enables the check of bandwidth combination set compliance with 3GPP
- Bandwidth checks are intended to avoid UE context release due to wrong configuration of the UE



Technical Details

UE level – UE capabilities check

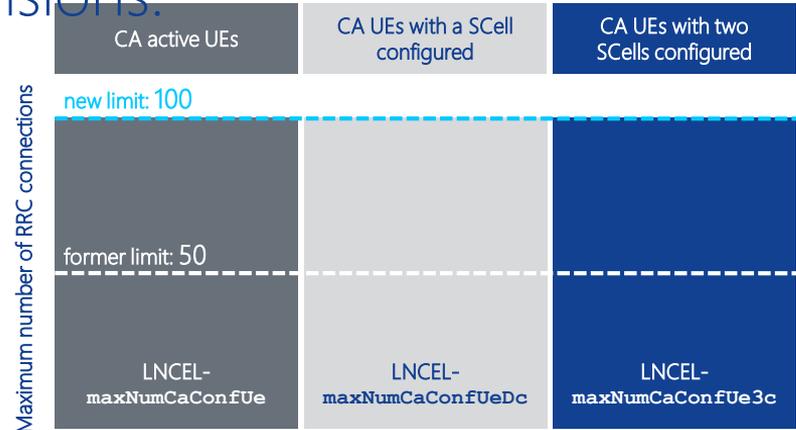
Information Element/ Group name	Need	Source	Semantics Description / Comments
rf-Parameters-v1020	OPTIONAL	UE	Must be present for CA Includes Carrier Aggregation and MIMO capabilities
>supportedBandCombination-r10		UE	SEQUENCE (1..128) List of band combinations
>>bandCombinationParameters-r10		UE	SEQUENCE(1..64) List of bands in a band combination
>>>BandParameters-r10		UE	Parameters for a band
>>>> bandEUTRA-r10		UE	ID of band (1..64)
>>>> bandParametersUL-r10	OPTIONAL	UE	SEQUENCE(1..16) List of bandwidth classes per band in UL Mandatory for PCell
>>>>> ca-BandwidthClassUL-r10		UE	CA bandwidth class {a, b, c, d, e, f, ...}
>>>>> supportedMIMO-CapabilityUL-r10	OPTIONAL	UE	MIMO capabilities for each band and bandwidth class {twoLayers, fourLayers}.
>>>>> bandParametersDL-r10	OPTIONAL	UE	SEQUENCE(1..16) List of bandwidth classes per band in DL Must be present
>>>>>> ca-BandwidthClassDL-r10		UE	CA bandwidth class {a, b, c, d, e, f, ...}
>>>>>> supportedMIMO-CapabilityDL-r10	OPTIONAL	UE	MIMO capabilities for each band and bandwidth class {twoLayers, fourLayers, eightLayers}. UE Category 1: ignored (not MIMO capable) UE Category 2-8: mandatory according to [3GPP 36.306 4.3.5.2]
rf-Parameters-v1060	OPTIONAL	UE	This IE contains band combination sets.
> supportedBandCombinationExt-r10			SEQUENCE (1..128) of BandCombinationParametersExt-r10 This sequence has the same order as the list supportedBandCombination-r10 in rf-Parameters-v1020.
>> BandCombinationParametersExt-r10			
>>> supportedBandwidthCombinationSet-r10	OPTIONAL		BIT STRING (SIZE (1..32)) for 32 possible sets
featureGroupIndRel10-v1060	OPTIONAL	UE	See table 2410.2
phyLayerParameters-v1130			
> multiACK-CSI-Reporting-r11	OPTIONAL	UE	Indicates whether the UE supports multi-cell HARQ ACK and periodic CSI reporting and SR on PUCCH Format 3.

Technical Details

UE level – configuration of SCell(s) (1/8)

Cell configuration (addition) extensions:

- Active UE – UE in RRC Connected state with DRB established (with or without data in the buffer)
- Up to 100 active UEs can use CA:
 - up to 100 of them can be configured with a SCell
 - up to 100 of them, can be configured with two SCells
- Recommendation: $\text{maxNumCaConfUeDc} \geq \text{maxNumCaConfUe3c}$

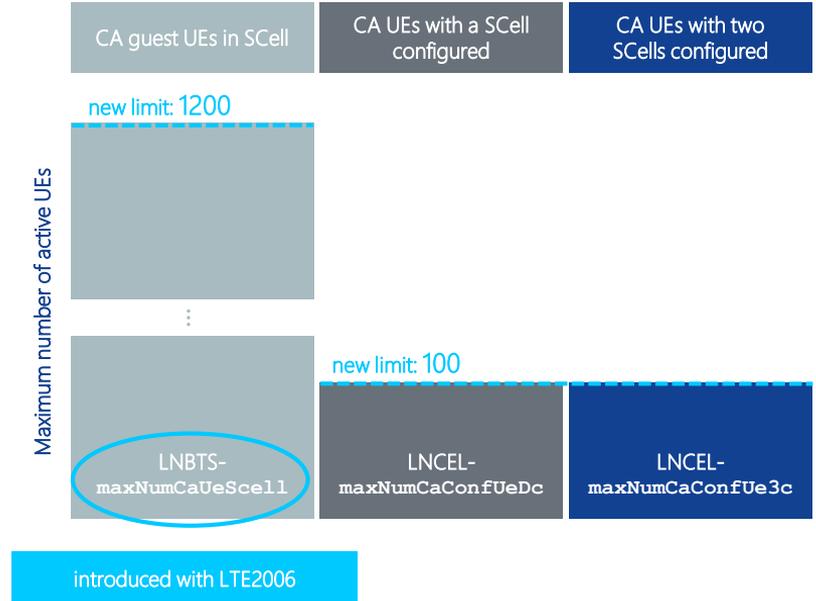


Technical Details

UE level – configuration of SCell(s) (2/8)

Cell configuration limitations (cont.):

- If the `LNbts-maxNumCaUeScell` parameter is set to the value lower than 200, it is possible that the limits of 100 CA UEs in PCell, i.e. `LNCEL-maxNumCaConfUe` cannot be reached, if two or more PCells work with the same SCell
- The possibility to have more than one SCell on one SCell frequency layer is provided by LTE2016 Flexible SCell selection feature



Technical Details

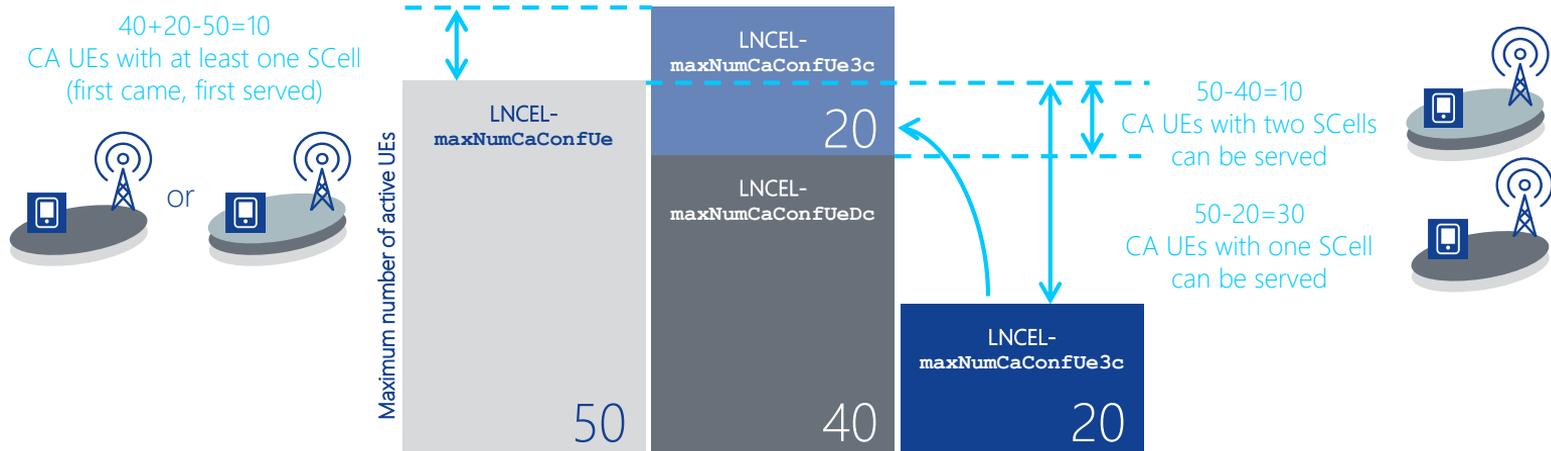
UE level – configuration of SCell(s) (3/8)

Example

- $\text{LNCEL-maxNumCaConfUe}=50$
- $\text{LNCEL-maxNumCaConfUeDc}=40$
- $\text{LNCEL-maxNumCaConfUe3c}=20$

Cell can serve up to:

- 40 UEs with one SCell + 10 UEs with two SCells or
- 30 UEs with one SCell + 20 UEs with two SCells



Technical Details

UE level – configuration of SCell(s) (4/8)

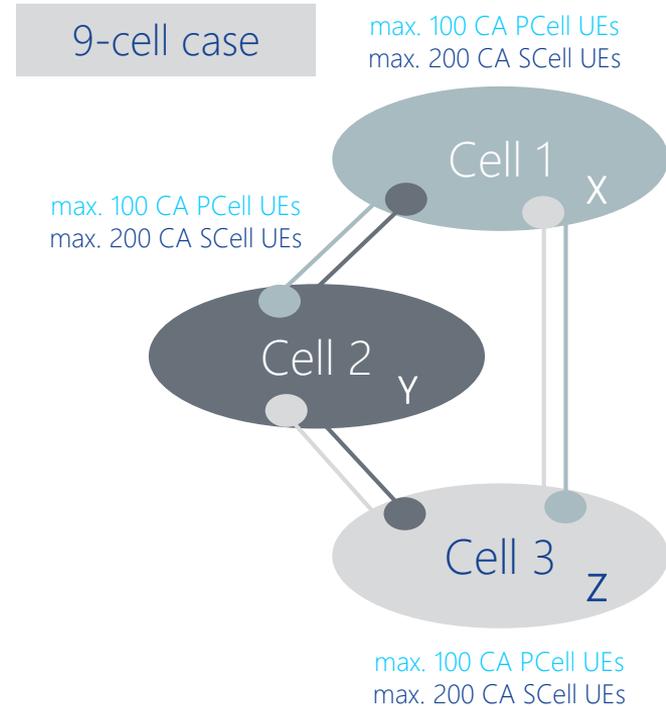
9-cell CA deployment limitations:

(three sectors of three cells each)

- At most $9 \cdot 100 = 900$ UEs can be configured with one or two SCell(s)
- Total number of RRC Connected UEs per eNB is then reduced with respect to the rule:

$$3 \cdot (X - 200) + 3 \cdot (Y - 200) + 3 \cdot (Z - 200)$$

where minuend X , Y and Z are the maximum number of RRC Connected UEs per cell with the given bandwidth



Technical Details

UE level – configuration of SCell(s) (5/8)

Result of SCell configuration – SCell perspective:

- number of RRC connections in the SCell is increased by one
- number of active UEs in the SCell is not impacted

RRC Connections
increase:

0 1

active UEs
increase:

0 0

Radio Admission Control (RAC) checks against:

- Limits of the UEs in PCell with configured SCell(s) -
LNCEL-maxNumCaConfUeDc, LNCEL-maxNumCaConfUe3c, LNCEL-maxNumCaConfUe PCell level
 - Limit of RRC connections in SCell(s) - LNCEL-maxNumRrc
 - Limit of CA guest UEs in SCell - LNBTS-maxNumCaUeScell SCell level
- No need for check against LNCEL-maxNumActUE in SCell(s)

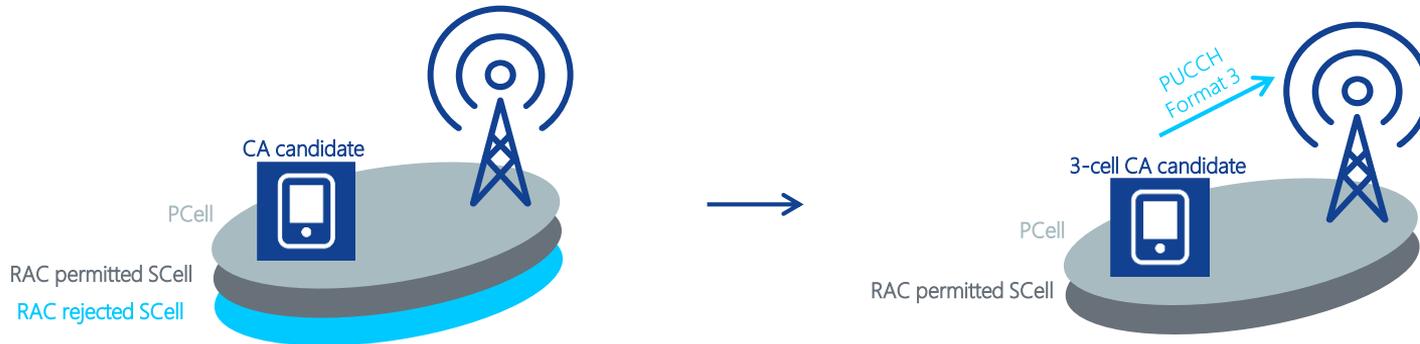
Technical Details

UE level – configuration of SCell(s) (6/8)

3-cell CA candidate – 3-cell CA capable UE that supports 3CC band combinations of all SCells.

RAC rejection:

- If addition of one of two SCells is rejected, UE 3-cell CA candidate is configured with one SCell
- 3-cell CA candidate is configured with PUCCH Format 3 even when only one SCell added



Technical Details

UE level – configuration of SCell(s) (7/8)

RAC rejection (cont.):

- 3CC capable UE, but not a 3-cell CA candidate is configured with PUCCH Format 1bwcs when one SCell added
- In this case LTE1562 - Carrier aggregation for multi-carrier eNBs functionality applies
- Nevertheless, this is not considered as stepwise configuration



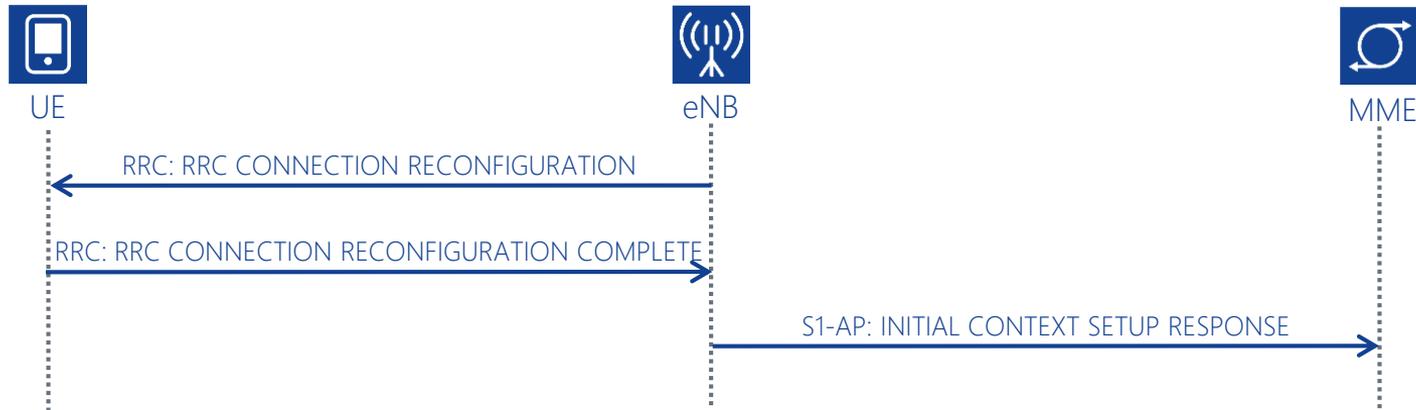
Technical Details

UE level – configuration of SCell(s) (8/8)

Result of SCell configuration – UE perspective:

- PCell CQI reports are sent in a CA-specific manner – with doubled periodicity and via PUCCH Format 3
- Necessary condition for SCell activation is satisfied

Configuration of SCell(s) is done via one RRC: RRC CONNECTION RECONFIGURATION message being sent to the UE

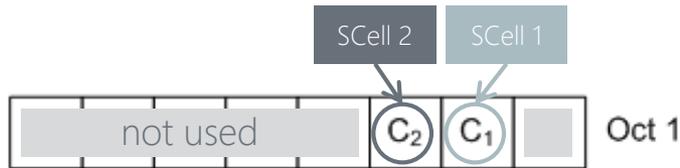


Technical Details

UE level – activation of SCell(s) (1/3)

Activation procedure

Activation of the SCell(s) is done by setting proper bits of Activation MAC Control Element (CE) to the value of 1



Activation methods:

- The variety of activation methods has been extended with LTE1804
- The method is selected with the `LNbts-sCellActivationMethod` parameter taking on values:

- blind activation	legacy implementation
- buffer based activation	
- buffer based stepwise activation	new value and new default

Technical Details

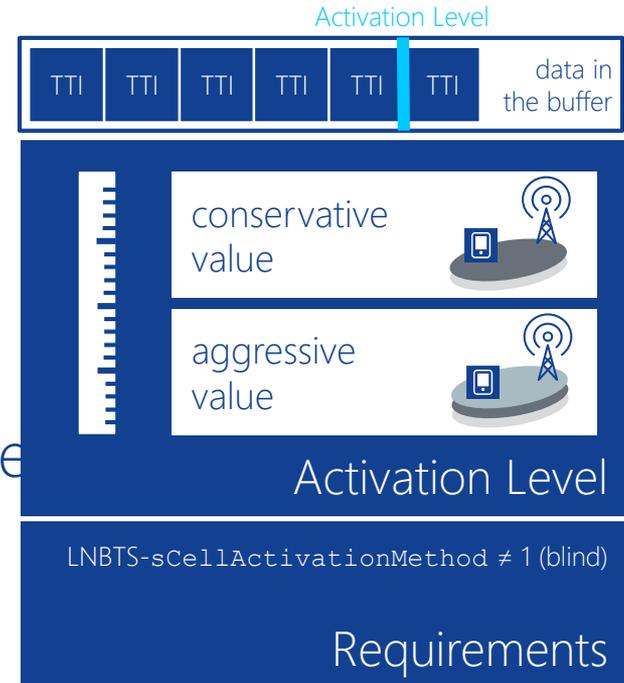
UE level – activation of SCell(s) (2/3)

Activation conservativeness level:

- Activation Level expressed in [TTI] defines the maximum period during which the data from UE's buffer can be transferred without triggering the activation of (next) SCell
- Activation Level value sets the activation conservativeness
- High activation conservativeness can reduce the throughput of CA UEs, but it can be beneficial for other UEs

Result of SCell activation – UE perspective

- PDCCHs of activated SCells are monitored for DL grants
- CQI/PMI/RI reporting for the SCells is performed via PCell

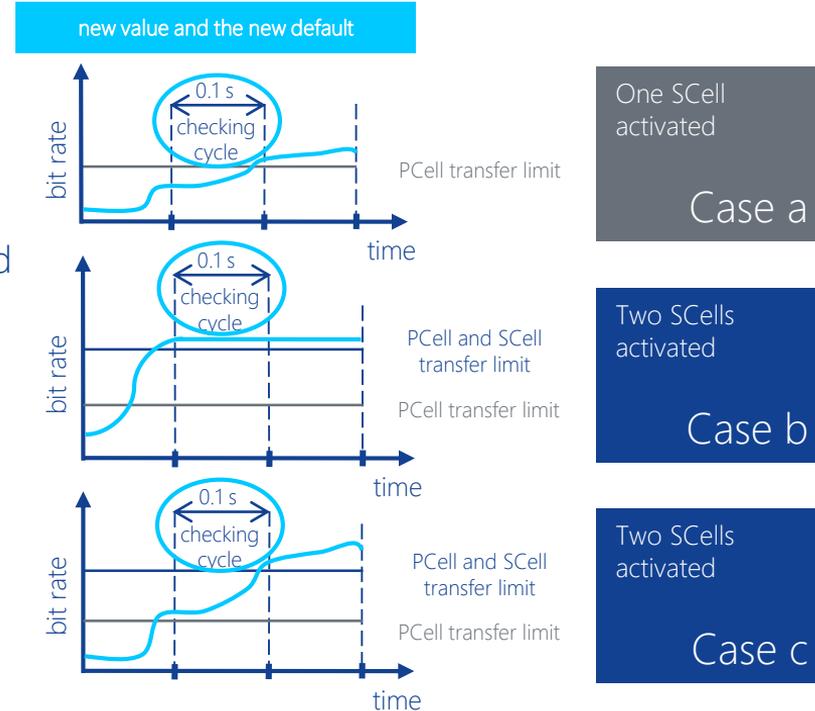


Technical Details

UE level – activation of SCell(s) (3/3)

Stepwise activation:

- Data in the buffer is compared with the data that can be drained on PCell or PCell and SCell during `LNBTs-scellActivationLevel`
- If data in the buffer exceeds the transfer limit multiplied by `LNBTs-scellActivationLevel` – activation is performed
- The check is done every `LNBTs-scellActivationCyclePeriod`
- SCell with lower Normalized Load Compare Value (NLCV) is activated in the first place
- NLCV is a load metric, considering PDCCH, non-GBR load and available PRBs for non-GBR traffic



Technical Details

Scheduling

Scheduling Fairness Factor

- Similarly to LTE1803, scheduling weight modification is given by the formula:

$$3 - 2 \cdot \text{LN}(\text{BTS-caSchedFairFact})$$

- Fairness Factor can take on values in range [0, 1], but value of 0 is recommended



CA UEs have high priority at the cost of non-CA UEs

0

CA and non-CA UEs are handled in a similar way

1

Scheduling extension:

- With LTE1804 the maximum number of PRBs assigned for PUCCH Format 3 is increased from one PRB to two PRBs
- Considering $\text{LNCEL-nPucchF3Prbs}=2$:
 - HARQ feedback of up to 10 3CC CA UEs can be multiplexed in standard UL subframe
 - HARQ feedback of up to 8 3CC CA UEs can be multiplexed in Sounding Reference Signals (SRS) subframe
- Maximum number of 3CC CA UEs depends on the number of available PUCCH 3 resources

UE peak data rate gains are not provided, but fast load balancing are

Technical Details

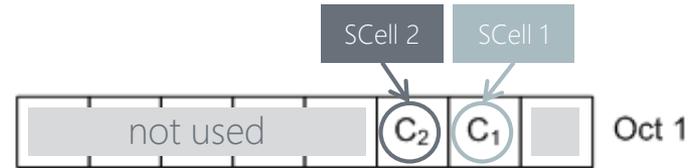
UE level – SCell deactivation

Conditions for deactivation:

- SCell is deactivated if during `LNBTs-sCellDeactivationTimerEnb` period:
 - no data was scheduled for the SCell
 - no L1 ACK was received
- Each SCell has its own deactivation timer
- It implies that SCells can be deactivated separately

Deactivation procedure

Deactivation of the SCell(s) is done by setting proper bits of Activation MAC CE to the value of 0



Result of SCell deactivation – UE perspective:

- No data can be scheduled on the SCell since the SCell PDCCH is not monitored anymore
- UE stops sending periodic CSI reports related to the SCell
- However CSI reporting pattern is not changed

Technical Details

UE level – SCell release

SCell release conditions:

- Cell locking or shutdown
- RRC Connection is released
- RRC: RRC CONNECTION REESTABLISHMENT REQUEST message is sent to the UE
- LTE1804 feature interworking limitations:
 - LTE907 TTI bundling is about to be switched on
 - LTE1406 Extended VoLTE Talk Time triggers
- Handover procedure:
 - If target cell supports CA, it can be configured as SCell right after the handover

Result of the release:

- Survivor SCell (if any remains) continues to serve the CA UE
- No SCell is scheduled during this transient period

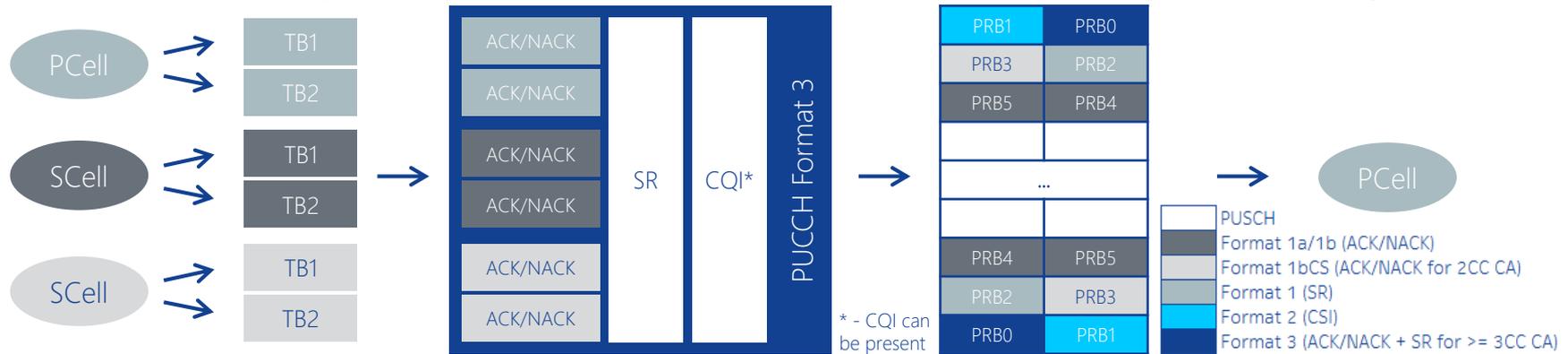


Technical Details

PUCCH transmission (1/3)

HARQ feedback from two SCells:

- Multi-cell ACK/NACK messages cover simultaneously all Transport Blocks (TB) for PCell and SCell(s)
- There are up to six TBs (two TBs for each cell)
- Sending more than 4 bits of HARQ feedback requires PUCCH Format 3
- PUCCH Format 3 reports are sent in dedicated PRBs allocated on the outer edge of PUCCH region

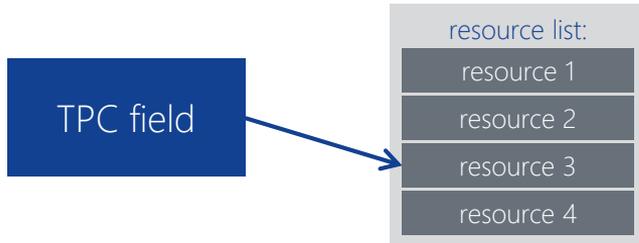


Technical Details

PUCCH transmission (2/3)

PUCCH Format 3 resources assignment:

- PUCCH Format 3 resources are provided to that UE in `n3PUCCH-AN-List-r10` IE
- Resource assigned in a TTI is signaled via TPC field
- Value in the TPC field points the position of the resource in `n3PUCCH-AN-List-r10` IE



PUCCH Format 3 capacity:

- Assuming two SCells configured, total length of a single PUCCH Format 3 message is given:
 - for TM1/TM2 (no MIMO):
3 ACK/NACK bits + 1 SR bit + CQI bit(s)*
 - for TM3/TM4 (MIMO):
6 ACK/NACK bits + 1 SR bit + CQI bit(s)*

* - if CQI bits configured to be sent
- PRB dedicated for PUCCH Format 3 contains:
 - five PUCCH Format 3 resources if sent in a non-SRS subframe
 - four PUCCH Format 3 resources if sent in a SRS subframe

Technical Details

PUCCH transmission (3/3)

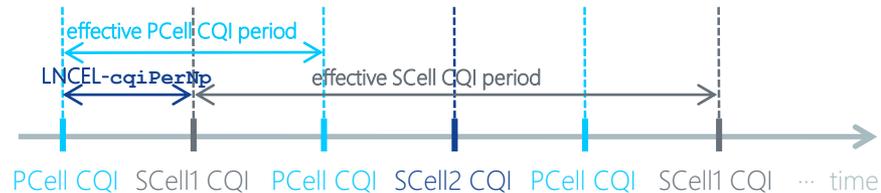
CQI reporting pattern

If SCell(s) configured:

- Periodicity of CQI related to PCell is doubled in comparison to non-CA case – $2 \cdot \text{LNCEL-cqiPerNp}$
- No CQI for the SCells are sent

If SCell(s) activated:

- Periodicity of CQI related to both SCells amount to $4 \cdot \text{LNCEL-cqiPerNp}$



RI reporting pattern:

- If CAREL is created under LNCEL and LNCEL-riEnable is set to *true*, then only LNCEL-riPerM value 1 is allowed
- Frequency is reduced as in case of CQI and RI

SR reporting pattern:

- In TTI when SR and HARQ feedback are to be sent together, PUCCH Format 3 is used for UEs with PUCCH Format 3 configured
- Otherwise – PUCCH Format 1/1a/1b is used

Technical Details

Multiplexing of CSI reporting on PUCCH Format 3

Simultaneous ACK/NACK, SR and CQI on PUCCH Format 3

Rel. 11 UE can be configured with flag `simultaneousAckNackAndCQI-Format3-r11` set to *true* when PUCCH Format 3 is configured if:

- UE is a 3-cell CA candidate
- UE supports:
 - PUCCH Format 3
 - Multi-cell HARQ feedback and periodic CSI reporting on PUCCH Format 3

Periodic CSI is not dropped in case it collides with ACK/NACK



Benefits and Gains



Table of contents

Benefits and Gains

Feature benefits

- Maximum aggregated bandwidth of 60 MHz
- Extended range of band and bandwidth combinations supported
- Stepwise SCell (de)activation
- Increased number of UEs with SCell(s) configured
- PUCCH Format 3 ACK/NACK and periodic CSI multiplexing

Improvement

- Boosted peak and mean DL UE throughput, including cell edge, increased User Experience (UX) level
- Improved fragmented spectrum tailoring
- Reduced UE power consumption, reduced Control Plane (CP) involvement
- More UEs can benefit from CA
- Reduced PDCCH scheduling limitations, increased downlink throughput

Benefit

Benefits and Gains

Feature benefits cont.

- 2 PRBs for PUCCH Format 3 assignment possible
- LNBTS-rlcProfile6 introduced

Improvement

- Increased connectivity
- Optimized RLC profile dedicated for 3CC

Benefit

Maximum downlink L1 throughput, assuming: perfect radio conditions, MIMO 2x2 and (20 + 20 + 20) MHz combination

452,3 Mbps

Benefits and Gains

Input data (2/2)

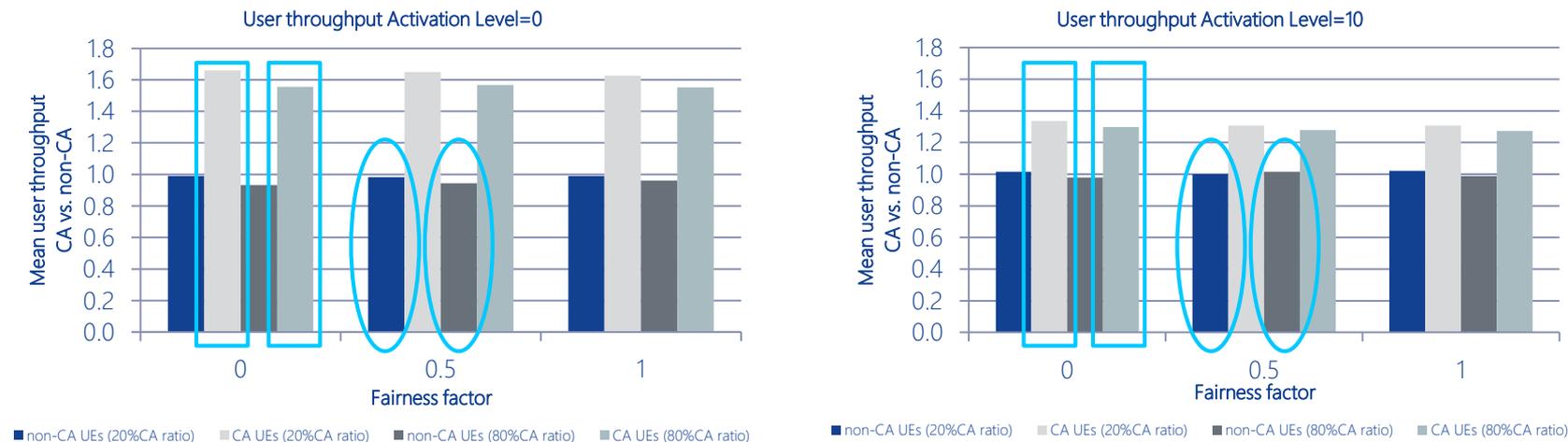
Parameter	Value
Layout	3GPP Macro Case 1 according to TR 25.814 (wrap around scenario)
ISD	500
Link	DL
Duplex mode	FDD
Antenna configuration	1 x-pol
Antenna type	according to 3GPP TR 25.814
Transmission modes	TM4 (2x2 MIMO)
Operational band (MHz)	2.1 GHz
Bandwidth (MHz)	20 + 20 + 20
Output power	eNB 43 dBm; UE 23 dBm
Indoor penetration loss	20 dB
Product release	FL 15A
Max MCS	MCS28

Parameter	Value
slow fading	Std. dev = 8 dB; corr. distance = 50 m
fast fading	TU3
scheduler, TDS	PF
scheduler, FDS	a) FDAC + b) PFSched

Standard DL parameters	
DL CQI measurement mode	mode 3
Measurement Interval	5 ms
Reporting Delay	4 ms
Measurement Bandwidth	6 PRBs (Mode 3)
MIMO switching threshold, up/down	15 dB / 10 dB

Benefits and Gains

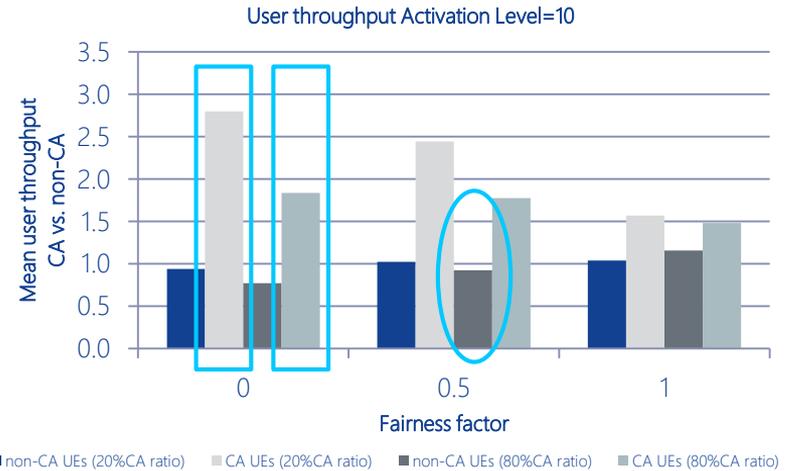
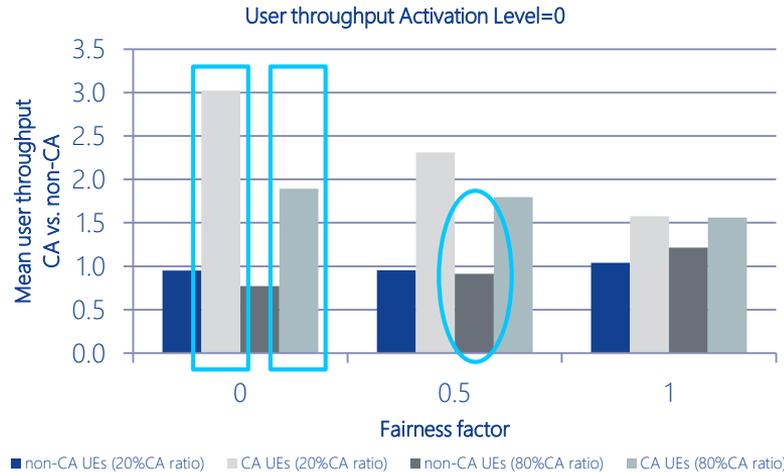
Mean user throughput as function of Fairness Factor in low loaded environment



- In case of low loaded network, the impact of Activation Level on user throughput can be observed for CA UE – the introduction of adjustable SCell activation conservativeness leads to the decrease of user throughput
- Non-CA UEs benefit from SCell activation conservativeness
- Both observations are correct regardless of Fairness Factor value

Benefits and Gains

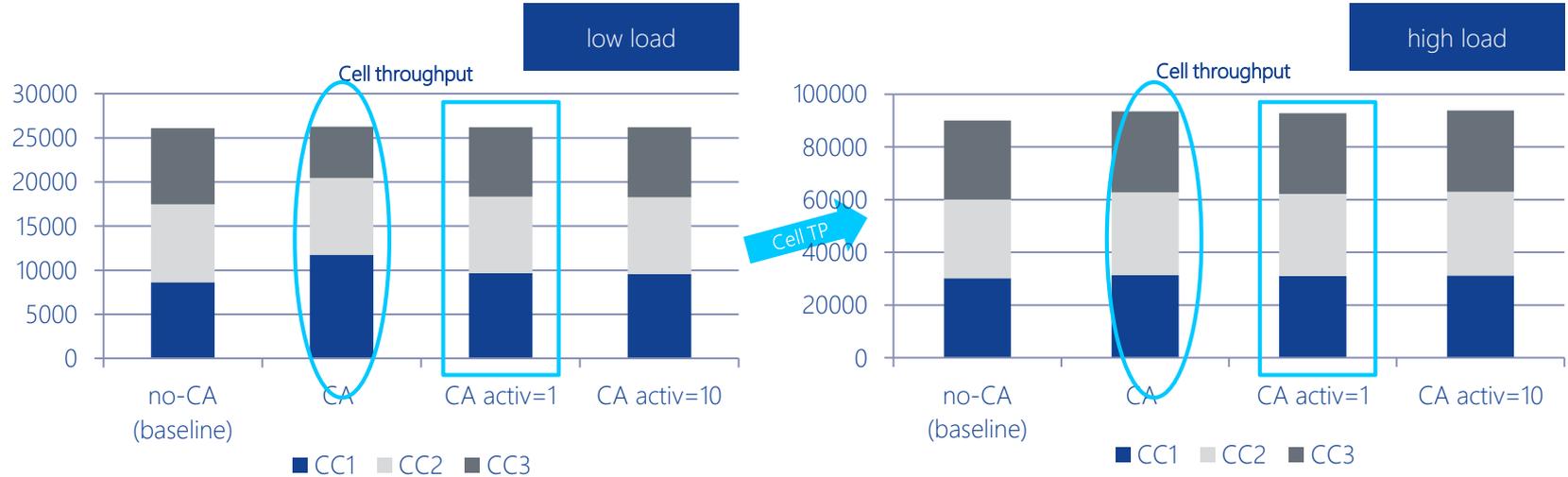
Mean user throughput as function of Fairness Factor in high loaded environment



- In case of highly loaded network, the impact of Activation Level on user throughput can be observed for CA UE – the introduction of adjustable SCell activation conservativeness leads to the decrease of user throughput
- However, the decrease is smaller than for low loaded network
- Non-CA UEs barely benefit from SCell activation conservativeness
- Both observations are correct regardless of Fairness Factor value

Benefits and Gains

Cell throughput as function of CC number



- The higher the load in the network exists, the better load balance between carriers can be seen
- The impact of Activation Level on load balancing can be observed – the introduction of adjustable SCell activation conservativeness leads to load equalization
- However, the impact on load balancing is more visible in highly loaded network

Configuration Management



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Configuration Management

New basic parameters

Abbreviated name	Full name	PKDB link
<code>LNbts-scellActivationLevel</code>	Conservativeness Level of SCell Activation	 Parameter Knowledge Database
<code>LNbts-rlcProfIdx3cc</code>	RLC Profile Index for 3CC CA	 Parameter Knowledge Database

Configuration Management

New advanced parameters

Abbreviated name	Full name	PKDB link
LN BTS-pollPdu	Poll PDU	 Parameter Knowledge Database
LN BTS-rlcProfileId	RLC Profile Id	 Parameter Knowledge Database
LN BTS-tPollRetr	Timer Poll Retransmit	 Parameter Knowledge Database
LN BTS-tProhib	Timer Status Prohibit	 Parameter Knowledge Database
LN BTS-tReord	Timer Reordering	 Parameter Knowledge Database
LN BTS-enableBwCombCheck	Enable Bandwidth Combination Checks	 Parameter Knowledge Database

LN BTS-rlcProf6

Configuration Management

Modified basic parameters (1/2)

Abbreviated name	Full name	PKDB link
<code>LNBTSSCellActivationCyclePeriod</code>	SCell Activation Cycle Period	 Parameter Knowledge Database
<code>LNCEL-nPucchF3Prbs</code>	Number of PUCCH PRBs for HARQ Format 3	 Parameter Knowledge Database
<code>LNCEL-maxNumCaConfUe3c</code>	Max Number Carrier Aggregation Configured UEs 3 Carriers	 Parameter Knowledge Database
<code>LNCEL-maxNumCaConfUe</code>	Max Number Carrier aggregation Configured Ues	 Parameter Knowledge Database
<code>LNCEL-maxNumCaConfUeDc</code>	Max number Carrier Aggregation Configured UEs Double Carrier	 Parameter Knowledge Database

Configuration Management

Modified basic parameters (2/2)

Abbreviated name	Full name	PKDB link
LNBTS-maxNumCaUeScell	Maximum Number of CA Guest UEs in SCell	 Parameter Knowledge Database

Configuration Management

Modified advanced parameters

Abbreviated name	Full name	PKDB link
LNBTS- sCellActivationMethod	SCell Activation Method	 Parameter Knowledge Database

Deployment Aspects



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Deployment Aspects

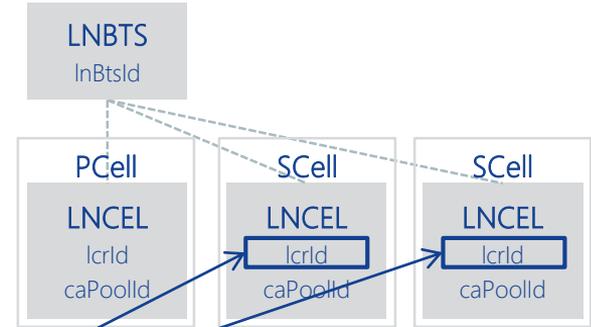
Feature activation step by step (1/8)

Step 1 – retrieving local cell resource IDs of the SCells

Path: MRBTS-0\LNBTBS-0\LNCEL-2

Large size random access MCS in uplink:	5	[0...15]
Liquid cell CSI-RS resource configuration in use:	Value set by the system	
Load filtering coefficient:	4	[0...19]
Load measurement RRM timer multiplier:	2	[1...32]
Load measurement RRM timer multiplier for eICIC:	2	[1...32]
Load measurement X2 timer for eICIC:	2000	
Load measurement X2 timer for MLB:	10000ms	
Local cell resource ID:	2	
Max number act DRB:	300	[0...4500]
Max number carrier aggr configured UEs:	50	[0...100]
Max number carrier aggr configured UEs 3 Carriers:	20	[0...100]
Max number QCI1 DRBs (GBRs):	100	[0...600]
Max packet aggregation UL:	2	[1...4]
Max. uplink transmission power own cell:		dBm [-30...33]
Maximum amount of users per TTI in DL:	14	[1...20]

Local cell resource IDs have to be checked in the cells intended to be SCells



Deployment Aspects

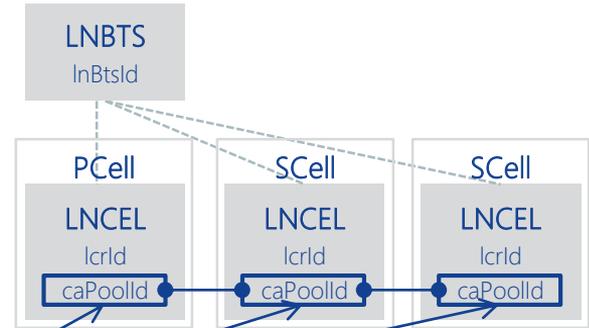
Feature activation step by step (2/8)

Step 2 – retrieving CA pool IDs of Serving Cells

Path: MRBTS-0/LNBTS-0/LNCEL-1

Aperiodic CQI feedback reporting mode:	FBT2
Apply UL out-of-sync state:	extendedDrxOnly
Assigned cell resource group profile:	[0...17]
Automatic AC Barring start timer:	300 s [30...3600]
Automatic AC Barring stop timer:	3600 s [30...3600]
Averaging filter constant for CRE tagging:	0.5 [0.05, 0.10, ...1.00]
Blanked PUCCH resources:	0 [0, 2, ...60]
Carrier aggregation pool ID:	1 [0...255]
CDMA2000 1xRTT cell ID info:	0 [0...1]
CDMA2000 1xRTT CSFB type:	forbidden
Cell based flag:	cellBased
Cell name:	
Cell power reduce:	0 dB [0.0, 0.1, ...20.0]
Cell power reduction for MBMS transmission:	dB [0.0, 0.1, ...6.0]
Cell reselection priority:	0 [0...7]

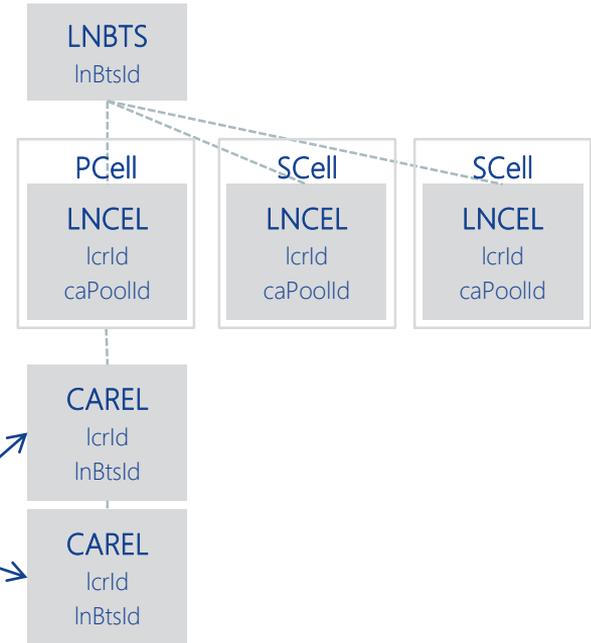
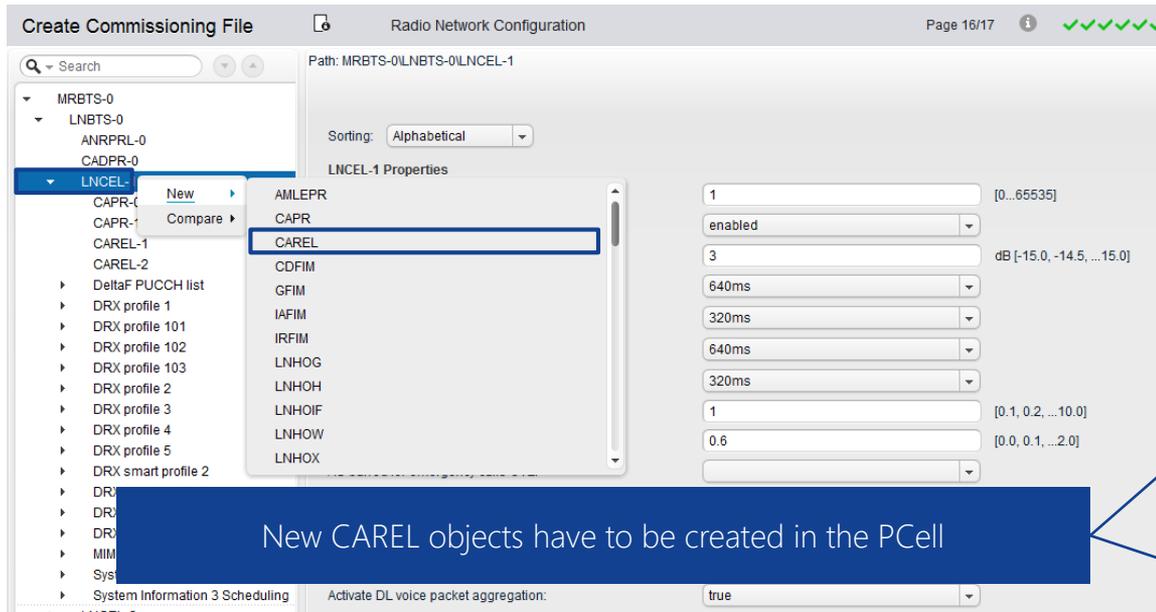
CA pool ID has to be the same for all cells involved in CA, including SCell candidates



Deployment Aspects

Feature activation step by step (3/8)

Step 3 – creation of new CAREL objects in PCell's LNCEL



Deployment Aspects

Feature activation step by step (4/8)

Step 4 – creation of relationship between PCell and SCells

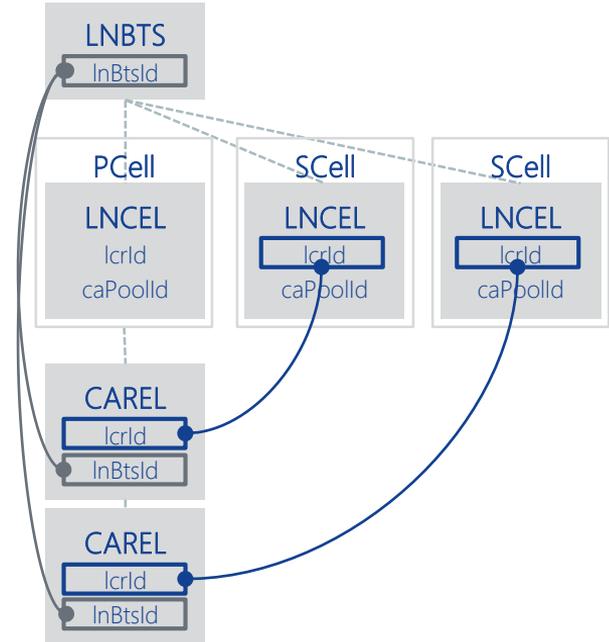
The screenshot shows the 'Create Commissioning File' window in the Radio Network Configuration tool. The path is 'MRBTS-0\LNBTBS-0\LNCEL-1\CAREL-1'. The 'CAREL-1 Properties' section is active, with the following fields highlighted by blue boxes:

- Carrier aggregation relation identifier: 1 [1...12]
- BTS ID of the parent eNB of the cell to be aggregated: 0 [0...1048575]
- Local cell resource ID of cell to be aggregated: 2 [0...255]
- SCell priority: 1 [1...10]

The left-hand tree view shows the hierarchy: MRBTS-0 > LNBTBS-0 > ANRPRL-0 > CADPR-0 > LNCEL-1 > CAPR-0 > CAPR-1 > CAREL-1 > CAREL-2. A blue box highlights the 'CAREL-1' and 'CAREL-2' entries.

A blue text box overlaid on the screenshot contains the following text:

Newly created CAREL objects in the PCell have to be configured to indicate SCells by using proper local cell resource IDs of the SCells (skipped in Step 2)



Deployment Aspects

Feature activation step by step (5/8)

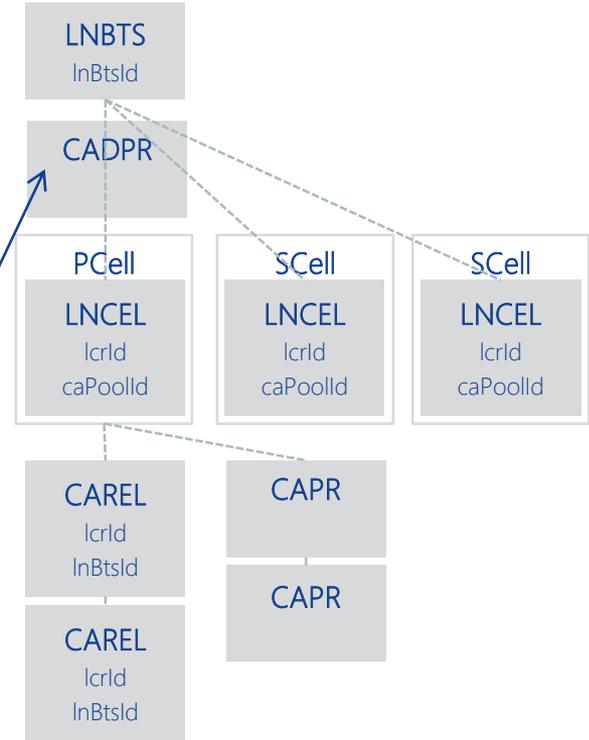
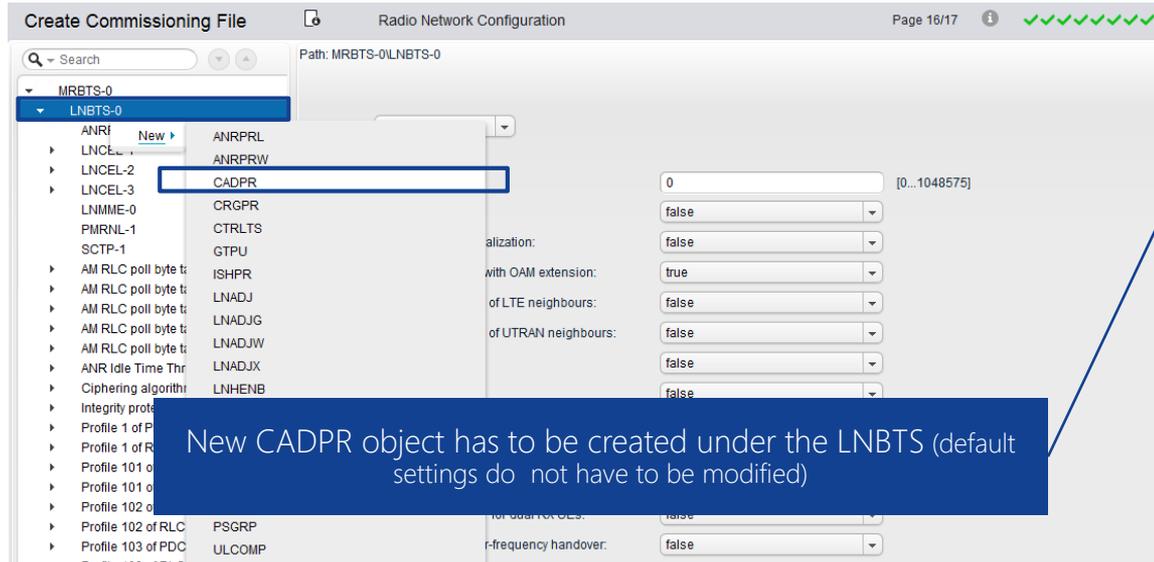
Step 5 – feature interdependencies and parameters cross-check

- `LNCEL-nPucchF3Prbs` in PCell must be greater than 0
- `LNCEL-maxNumSce11s` in PCell must be set to 2
- `LNbts-actEnhAcAndGbrServices` has to be set to *true*
- `LNbts-sCellActivationMethod` should be different from 1 (*blind*)
- `LNCEL-nCqiRb` in PCell must be greater than 1
- `LNCEL-cqiPerNp` in PCell must be less than or equal to 40 ms
- `LNCEL-riEnable` has to be set to the same value in PCell and SCells
- `LNCEL-riPerM` must be set to 1 if `LNCEL-riEnable` set to *true*
- `LNCEL-cqiPerSbCycK` has to be set to the same value in PCell and SCells
- `LNCEL-deltaPucchShift` in PCell must be less than or equal to 2
- PUCCH and Admission Control dimensioning rules have to be satisfied

Deployment Aspects

Feature activation step by step (6/8)

Step 6 – CADPR* object creation



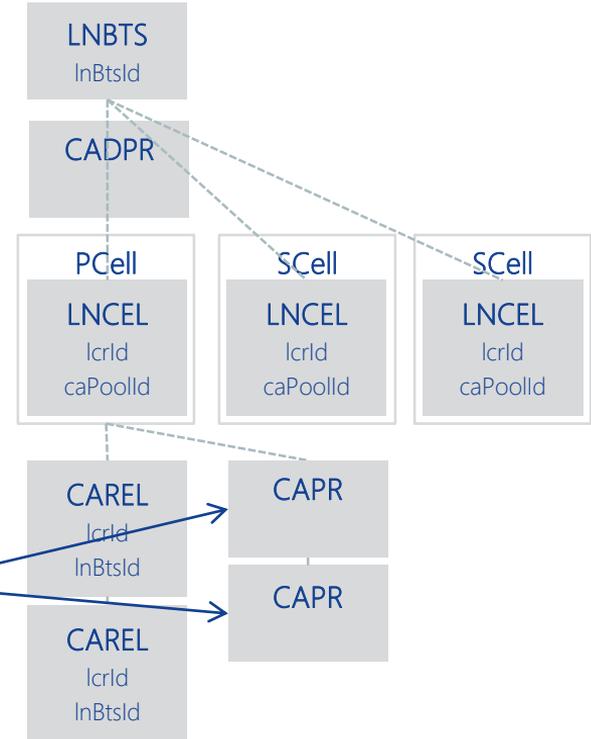
* - CAPDR object has been introduced with LTE2006 and is mandatory from LTE15A onwards

Deployment Aspects

Feature activation step by step (7/8)

Step 7 – optional CAPR* object creation

New CAPR objects can be created in the PCell for all involved frequency layers for flexible A6 measurement configuration (default settings do not have to be modified)



* - CAPR object has been introduced with LTE2006

Deployment Aspects

Feature activation step by step (8/8)

Step 8 – Carrier Aggregation activation

Path: MRBTS-0\LNBTBS-0

Activation idle mode mobility CDMA1xRTT:	false
Activation idle mode mobility CDMA1eHRPD:	false
Activation of Automatic AC Barring:	false
Activation of C-plane overload handling:	false
Activation of complete consistency checks:	true
Activation of downlink carrier aggregation:	true
Activation of idle mode load balancing (IdleLB):	false
Activation of inter-frequency load balancing (IFLB):	false
Activation of intra-frequency load balancing:	false

Activation and deactivation of the feature (i.e. operations on the LNBTBS-actDLCAggr parameter or LNCEL- maxNumCells) require BTS restart



LNBTBS-actDLCAggr = true

Dimensioning Aspects



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Dimensioning Aspects

Feature activation

CA features activation general rules:

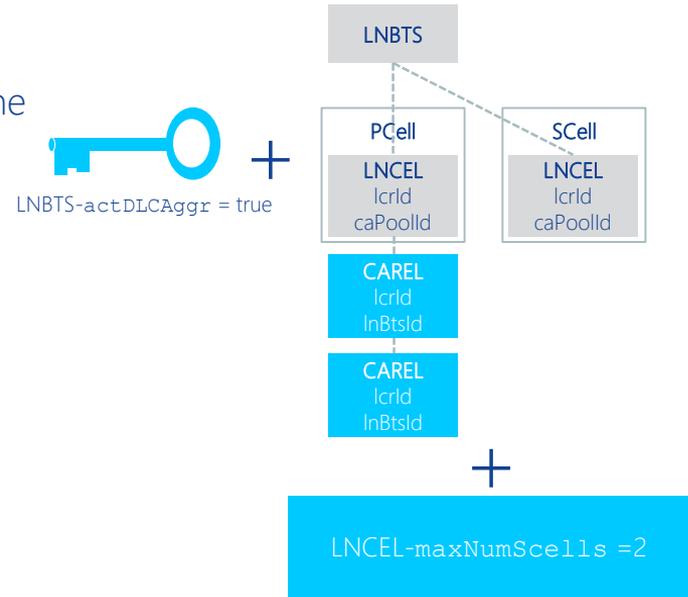
CA features activation should be understood as follows:

- CA activated – LNBTS-actDLCAggr set to *true* and at least one CAREL object created
- CA not activated – no CAREL object created

Note: Although LNBTS-actDLCAggr set to *false* deactivates CA feature, existence of CAREL object still impacts PUCCH

LTE1804 activation:

- Satisfying all of above-mentioned conditions is necessary but not sufficient
- Two extra conditions has to be met:
 - LNCEL-maxNumScells equals to 2
 - two CAREL objects exist



Dimensioning Aspects

Impact on PUCCH capacity

PUCCH re-dimensioning:

- Restrictions related to 2CC CA case are still effective
 - Restrictions introduced with LTE1803:
 - Introduction of PUCCH Format 3 needed for 3CC CA UEs
 - Additional restrictions introduced with LTE1804:
 - Maximum number of PRBs for PUCCH Format 3 is increased to 2
- Cell being a SCell is not affected unless it becomes a PCell
 - PUCCH resources need to be adjusted once CAREL object is created under the LNCEL, i.e. the cell is enabled to be a PCell
 - The bigger PUCCH size, the less PRBs for PUSCH are left, which decreases UL cell capacity



Dimensioning Aspects

Additional PUCCH Format 3 resources (1/4)

MIMO modes with spatial multiplexing cases

If all of the following conditions satisfied: CA activated, LNCEL-riEnable = true, LNCEL-n1PucchAn≠10, LNCEL-deltaPucchShift=1 and:

- LNCEL-srsConfiguration set to any value:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - \text{nPucchF3Prbs}) \cdot 6 \cdot cqiPerNp/2 \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (n1PucchAn - 48) \cdot \text{cellSrPeriod} - 6 \cdot \text{cellSrPeriod}/5 \cdot n1PucchAn/36 \end{aligned}$$

In order to keep the same PUCCH Format 2 capacity, LNCEL-nCqiRB has to be increased depending on the number of SCells

- LNCEL-srsConfiguration not configured:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - \text{nPucchF3Prbs}) \cdot 6 \cdot cqiPerNp/2 \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (n1PucchAn - 48) \cdot \text{cellSrPeriod} \end{aligned}$$

Dimensioning Aspects

Additional PUCCH Format 3 resources (2/4)

MIMO modes with spatial multiplexing cases (cont.)

If all of the following conditions satisfied: CA activated, LNCEL-riEnable = true and:

- LNCEL-n1PucchAn≠10, LNCEL-deltaPucchShift≠1:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((n\text{CqiRb} - \text{blankedPucch}) - (n\text{PucchF3Prbs})) \cdot 6 \cdot \text{cqiPerNp} / 2 \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (n1\text{PucchAn} - 48) \cdot \text{cellSrPeriod} \end{aligned}$$

- LNCEL-n1PucchAn=10:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((n\text{CqiRb} - \text{blankedPucch}) - (n\text{PucchF3Prbs})) \cdot 6 \cdot \text{cqiPerNp} / 2 \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq 2 \cdot \text{cellSrPeriod} \end{aligned}$$

Dimensioning Aspects

Additional PUCCH Format 3 resources (3/4)

Single transmit antenna or TX diversity cases

If all of the following conditions satisfied: CA activated, LNCEL-riEnable = false, LNCEL-n1PucchAn≠10, LNCEL-deltaPucchShift=1 and:

- LNCEL-srsConfiguration set to any value:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - (\text{nPucchF3Prbs})) \cdot 6 \cdot cqiPerNp \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (\text{n1PucchAn} - 36) \cdot \text{cellSrPeriod} - 6 \cdot \text{cellSrPeriod}/5 \cdot \text{n1PucchAn}/36 \end{aligned}$$

- LNCEL-srsConfiguration not configured:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - (\text{nPucchF3Prbs})) \cdot 6 \cdot cqiPerNp \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (\text{n1PucchAn} - 36) \cdot \text{cellSrPeriod} \end{aligned}$$

Dimensioning Aspects

Additional PUCCH Format 3 resources (4/4)

Single transmit antenna or TX diversity cases (cont.)

If all of the following conditions satisfied: CA activated, `LNCEL-riEnable = false` and:

- `LNCEL-n1PucchAn ≠ 10`, `LNCEL-deltaPucchShift ≠ 1`:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - \text{nPucchF3Prbs}) \cdot 6 \cdot cqiPerNp \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq (n1PucchAn - 36) \cdot cellSrPeriod \end{aligned}$$

- `LNCEL-n1PucchAn = 10`:

$$\begin{aligned} \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq ((nCqiRb - \text{blankedPucch}) - \text{nPucchF3Prbs}) \cdot 6 \cdot cqiPerNp \\ &\text{and} \\ \maxNumRrc + \max(\text{addAUeRrHo}, \text{addAUeTcHo}) &\leq 6 \cdot cellSrPeriod \end{aligned}$$

All presented formulas need to be updated in PDDB as they do not consider the number of PUCCH PRBs for HARQ Format 3 yet (**highlighted**)

Performance Aspects



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Performance Aspects

New counters

M8011C166 counter

SCell scheduling blocking rate due to conflicts on PUCCH Format 1bwcs resources

PUCCH_BLOCK_RATE_FMT_1BWCS

Update trigger: each PUCCH Format 1bwcs scheduling attempt

$$M8011C166 = \frac{\text{number of blocked PUCCH Format 1bwcs attempts}}{\text{total number of PUCCH Format 1bwcs attempts}} \cdot 100$$

Can verify whether PUCCH Format 1bwcs scheduling conflicts occur

M8011C167 counter

SCell scheduling blocking rate due to conflicts on PUCCH Format 3 resources

PUCCH_BLOCK_RATE_FMT_3

Update trigger: each PUCCH Format 3 scheduling attempt

$$M8011C167 = \frac{\text{number of blocked PUCCH Format 3 attempts}}{\text{total number of PUCCH Format 3 attempts}} \cdot 100$$

Can verify whether PUCCH Format 3 scheduling conflicts occur

Countermeasures: reduction of the number of UEs configured with SCell(s), increase of the configured PUCCH resources, increase of the SCell activation conservativeness level

Performance Aspects

Existing counters for 3CC CA

Counters supporting 3CC cases (introduced with LTE1803)

Counter Id	Name	Counter description (links)
M8001C497	Average number of DL carrier aggregated capable UEs for 3CCs	CA_DL_CAP_UE_3CC_AVG
M8001C498	Average number of UEs with two configured SCells	CA_2SCELLS_CONF_UE_AVG
M8001C499	Average number of UEs with two activated SCells	CA_2SCELLS_ACTIVE_UE_AVG

Performance Aspects

Existing counters for 2CC CA

Counters supporting 2CC cases (introduced with LTE1089, RL50)

Counter Id	Name	Counter description (links)
M8001C494	Average number of DL carrier aggregated capable UEs for 2CCs	CA_DL_CAP_UE_AVG
M8001C495	Average number of UEs with one configured SCell	CA_SCELL_CONF_UE_AVG
M8001C496	Average number of UEs with one activated SCell	CA_SCELL_ACTIVE_UE_AVG
M8011C67	Number of SCell configuration attempts	CA_SCELL_CONFIG_ATT
M8011C68	Number of successful SCell configurations	CA_SCELL_CONFIG_SUCC
M8012C151	PCell RLC data volume in DL via SCell	RLC_PDU_DL_VOL_CA_SCELL

The same measurement (M8011) as newly introduced counters – LTE_Cell_Resource

Performance Aspects

New KPIs

LTE_5700a KPI

E-UTRAN SCell Scheduling Blocking Rate due to Conflicts on PUCCH Format 1bwcs Resources

Abbreviation: SCell Sched block r, conflict PUCCH format 1bwcs rsrc

Class: Usage

Measurement: LTE Cell Resource

$$\text{LTE_5700a} = \text{avg}(\text{PUCCH_BLOCK_RATE_FORMT_1BWCS})$$

M8011C166 counter

Can verify whether issues with SCell scheduling with PUCCH Format 1bwcs occur

LTE_5701a KPI

E-UTRAN SCell Scheduling Blocking Rate due to Conflicts on PUCCH Format 3 Resources

Abbreviation: SCell Sched block r, conflict PUCCH format 3 rsrc

Class: Usage

Measurement: LTE Cell Resource

$$\text{LTE_5701a} = \text{avg}(\text{PUCCH_BLOCK_RATE_FORMT_3})$$

M8011C167 counter

Can verify whether issues with SCell scheduling with PUCCH Format 3 occur

Performance Aspects

Performance monitoring after LTE1804 enabling (1/3)

Feature impact	How to measure
<p>Improved mean and instantaneous DL UE throughput for UEs with activated SCell (non-GBR data only)</p> <p>Gain depends on the overall network load – once the load is high, better performance (in terms of mean throughput) for CA UEs is no longer assured.</p> <p>To test achievable peak throughput values, network must not be loaded.</p>	<p>E-UTRAN Averaged IP scheduled Throughput in DL for QCI 5 – 9 (LTE_5354a - LTE_5358a)</p>
<p>Higher achievable peak throughput in the sector</p> <p>All involved (paired) cells have to be analyzed jointly.</p>	<p>PDCP_DATA_RATE_MAX_DL M8012C25</p>

Performance Aspects

Performance monitoring after LTE1804 enabling (2/3)

Feature impact	How to measure
<p>DL cell capacity improvements</p> <p>In general, some DL cell capacity improvements can be observed. Nevertheless, in certain deployments and traffic profiles possible gain is not very high.</p> <p>DL capacity calculations should consider simultaneously all involved cells where CA is activated. Total sector capacity should be analyzed before and after CA introduction.</p>	<p>Average PDCP Layer Active Cell Throughput DL</p> <p>LTE_5292d</p>
<p>Decreased UL capacity in the cell with configured secondary cell (less number of PUSCH PRBs)</p> <p>If PUCCH size is increased to facilitate CA deployment, the number of PRBs available for PUSCH is reduced. Consequently, UL capacity is in such a case decreased. This effect will be visible only in case of heavy UL load.</p>	<p>Average PDCP Layer Active Cell Throughput UL</p> <p>LTE_5289d</p>

Performance Aspects

Performance monitoring after LTE1804 enabling (3/3)

Feature impact	How to measure
<p>Decreased amount of mean/peak Active UEs / RRC Connected UEs served by the system (less number of UEs handled by the same PUCCH resources)</p> <p>Existence of the effect depends on the PUCCH dimensioning and will be visible only if significant amount of UEs is connected to the cell.</p> <p>If average number of RRC Connected users suggests that the AC limits will be soon met in the cell or Admission Control rejection rate has been already increased, PUCCH should be re-dimensioned.</p>	<p>Average number of active users per cell (LTE_717a) Maximum number of active users per cell (LTE_718a) Average of RRC connected users (LTE_805a) Maximum of RRC connected users (LTE_806a)</p> <p>Once the limits posed by PUCCH dimensioning are reached, then new connection will be rejected by the Admission Control:</p> <p>E-UTRAN RRC Connection Setup Failure Ratio per Cause RRM RAC (LTE_5231b) E-UTRAN HO Preparation Failure Ratio per Cause, intra eNB AC (LTE_5104b) E-UTRAN HO Preparation Failure Ratio per Cause, inter eNB X2 based AC (LTE_5107b)</p>

Compliance Aspects



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Compliance Aspects

References

Reference

3GPP 36.213: PUCCH Format 3 used for eligible UEs configured with one SCell

3GPP 36.213/36.212/36.211/36.306/36.331: `simultaneousAckNackAndCQI-Format3-r11` set to *true*

3GPP 36.306: support of UE category 9 and 10

3GPP 36.101: supported band combinations

LTE1804 CFAM, ver. 7.0

LTE1803 Network Engineering Information (NEI) document

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