

CHANGE REQUEST		CR-Form-v9.6
36.300	CR 0230	rev 3
Current version:		9.3.0

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Proposed change affects: UICC apps ☐ ME ☒ Radio Access Network ☒ Core Network ☐

Title:	Stage 2 description of Carrier Aggregation		
Source to WG:	Nokia Siemens Networks (Rapporteur)		
Source to TSG:	R2		
Work item code:	LTE_CA-Core	Date:	May 2010
Category:	B	Release:	Rel-10
Use one of the following categories:		Use one of the following releases:	
F (correction)		R99 (Release 1999)	
A (corresponds to a correction in an earlier release)		Rel-4 (Release 4)	
B (addition of feature),		Rel-5 (Release 5)	
C (functional modification of feature)		Rel-6 (Release 6)	
D (editorial modification)		Rel-7 (Release 7)	
Detailed explanations of the above categories can be found in 3GPP TR 21.900.		Rel-8 (Release 8)	
		Rel-9 (Release 9)	
		Rel-10 (Release 10)	

Reason for change:	Stage 2 description of Carrier Aggregation is missing from the specification. RAN2 agreements on Carrier Aggregation are not captured.		
Summary of change:	Relevant Stage 2 agreements on Carrier Aggregation are added to appropriate subclauses. A new Annex is created to reflect all other agreements on Carrier Aggregation taken in RAN2.		
Consequences if not approved:	Stage 2 description of Carrier Aggregation is missing from the specification. Agreements on Carrier Aggregation are not captured.		
Clauses affected:	3.1, 3.2, 5.1.1, 5.2.1, 5.5, 6, 6.4, 7.4, 7.5, 10.1.5, 11.1, 11.2, 12, Annex X (new)		
Other specs affected:	Y	N	
	X		Other core specifications
	X		Test specifications
	X		O&M Specifications
Other comments:	Work on this CR has already started February 2010, see R2-101846 CR0190r1		

Commented [H1]: Document numbers are allocated by the Working Group Secretary. Use the format of document number specified by the 3GPP Working Procedures.

Commented [H2]: Enter the specification number in this box. For example, 04.08 or 31.102. Do not prefix the number with anything . i.e. do not use "TS", "GSM" or "3GPP" etc.

Commented [H3]: Enter the CR number here. This number is allocated by the 3GPP support team. It consists of at least four digits, padded with leading zeros if necessary.

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Commented [H10]: One or more organizations (3GPP Individual Members) which drafted the CR and are presenting it to the Working Group.

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x = "C" for TSG CT, "R" for TSG RAN, "S" for TSG SA, "G" for TSG GERAN;
n = digit identifying the Working Group; for CRs drafted during the TSG meeting itself, use "P".
Examples: "C4", "R5", "G3new", "SP".

Commented [H12]: Enter the acronym for the work item which is applicable to the change. This field is mandatory for category F, A, B & C CRs for Release 4 and later. A list of work item acronyms can be found in the 3GPP work plan. See <http://www.3gpp.org/ftp/Specs/html-info/WI-List.htm>.

Commented [H13]: Enter the date on which the CR was last revised. Format to be interpretable by English version of MS Windows ® applications, e.g. 19/02/2006.

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Commented [H15]: Enter a single release code from the list below.

Commented [H16]: Enter text which explains why the change is necessary.

Commented [H17]: Enter text which describes the most important components of the change. i.e. How the change is made.

Commented [H18]: Enter here the consequences if this CR were to be rejected. It is mandatory to complete this section only ...

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Commented [H21]: List here the specifications which are affected or the CRs which are linked.

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3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Carrier frequency: center frequency of the cell.

Cell: combination of downlink and optionally uplink resources. The linking between the carrier frequency of the downlink resources and the carrier frequency of the uplink resources is indicated in the system information transmitted on the downlink resources.

E-RAB: An E-RAB uniquely identifies the concatenation of an S1 Bearer and the corresponding Data Radio Bearer. When an E-RAB exists, there is a one-to-one mapping between this E-RAB and an EPS bearer of the Non Access Stratum as defined in [17].

Hybrid cell: A cell broadcasting a CSG identity which is accessible as a CSG cell by UEs which are members of the CSG and as a normal cell by all other UEs.

MBMS-dedicated cell: cell dedicated to MBMS transmission. MBMS-dedicated cell is not supported in this release.

Frequency layer: set of cells with the same carrier frequency.

Handover: procedure that changes the serving cell of a UE in RRC_CONNECTED.

MBMS/Unicast-mixed: cell supporting both unicast and MBMS transmissions.

Membership Verification: The process that checks whether a UE is a member or non-member of a hybrid cell

Access Control: The process that checks whether a UE is allowed to access and to be granted services in a closed cell

CSG ID Validation: The process that checks whether the CSG ID received via handover messages is the same as the one broadcast by the target E-UTRAN

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ACK	Acknowledgement
ACLR	Adjacent Channel Leakage Ratio
AM	Acknowledged Mode
AMBR	Aggregate Maximum Bit Rate
ANR	Automatic Neighbour Relation
ARQ	Automatic Repeat Request
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BSR	Buffer Status Report
C/I	Carrier-to-Interference Power Ratio
CAZAC	Constant Amplitude Zero Auto-Correlation
CA	Carrier Aggregation
CBC	Cell Broadcast Center
CC	Component Carrier
CIF	Carrier Indicator Field
CMAS	Commercial Mobile Alert Service
CMC	Connection Mobility Control
CP	Cyclic Prefix
C-plane	Control Plane
C-RNTI	Cell RNTI
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSA	Common Subframe Allocation

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CSG	Closed Subscriber Group
DCCH	Dedicated Control Channel
DL	Downlink
DFTS	DFT Spread OFDM
DRB	Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
DwPTS	Downlink Pilot Time Slot
ECGI	E-UTRAN Cell Global Identifier
ECM	EPS Connection Management
EMM	EPS Mobility Management
E-CID	Enhanced Cell-ID (positioning method)
eNB	E-UTRAN NodeB
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
FDD	Frequency Division Duplex
FDM	Frequency Division Multiplexing
GERAN	GSM EDGE Radio Access Network
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile communication
GBR	Guaranteed Bit Rate
GP	Guard Period
HARQ	Hybrid ARQ
HO	Handover
HRPD	High Rate Packet Data
HSDPA	High Speed Downlink Packet Access
ICIC	Inter-Cell Interference Coordination
IP	Internet Protocol
LB	Load Balancing
LCG	Logical Channel Group
LCR	Low Chip Rate
LPPa	LTE Positioning Protocol Annex
LTE	Long Term Evolution
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBR	Maximum Bit Rate
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MCCH	Multicast Control Channel
MCE	Multi-cell/multicast Coordination Entity
MCH	Multicast Channel
MCS	Modulation and Coding Scheme
MIB	Master Information Block
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
MSA	MCH Subframe Allocation
MSI	MCH Scheduling Information
MSP	MCH Scheduling Period
MTCH	Multicast Traffic Channel
NACK	Negative Acknowledgement
NAS	Non-Access Stratum
NCC	Next Hop Chaining Counter
NH	Next Hop key
NNSF	NAS Node Selection Function
NR	Neighbour cell Relation
NRT	Neighbour Relation Table
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access

OTDOA	Observed Time Difference Of Arrival (positioning method)
P-GW	PDN Gateway
P-RNTI	Paging RNTI
PA	Power Amplifier
PAPR	Peak-to-Average Power Ratio
PBCH	Physical Broadcast CHannel
PBR	Prioritised Bit Rate
<u>PCC</u>	<u>Primary Component Carrier</u>
PCCH	Paging Control Channel
<u>PCell</u>	<u>Primary Serving Cell</u>
PCFICH	Physical Control Format Indicator CHannel
PCH	Paging Channel
PCI	Physical Cell Identifier
PDCCH	Physical Downlink Control CHannel
PDSCH	Physical Downlink Shared CHannel
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PHICH	Physical Hybrid ARQ Indicator CHannel
PHY	Physical layer
PLMN	Public Land Mobile Network
PMCH	Physical Multicast CHannel
PRACH	Physical Random Access CHannel
PRB	Physical Resource Block
PSC	Packet Scheduling
PUCCH	Physical Uplink Control CHannel
PUSCH	Physical Uplink Shared CHannel
PWS	Public Warning System
QAM	Quadrature Amplitude Modulation
QCI	QoS Class Identifier
QoS	Quality of Service
RA-RNTI	Random Access RNTI
RAC	Radio Admission Control
RACH	Random Access Channel
RAT	Radio Access Technology
RB	Radio Bearer
RBC	Radio Bearer Control
RF	Radio Frequency
RIM	RAN Information Management
RLC	Radio Link Control
RNC	Radio Network Controller
RNL	Radio Network Layer
RNTI	Radio Network Temporary Identifier
ROHC	Robust Header Compression
RRC	Radio Resource Control
RRM	Radio Resource Management
RU	Resource Unit
S-GW	Serving Gateway
S1-MME	S1 for the control plane
<u>SCC</u>	<u>Secondary Component Carrier</u>
<u>SCell</u>	<u>Secondary Serving Cell</u>
SI	System Information
SIB	System Information Block
SI-RNTI	System Information RNTI
S1-U	S1 for the user plane
SAE	System Architecture Evolution
SAP	Service Access Point
SC-FDMA	Single Carrier – Frequency Division Multiple Access
SCH	Synchronization Channel
SDF	Service Data Flow
SDMA	Spatial Division Multiple Access
SDU	Service Data Unit
SeGW	Security Gateway

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SFN	System Frame Number
SPID	Subscriber Profile ID for RAT/Frequency Priority
SR	Scheduling Request
SRB	Signalling Radio Bearer
SU	Scheduling Unit
TA	Tracking Area
TB	Transport Block
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TFT	Traffic Flow Template
TM	Transparent Mode
TNL	Transport Network Layer
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UM	Unacknowledged Mode
UMTS	Universal Mobile Telecommunication System
U-plane	User plane
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
UpPTS	Uplink Pilot Time Slot
VRB	Virtual Resource Block
X2-C	X2-Control plane
X2-U	X2-User plane

Next Modified Subclause

5.1.1 Basic transmission scheme based on OFDM

The downlink transmission scheme is based on conventional OFDM using a cyclic prefix. The OFDM sub-carrier spacing is $\Delta f = 15\text{ kHz}$. 12 consecutive sub-carriers during one slot correspond to one downlink *resource block*. In the frequency domain, the number of resource blocks, N_{RB} , can range from $N_{RB-min} = 6$ to $N_{RB-max} = 110$ per carrier or per CC in case of CA.

In addition there is also a reduced sub-carrier spacing $\Delta f_{low} = 7.5\text{ kHz}$, only for MBMS-dedicated cell.

In the case of 15 kHz sub-carrier spacing there are two cyclic-prefix lengths, corresponding to seven and six OFDM symbols per slot respectively.

- Normal cyclic prefix: $T_{CP} = 160 \times T_s$ (OFDM symbol #0) , $T_{CP} = 144 \times T_s$ (OFDM symbol #1 to #6)
- Extended cyclic prefix: $T_{CP-e} = 512 \times T_s$ (OFDM symbol #0 to OFDM symbol #5)

where $T_s = 1 / (2048 \times \Delta f)$

In case of 7.5 kHz sub-carrier spacing, there is only a single cyclic prefix length $T_{CP-low} = 1024 \times T_s$, corresponding to 3 OFDM symbols per slot.

In case of FDD, operation with half duplex from UE point of view is supported.

Next Modified Subclause

5.2.1 Basic transmission scheme

For both FDD and TDD, the uplink transmission scheme is based on single-carrier FDMA, more specifically DFTS-OFDM.

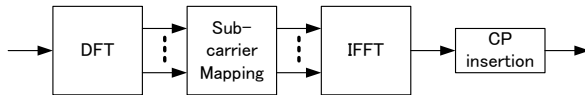


Figure 5.2.1-1: Transmitter scheme of SC-FDMA

The uplink sub-carrier spacing $\Delta f = 15$ kHz. The sub-carriers are grouped into sets of 12 consecutive sub-carriers, corresponding to the uplink resource blocks. 12 consecutive sub-carriers during one slot correspond to one uplink resource block. In the frequency domain, the number of resource blocks, N_{RB} , can range from $N_{RB-min} = 6$ to $N_{RB-max} = 110$ per carrier or per CC in case of CA.

There are two cyclic-prefix lengths defined: Normal cyclic prefix and extended cyclic prefix corresponding to seven and six SC-FDMA symbol per slot respectively.

- Normal cyclic prefix: $T_{CP} = 160 \times T_s$ (SC-FDMA symbol #0), $T_{CP} = 144 \times T_s$ (SC-FDMA symbol #1 to #6)
- Extended cyclic prefix: $T_{CP-e} = 512 \times T_s$ (SC-FDMA symbol #0 to SC-FDMA symbol #5)

Next Modified Subclause

5.5 Carrier Aggregation

In *Carrier Aggregation* (CA), two or more *component carriers* (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz. A UE may simultaneously receive or transmit one or multiple CCs depending on its capabilities:

- A Rel-10 UE with reception and/or transmission capabilities for CA can simultaneously receive and/or transmit on multiple CCs corresponding to multiple serving cells;
- A Rel-8/9 UE can receive on a single CC and transmit on a single CC corresponding to one serving cell only.

CA is supported for both contiguous and non-contiguous CCs with each CC limited to a maximum of 110 Resource Blocks in the frequency domain using the Rel-8/9 numerology.

It is possible to configure a UE to aggregate a different number of CCs originating from the same eNB and of possibly different bandwidths in the UL and the DL.

- The number of DL CCs that can be configured depends on the DL aggregation capability of the UE;
- The number of UL CCs that can be configured depends on the UL aggregation capability of the UE;
- It is not possible to configure a UE with more UL CCs than DL CCs;
- In typical TDD deployments, the number of CCs and the bandwidth of each CC in UL and DL is the same.

CCs originating from the same eNB need not to provide the same coverage but shall be LTE Rel-8/9 compatible.

The spacing between centre frequencies of contiguously aggregated CCs shall be a multiple of 300 kHz. This is in order to be compatible with the 100 kHz frequency raster of Rel-8/9 and at the same time preserve orthogonality of the subcarriers with 15 kHz spacing. Depending on the aggregation scenario, the $\mu \times 300$ kHz spacing can be facilitated by insertion of a low number of unused subcarriers between contiguous CCs.

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6 Layer 2

Layer 2 is split into the following sublayers: Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP).

This subclause gives a high level description of the Layer 2 sub-layers in terms of services and functions. The two figures below depict the PDCP/RLC/MAC architecture for downlink and uplink, where:

- Service Access Points (SAP) for peer-to-peer communication are marked with circles at the interface between sublayers. The SAP between the physical layer and the MAC sublayer provides the transport channels. The SAPs between the MAC sublayer and the RLC sublayer provide the logical channels.
- The multiplexing of several logical channels (i.e. radio bearers) on the same transport channel (i.e. transport block) is performed by the MAC sublayer;
- In both uplink and downlink, when CA is not configured, only one transport block is generated per TTI in the absence of spatial multiplexing~~non-MIMO case~~.

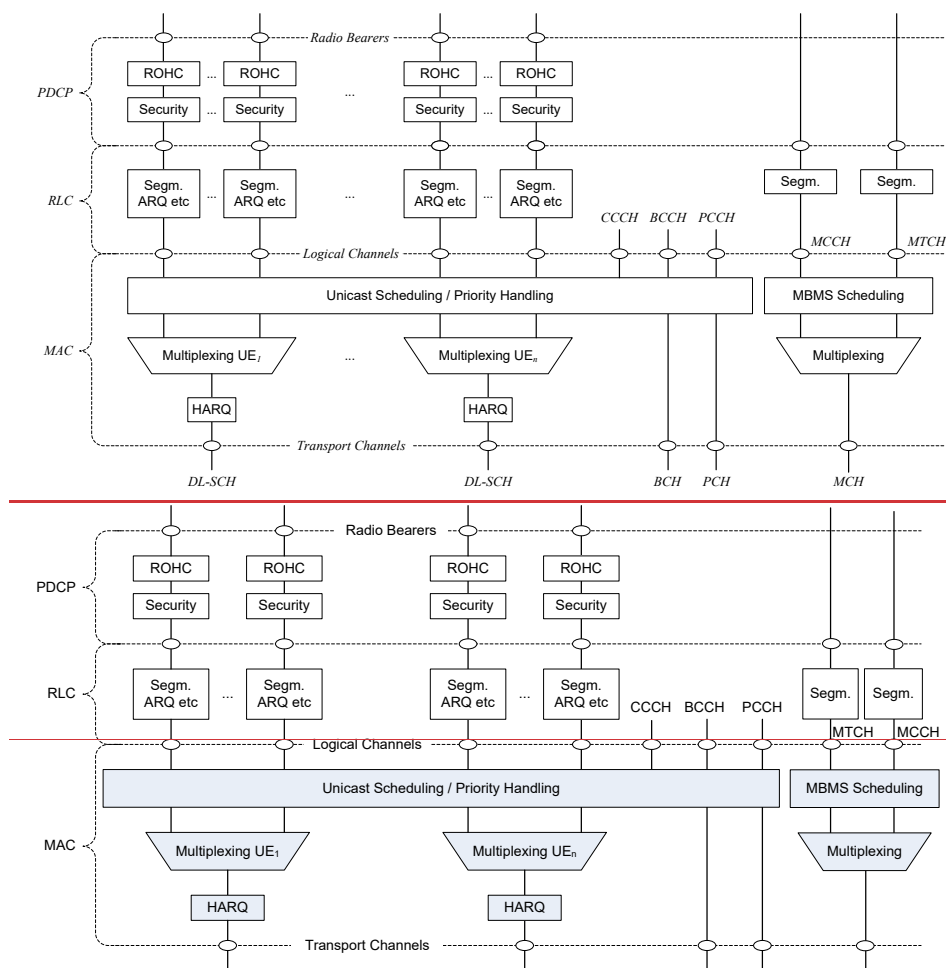


Figure 6-1: Layer 2 Structure for DL

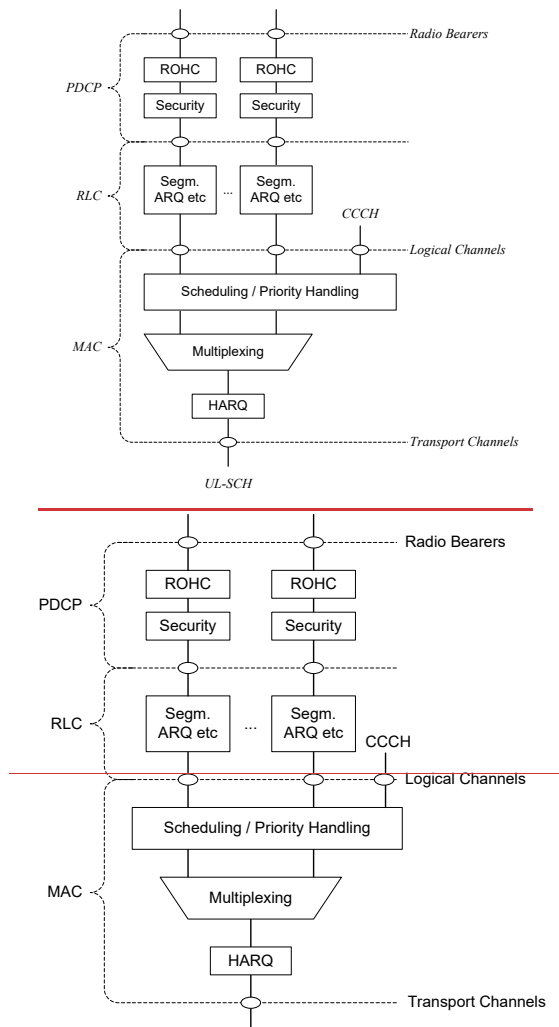


Figure 6-2: Layer 2 Structure for UL

NOTE: The eNB may not be able to guarantee that a L2 buffer overflow will never occur. If such overflow occurs, UE may discard packets in the L2 buffer.

Next Modified Subclause

6.4 ~~Void~~ Carrier Aggregation

In case of CA, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per serving cell;

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- In both uplink and downlink, there is one independent hybrid-ARQ entity per serving cell and one transport block is generated per TTI per serving cell in the absence of spatial multiplexing. Each transport block and its potential HARQ retransmissions are mapped to a single serving cell.

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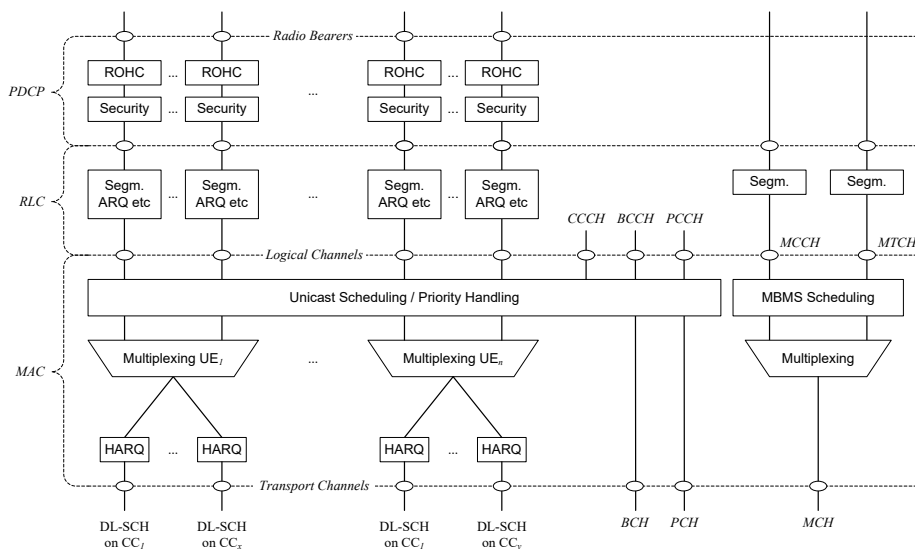


Figure 6.4-1: Layer 2 Structure for DL with CA configured

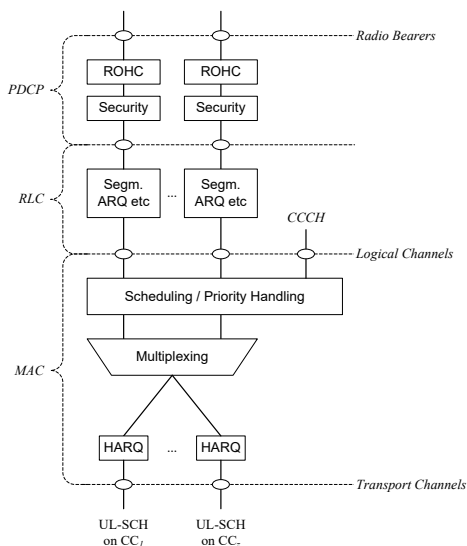


Figure 6.4-2: Layer 2 Structure for UL with CA configured

7.4 System Information

System information is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs):

- *MasterInformationBlock* defines the most essential physical layer information of the cell required to receive further system information;
- *SystemInformationBlockType1* contains information relevant when evaluating if a UE is allowed to access a cell and defines the scheduling of other system information blocks;
- *SystemInformationBlockType2* contains common and shared channel information;
- *SystemInformationBlockType3* contains cell re-selection information, mainly related to the serving cell;
- *SystemInformationBlockType4* contains information about the serving frequency and intra-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SystemInformationBlockType5* contains information about other E-UTRA frequencies and inter-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SystemInformationBlockType6* contains information about UTRA frequencies and UTRA neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SystemInformationBlockType7* contains information about GERAN frequencies relevant for cell re-selection (including cell re-selection parameters for each frequency);
- *SystemInformationBlockType8* contains information about CDMA2000 frequencies and CDMA2000 neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);
- *SystemInformationBlockType9* contains a home eNB identifier (HNBID);
- *SystemInformationBlockType10* contains an ETWS primary notification;
- *SystemInformationBlockType11* contains an ETWS secondary notification;
- *SystemInformationBlockType12* contains a CMAS warning notification;
- *SystemInformationBlockType13* contains MBMS-related information.

The MIB is mapped on the BCCH and carried on BCH while all other SI messages are mapped on the BCCH and dynamically carried on DL-SCH where they can be identified through the SI-RNTI (System Information RNTI). Both the MIB and *SystemInformationBlockType1* use a fixed schedule with a periodicity of 40 and 80 ms respectively while the scheduling of other SI messages is flexible and indicated by *SystemInformationBlockType1*.

The eNB may schedule DL-SCH transmissions concerning logical channels other than BCCH in the same subframe as used for BCCH. The minimum UE capability restricts the BCCH mapped to DL-SCH e.g. regarding the maximum rate.

The Paging message is used to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change.

System information may also be provided to the UE by means of dedicated signalling e.g. upon handover.

7.5 ~~Void~~Carrier Aggregation

When CA is configured, the UE only has one RRC connection with the network. At RRC connection establishment/re-establishment, one serving cell provides the security input (one ECGI, one PCI and one ARFCN) and the NAS mobility information (e.g. TAI) similarly as in Rel-8/9. This cell is referred to as the Primary Serving Cell (PCell). In the downlink, the carrier corresponding to the PCell is the Downlink Primary Component Carrier (DL PCC) while in the uplink it is the Uplink Primary Component Carrier (UL PCC).

Depending on UE capabilities, Secondary Serving Cells (SCells) can be configured to form together with the PCell a set of serving cells. In the downlink, the carrier corresponding to an SCell is a Downlink Secondary Component Carrier (DL SCC) while in the uplink it is an Uplink Secondary Component Carrier (UL SCC).

The configured set of serving cells for a UE therefore always consists of one PCell and one or more SCells:

- For each SCell the usage of uplink resources by the UE in addition to the downlink ones is configurable (the number of DL SCCs configured is therefore always larger or equal to the number of UL SCCs and no SCell can be configured for usage of uplink resources only);
- The number of serving cells that can be configured depends on the aggregation capability of the UE (see subclause 5.5);
- PCell can only be changed with handover procedure (i.e. with security key change and RACH procedure);

NOTE: PCell change optimisations (e.g. not involving a handover procedure) are FFS.

- PCell is used for transmission of PUCCH;
- Unlike SCells, PCell cannot be de-activated (see subclause 12.1);
- Re-establishment is triggered when PCell experiences RLF, not when SCells experience RLF;
- NAS information is taken from PCell.

The reconfiguration, addition and removal of SCells can be performed by RRC. At intra-LTE handover, RRC can also add, remove, or reconfigure SCells for usage with the target PCell. When adding a new SCell, dedicated RRC signalling is used for sending the system information of the SCell required for transmission/reception (similarly as in Rel-8/9 for handover).

Next Modified Subclause

10.1.5 Random Access Procedure

The random access procedure is characterized by:

- Common procedure for FDD and TDD;
- One procedure irrespective of cell size and number serving cells when CA is configured;

The random access procedure is performed for the following six events:

- Initial access from RRC_IDLE;
- RRC Connection Re-establishment procedure;
- Handover;
- DL data arrival during RRC_CONNECTED requiring random access procedure;
 - E.g. when UL synchronisation status is “non-synchronised”;
- UL data arrival during RRC_CONNECTED requiring random access procedure;

- E.g. when UL synchronisation status is "non-synchronised" or there are no PUCCH resources for SR available.
- For positioning purpose during RRC_CONNECTED requiring random access procedure;
- E.g. when timing advance is needed for UE positioning;

Furthermore, the random access procedure takes two distinct forms:

- Contention based (applicable to first five events);
- Non-contention based (applicable to only handover, DL data arrival and positioning).

Normal DL/UL transmission can take place after the random access procedure.

10.1.5.1 Contention based random access procedure

The contention based random access procedure is outlined on Figure 10.1.5.1-1 below:

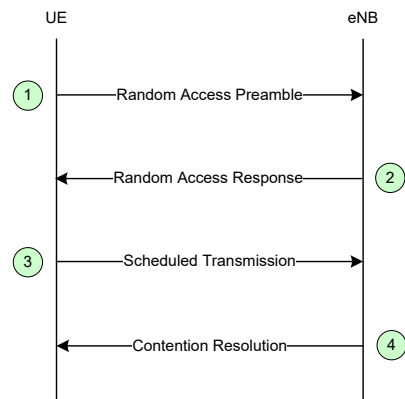


Figure 10.1.5.1-1: Contention based Random Access Procedure

The four steps of the contention based random access procedures are:

- 1) Random Access Preamble on RACH in uplink:
 - There are two possible groups defined and one is optional. If both groups are configured the size of message 3 and the pathloss are used to determine which group a preamble is selected from. The group to which a preamble belongs provides an indication of the size of the message 3 and the radio conditions at the UE. The preamble group information along with the necessary thresholds are broadcast on system information.
- 2) Random Access Response generated by MAC on DL-SCH:
 - Semi-synchronous (within a flexible window of which the size is one or more TTI) with message 1;
 - No HARQ;
 - Addressed to RA-RNTI on PDCCH;
 - Conveys at least RA-preamble identifier, Timing Alignment information, initial UL grant and assignment of Temporary C-RNTI (which may or may not be made permanent upon Contention Resolution);
 - Intended for a variable number of UEs in one DL-SCH message.
- 3) First scheduled UL transmission on UL-SCH:
 - Uses HARQ;

- Size of the transport blocks depends on the UL grant conveyed in step 2 and is at least 80 bits.
 - For initial access:
 - Conveys the RRC Connection Request generated by the RRC layer and transmitted via CCCH;
 - Conveys at least NAS UE identifier but no NAS message;
 - RLC TM: no segmentation;
 - For RRC Connection Re-establishment procedure:
 - Conveys the RRC Connection Re-establishment Request generated by the RRC layer and transmitted via CCCH;
 - RLC TM: no segmentation;
 - Does not contain any NAS message.
 - After handover, in the target cell:
 - Conveys the ciphered and integrity protected RRC Handover Confirm generated by the RRC layer and transmitted via DCCH;
 - Conveys the C-RNTI of the UE (which was allocated via the Handover Command);
 - Includes an uplink Buffer Status Report when possible.
 - For other events:
 - Conveys at least the C-RNTI of the UE.
- 4) Contention Resolution on DL:
- Early contention resolution shall be used i.e. eNB does not wait for NAS reply before resolving contention
 - Not synchronised with message 3;
 - HARQ is supported;
 - Addressed to:
 - The Temporary C-RNTI on PDCCH for initial access and after radio link failure;
 - The C-RNTI on PDCCH for UE in RRC_CONNECTED;
 - HARQ feedback is transmitted only by the UE which detects its own UE identity, as provided in message 3, echoed in the Contention Resolution message;
 - For initial access and RRC Connection Re-establishment procedure, no segmentation is used (RLC-TM).

The Temporary C-RNTI is promoted to C-RNTI for a UE which detects RA success and does not already have a C-RNTI; it is dropped by others. A UE which detects RA success and already has a C-RNTI, resumes using its C-RNTI.

When CA is configured, the first three steps of the contention based random access procedures occur on the PCell.

10.1.5.2 Non-contention based random access procedure

The non-contention based random access procedure is outlined on Figure 10.1.5.2-1 below:

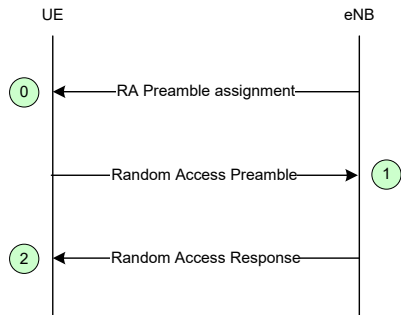


Figure 10.1.5.2-1: Non-contention based Random Access Procedure

The three steps of the non-contention based random access procedures are:

- 0) Random Access Preamble assignment via dedicated signalling in DL:
 - eNB assigns to UE a non-contention Random Access Preamble (a Random Access Preamble not within the set sent in broadcast signalling).
 - Signalled via:
 - HO command generated by target eNB and sent via source eNB for handover;
 - PDCCH in case of DL data arrival or positioning.
- 1) Random Access Preamble on RACH in uplink:
 - UE transmits the assigned non-contention Random Access Preamble.
- 2) Random Access Response on DL-SCH:
 - Semi-synchronous (within a flexible window of which the size is two or more TTIs) with message 1;
 - No HARQ;
 - Addressed to RA-RNTI on PDCCH;
 - Conveys at least:
 - Timing Alignment information and initial UL grant for handover;
 - Timing Alignment information for DL data arrival;
 - RA-preamble identifier.
 - Intended for one or multiple UEs in one DL-SCH message.

When CA is configured, the two steps of the non-contention based random access procedure occur on the PCell.

Next Modified Subclause

11.1 Basic Scheduler Operation

MAC in eNB includes dynamic resource schedulers that allocate physical layer resources for the DL-SCH and UL-SCH transport channels. Different schedulers operate for the DL-SCH and UL-SCH.

The scheduler should take account of the traffic volume and the QoS requirements of each UE and associated radio bearers, when sharing resources between UEs. Only “per UE” grants are used to grant the right to transmit on the UL-SCH (i.e. there are no “per UE per RB” grants).

Schedulers may assign resources taking account the radio conditions at the UE identified through measurements made at the eNB and/or reported by the UE.

Radio resource allocations can be valid for one or multiple TTIs.

Resource assignment consists of physical resource blocks (PRB) and MCS. Allocations for time periods longer than one TTI might also require additional information (allocation time, allocation repetition factor...).

When CA is configured, a UE may be scheduled over multiple serving cells simultaneously but at most one random access procedure shall be ongoing at any time. Cross-carrier scheduling with the Carrier Indicator Field (CIF) allows the PDCCH of a serving cell to schedule resources on another serving cell. A linking between UL and DL allows identifying the serving cell for which the grant applies when the CIF is not present:

- DL assignment received in PCell corresponds to downlink transmission in PCell;
- UL grant received in PCell corresponds to uplink transmission in PCell;
- DL assignment received on in SCell_n corresponds to downlink transmission on in SCell_n;
- UL grant received in SCell_n corresponds to uplink transmission in SCell_n. If SCell_n is not configured for uplink usage by the UE, the grant is ignored by the UE.

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11.1.1 Downlink Scheduling

In the downlink, E-UTRAN can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on PDCCH(s). A UE always monitors the PDCCH(s) in order to find possible allocation when its downlink reception is enabled (activity governed by DRX when configured). When CA is configured, the same C-RNTI applies to all serving cells.

In addition, E-UTRAN can allocate semi-persistent downlink resources for the first HARQ transmissions to UEs:

- RRC defines the periodicity of the semi-persistent downlink grant;
- PDCCH indicates whether the downlink grant is a semi-persistent one i.e. whether it can be implicitly reused in the following TTIs according to the periodicity defined by RRC.

When required, retransmissions are explicitly signalled via the PDCCH(s). In the sub-frames where the UE has semi-persistent downlink resource, if the UE cannot find its C-RNTI on the PDCCH(s), a downlink transmission according to the semi-persistent allocation that the UE has been assigned in the TTI is assumed. Otherwise, in the sub-frames where the UE has semi-persistent downlink resource, if the UE finds its C-RNTI on the PDCCH(s), the PDCCH allocation overrides the semi-persistent allocation for that TTI and the UE does not decode the semi-persistent resources.

When CA is configured, semi-persistent downlink resources can only be configured for the PCell.

11.1.2 Uplink Scheduling

In the uplink, E-UTRAN can dynamically allocate resources (PRBs and MCS) to UEs at each TTI via the C-RNTI on PDCCH(s). A UE always monitors the PDCCH(s) in order to find possible allocation for uplink transmission when its downlink reception is enabled (activity governed by DRX when configured). When CA is configured, the same C-RNTI applies to all serving cells.

In addition, E-UTRAN can allocate a semi-persistent uplink resource for the first HARQ transmissions and potentially retransmissions to UEs:

- RRC defines the periodicity of the semi-persistent uplink grant;
- PDCCH indicates whether the uplink grant is a semi-persistent one i.e. whether it can be implicitly reused in the following TTIs according to the periodicity defined by RRC.

In the sub-frames where the UE has semi-persistent uplink resource, if the UE cannot find its C-RNTI on the PDCCH(s), an uplink transmission according to the semi-persistent allocation that the UE has been assigned in the TTI can be made. The network performs decoding of the pre-defined PRBs according to the pre-defined MCS. Otherwise, in the sub-frames where the UE has semi-persistent uplink resource, if the UE finds its C-RNTI on the PDCCH(s), the PDCCH allocation overrides the persistent allocation for that TTI and the UE's transmission follows the PDCCH allocation, not the semi-persistent allocation. Retransmissions are either implicitly allocated in which case the UE uses the semi-persistent uplink allocation, or explicitly allocated via PDCCH(s) in which case the UE does not follow the semi-persistent allocation.

NOTE: there is no blind decoding in uplink and when the UE does not have enough data to fill the allocated resource, padding is used.

When the UE is provided with valid uplink grants in several serving cells in one TTI, the order in which the grants are processed during logical channel prioritisation and whether joint or serial processing is applied are left up to UE implementation.

Similarly as for the downlink, semi-persistent uplink resources can only be configured for the PCell.

Next Modified Subclause

11.2 VoidActivation/Deactivation Mechanism

To enable reasonable UE battery consumption when CA is configured, a downlink activation/deactivation mechanism of SCells is supported (i.e. activation/deactivation does not apply to PCell). When an SCell is deactivated, the UE does not need to receive the corresponding PDCCH or PDSCH, nor is it required to perform CQI measurements. Conversely, when an SCell is active, the UE shall receive PDSCH and PDCCH (if the UE is configured to monitor PDCCH from this SCell), and is expected to be able to perform CQI measurements. In the uplink however, a UE is always required to be able to transmit on PUSCH on any SCells when scheduled on the corresponding PDCCH (i.e. there is no explicit activation of SCells in uplink).

The activation/deactivation mechanism is based on the combination of a MAC control element and deactivation timers. The MAC control element carries a bitmap for the downlink activation and deactivation of SCells: a bit set to 1 denotes activation of the corresponding SCell, while a bit set to 0 denotes deactivation. With the bitmap, SCells can be activated and deactivated individually, and a single activation/deactivation command can activate/deactivate a subset of the SCells. One deactivation timer is maintained per SCell but one common value is configured per UE by RRC. The deactivation timer of SCell_n is started or restarted when:

- SCell_n is activated;
- PDCCH on SCell_n indicates an uplink grant or downlink assignment;
- PDCCH on the scheduling DL CC indicates a downlink assignment for SCC_n.

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At reconfiguration without mobility control information:

- SCells added to the set of serving cells are initially “deactivated”;
- SCells which remain in the set of serving cells (either unchanged or reconfigured) do not change their activation status (“activated” or “deactivated”).

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At reconfiguration with mobility control information (i.e. handover):

- SCells are “deactivated” up to contention resolution.

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Next Modified Subclause

12 DRX in RRC_CONNECTED

In order to enable reasonable UE battery consumption, DRX in E-UTRAN is characterised by the following:

- Per UE mechanism (as opposed to per radio bearer);
- No RRC or MAC substate to distinguish between different levels of DRX;
- Available DRX values are controlled by the network and start from non-DRX up to x seconds. Value x may be as long as the paging DRX used in ECM-IDLE;
- Measurement requirement and reporting criteria can differ according to the length of the DRX interval i.e. long DRX intervals may experience more relaxed requirements;
- Irrespective of DRX, UE may use first available RACH opportunity to send an UL measurement report;
- Immediately after sending a measurement report, the UE may change its DRX. This mechanism would be pre-configured by the eNB;
- HARQ operation related to data transmission is independent of DRX operation and the UE wakes up to read the PDCCH for possible retransmissions and/or ACK/NAK signalling regardless of DRX. In the downlink, a timer is used to limit the time the UE stays awake awaiting for a retransmission;
- When DRX is configured, the UE may be further configured with an "on-duration" timer during which time the UE monitors the PDCCHs for possible allocations;
- When DRX is configured, periodic CQI reports can only be sent by the UE during the "active-time". RRC can further restrict periodic CQI reports so that they are only sent during the on-duration;
- A timer in the UE is used to detect need for obtaining timing advance.

The following definitions apply to DRX in E-UTRAN:

- **on-duration**: duration in downlink subframes that the UE waits for, after waking up from DRX, to receive PDCCHs. If the UE successfully decodes a PDCCH, the UE stays awake and starts the inactivity timer;
- **inactivity-timer**: duration in downlink subframes that the UE waits to successfully decode a PDCCH, from the last successful decoding of a PDCCH, failing which it re-enters DRX. The UE shall restart the inactivity timer following a single successful decoding of a PDCCH for a first transmission only (i.e. not for retransmissions).
- **active-time**: total duration that the UE is awake. This includes the "on-duration" of the DRX cycle, the time UE is performing continuous reception while the inactivity timer has not expired and the time UE is performing continuous reception while waiting for a DL retransmission after one HARQ RTT. Based on the above the minimum active time is of length equal to on-duration, and the maximum is undefined (infinite);

Of the above parameters the on-duration and inactivity-timer are of fixed lengths, while the active-time is of varying lengths based on scheduling decision and UE decoding success. Only on-duration and inactivity-timer duration are signalled to the UE by the eNB:

- There is only one DRX configuration applied in the UE at any time;
- UE shall apply an on-duration on wake-up from DRX sleep;

NOTE: this is also applicable for the case where the UE has only one service (e.g. Real Time) that is being handled through the allocation of predefined resources; this allows for other signalling such as RRC to be sent during the remaining portion of the active time.

- New transmissions can only take place during the active-time (so that when the UE is waiting for one retransmission only, it does not have to be "awake" during the RTT).
- If PDCCH has not been successfully decoded during the on-duration, the UE shall follow the DRX configuration (i.e. the UE can enter DRX sleep if allowed by the DRX configuration):
 - This applies also for the sub-frames where the UE has been allocated predefined resources.

- If it successfully decodes a PDCCH for a first transmission, the UE shall stay awake and start the inactivity timer (even if a PDCCH is successfully decoded in the sub-frames where the UE has also been allocated predefined resources) until a MAC control message tells the UE to re-enter DRX, or until the inactivity timer expires. In both cases, the DRX cycle that the UE follows after re-entering DRX is given by the following rules:
 - If a short DRX cycle is configured; the UE first follows the short DRX cycle and after a longer period of inactivity the UE follows the long DRX cycle;
 - Else the UE follows the long DRX cycle directly.

NOTE: When DRX is configured, the network should detect whether UE remains in EUTRAN coverage by requesting UE to send periodic signals to the network.

In CA, whenever a UE is configured with only one serving cell (i.e. PCell) Rel-8/9 DRX applies. In other cases, the same DRX operation applies to all configured and activated serving cells (i.e. identical active time for PDCCH monitoring).

Next Modified Subclause

Annex X (informative): Carrier Aggregation

This Annex reflects the agreements reached on carrier aggregation that may not necessarily fit in the core of the specification but which needs to be captured in the absence of corresponding details in Stage 3 specifications.

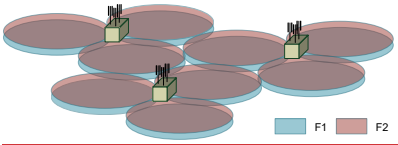
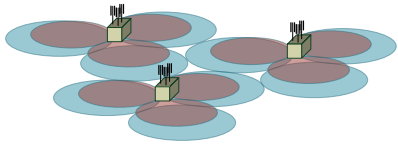
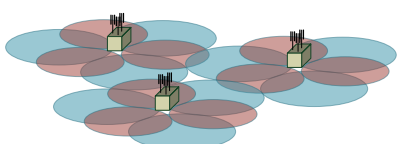
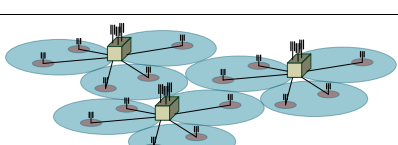
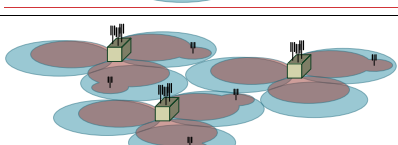
X.1 Deployment Scenarios

Table X.1-1 shows some of the potential deployment scenarios for CA. In Rel-10, for the uplink, the focus is laid on the support of intra-band carrier aggregations (e.g. scenarios #1, as well as scenarios #2 and #3 when F1 and F2 are in the same band). For the downlink, all scenarios should be supported in Rel-10.

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Table X.1-1: CA Deployment Scenarios (F2 > F1).

#	Description	Example
1	F1 and F2 cells are co-located and overlaid, providing nearly the same coverage. Both layers provide sufficient coverage and mobility can be supported on both layers. Likely scenario when F1 and F2 are of the same band, e.g., 2 GHz, 800 MHz, etc. It is expected that aggregation is possible between overlaid F1 and F2 cells.	
2	F1 and F2 cells are co-located and overlaid, but F2 has smaller coverage due to larger path loss. Only F1 provides sufficient coverage and F2 is used to provide throughput. Mobility is performed based on F1 coverage. Likely scenario when F1 and F2 are of different bands, e.g., F1 = {800 MHz, 2 GHz} and F2 = {3.5 GHz}, etc. It is expected that aggregation is possible between overlaid F1 and F2 cells.	
3	F1 and F2 cells are co-located but F2 antennas are directed to the cell boundaries of F1 so that cell edge throughput is increased. F1 provides sufficient coverage but F2 potentially has holes, e.g., due to larger path loss. Mobility is based on F1 coverage. Likely scenario when F1 and F2 are of different bands, e.g., F1 = {800 MHz, 2 GHz} and F2 = {3.5 GHz}, etc. It is expected that F1 and F2 cells of the same eNB can be aggregated where coverage overlap.	
4	F1 provides macro coverage and on F2 Remote Radio Heads (RRHs) are used to provide throughput at hot spots. Mobility is performed based on F1 coverage. Likely scenario when F1 and F2 are of different bands, e.g., F1 = {800 MHz, 2 GHz} and F2 = {3.5 GHz}, etc. It is expected that F2 RRHs cells can be aggregated with the underlying F1 macro cells.	
5	Similar to scenario #2, but frequency selective repeaters are deployed so that coverage is extended for one of the carrier frequencies. It is expected that F1 and F2 cells of the same eNB can be aggregated where coverage overlap.	

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The reception timing difference at the physical layer of DL assignments and UL grants for the same TTI but from different serving cells (e.g. depending on number of control symbols, propagation and deployment scenario) does not affect MAC operation.

X.2 Layer 2 Architecture

The PDCP and RLC protocol of LTE Rel-8/9 also applies to carrier aggregation and allows handling data rate up to 1Gbps. Further enhancements (e.g. increased SN size) can be considered.

In MAC, from a UE perspective, the Layer 2 aspects of HARQ are kept Rel-8/9 compliant unless modifications provide significant gains.

The C-Plane architecture of LTE Rel-8/9 also applies to CA.

X.3 RRC procedures

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X.3.1 System Information

A cell is identified by a unique ECGI and corresponds to the transmission of system information in one CC. Rel-8/9 relevant system information and possible extensions for Rel-10 are delivered on “backward compatible” cells. Each cell provides on BCCH the system information which is specific to it.

With regards to the system information reception for the PCell, the Rel-8/9 procedure applies.

When adding an SCell, dedicated RRC signalling is used for sending the system information which is necessary for transmission/reception (similarly as in Rel-8/9 for handover).

NOTE: this does not include e.g. PRACH resource configurations.

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There is no need for the UE to acquire system information directly from SCells. The system information of an SCell remains valid as long as the SCell is configured. Changes in system information of an SCell can only be handled through the removal and addition of the SCell. Removal and addition of an SCell can be done with one RRC procedure.

X.3.2 Connection Control

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After RRC connection establishment to the PCell, the reconfiguration, addition and removal of individual SCells can be performed by *RRCConnectionReconfiguration* including *mobilityControlInfo* (i.e. “intra-cell handover”). *RRCConnectionReconfiguration* without *mobilityControlInfo* can also be used for the reconfiguration, addition and removal of individual SCells. The usage of *RRCConnectionReconfiguration* without *mobilityControlInfo* for PCell change is FFS.

At intra-LTE handover, the *RRCConnectionReconfiguration* with *mobilityControlInfo* (i.e. “handover command”) can remove, reconfigure or add individual SCells for usage in the target cell.

The combination of CA and UL bundling cannot be configured for a UE.

RRC connection re-establishment triggers at the UE include:

- 1) Failure of the PCell according to same criteria as used for RLF detection in Rel-8/9 (i.e. based on N310/N311/T310);
- 2) Random access problem in PCell (as in Rel-8/9);
- 3) Indication from RLC that the maximum number of retransmissions has been reached (as in Rel-8/9).

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Upon initiation of the re-establishment procedure, the UE falls back to a non-CA default configuration for *physicalConfigDedicated*, *MAC-MainConfig* and *sps-Config* (i.e. SCells configurations are released). First reconfiguration after the re-establishment can again configure SCells.

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With respect to SCells:

- Deactivation and removal of SCell(s) suffering from poor link quality is under eNB control and no autonomous UE deactivation and removal of such serving cells is permitted (with the exception of the timer-based deactivation of as described in subclause 12.1);
- UE never stops transmitting in an SCell autonomously based on downlink SCell quality.
- Radio link monitoring (i.e. physical layer problem detection based on N310/N311/T310) of DL SCC by the UE is not needed. The eNB can detect poor link quality e.g. from CQI reports and/or existing RRM measurement reports for activated SCells and from existing RRM measurement reports for deactivated SCells.

X.3.3 Linking between UL and DL

Linking between UL PCC and DL PCC is based on SIB2 of the PCell and if DL PCC changes, UL PCC also changes.

Apart from power control, there are two cases requiring a linking between uplink and downlink:

- RACH (contention based and contention free access);
- The random access response corresponding to a random access on a RACH resource from the uplink of a serving cell is transmitted in the downlink of the same serving cell.
- Grant without CIF (see subclause 11.1).
- UL grant received in PCell corresponds to uplink transmission in PCell;
- UL grant received in SCell_n corresponds to uplink transmission in SCell_n.

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X.3.4 Measurements

UE sees a CC as any other carrier frequency and a measurement object needs to be set up for a CC in order for the UE to measure it. Inter-frequency neighbour measurements encompass all the carrier frequencies for which no serving cell is configured.

All Rel-8/9 measurement events are applicable for a UE configured with CA:

- At most one serving cell (PCell or SCell) per measurement ID;
- For measurement events A1, A2 and A3 the serving cell of the event is the configured serving cell (PCell or SCell) corresponding to the measurement object (i.e. the eNB may configure separate events A1, A2 and A3 for each serving cell);
- For measurement event A5 and B2, the serving cell used as a reference is the PCell;
- The measurement object linked to an A5 event can be any frequency and if an SCC is the target object, the corresponding SCell is included in the comparison.

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In addition, A3-PCC is introduced for which the reference cell is PCell and target object can be any frequency for which a measurement object is defined. If an SCC is the target object, the corresponding SCell is included in the comparison.

Measurements on activated CCs can be done without measurement gaps.

The serving quality threshold (*s-measure*) criteria applies to PCell and controls all non-serving cell measurements i.e. when PCell RSRP, after layer 3 filtering, is higher than *s-measure* all measurements other than those that are only on the PCell or only on an SCell can be disabled.

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X.4 MAC procedures

As in Rel-8/9, there can only be one BSR per transport block but in a TTI, there can be several BSRs:

- zero or one Regular/Periodic BSR; and
- zero, one or more Padding BSRs.

All BSRs transmitted in a TTI always reflect the buffered data left after all MAC PDUs have been built for the TTI. When an LCG is reported in several BSRs of the same TTI, the same value shall be indicated. When more than one serving cell allows a Regular/Periodic BSR to be sent in a TTI, the UE can choose the serving cell in which the Regular/Periodic BSR is sent.

At least one additional BSR table is introduced for the support of higher data rates.

In uplink, the maximum number of HARQ transmissions is configured by the eNB and applies to all serving cells.

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X.5 Idle mode procedures

Idle mode mobility procedures of Rel-8/9 also apply in a network deploying CA. It should be possible for a network to configure only a subset of CCs for idle mode camping.

X.6 Inter-eNB Mobility

The source eNB selects a target PCell and indicates it in the relevant X2/S1 messages, to ensure backwards compatibility. The target eNB however has the possibility to change the PCell (as in Rel-8/9 for the target cell):

- For X2 handovers, the selected PCell must belong to the set of cells for which a keNB* is provided by the source eNB.
- For S1 handovers, no such restrictions exist.

The target eNB decides which SCells to configure at handover.

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