UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZTE (USA) Inc.,
HTC Corporation, and
HTC America, Inc.

Petitioners

v.

Evolved Wireless LLC,

Patent Owner

DECLARATION OF MA WEI

Case No. IPR2016-00757

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1. My name is Ma Wei. I am a Standard Engineer at ZTE Corporation. I have been employed by ZTE Corporation since 2008.

2. Since 2008, I have served as one of ZTE's delegates to the Third Generation Partnership Project ("3GPP") in subgroups of 3GPP's Technical Specification Group - Radio Access Network ("TSG-RAN") known as Working Group 2 ("WG2") and Working Group 5 ("WG5").

3. In 2008, I attended WG2's meetings and subscribed to WG2's reflector list (3GPP_TSG_RAN_WG2@list.etsi.org), through which I both sent and received e-mail messages. Since at least early 2009, I have also attended WG5's meetings and subscribed to WG5's reflector list, through which I have sent and received hundreds of e-mail messages. In general, before each Working Group meeting that I attended, I received e-mail messages from delegates of other companies through that group's reflector list, providing technical documents, called contributions, for discussion at the meeting. Some of those e-mail messages provided the technical documents as e-mail attachments, while other e-mail messages provided links to the locations where the technical documents were stored on 3GPP's publicly available website <http://www.3gpp.org>. Regardless of how the e-mail messages provided access to the technical documents, those documents were also uploaded to and available for download at 3GPP's publicly available website.

4. As a 3GPP delegate, I sent e-mail messages submitting technical documents on ZTE's behalf to WG2's and WG5's reflector lists before the meeting for which the documents were submitted for discussion. I also uploaded technical documents to 3GPP's publicly available website before the meeting for which the technical documents were submitted for discussion.

5. As a delegate for WG2, I have also regularly accessed the location on 3GPP's website storing technical documents submitted to WG2. That location is available at the uniform resource identifier <http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/>, which I refer to in this declaration as "WG2's public directory." Since February 2008, I accessed WG2's public directory in several ways, such as, for example, by entering the uniform resource identifier of WG2's public directory into an Internet browser and by accessing 3GPP's homepage <http://www.3gpp.org> and then navigating to the uniform resource identifier of WG2's public directory. Regardless of which method I used to access WG2's public directory, I never encountered a password requirement or any other restriction that would prevent me or a member of the general public from accessing WG2's public directory or any intermediate location. Based on my 7 years of experience as a 3GPP delegate, since 2008 to the present, any member of the public could freely access WG2's public directory, browse it, and download technical documents stored to it without restriction.

6. As a delegate for WG2, I also routinely consulted 3GPP technical specifications. In my experience, since I started as a delegate in 2008, specifications have been made available on 3GPP's website to any member of the public without any restrictions. In preparing this declaration, I accessed the location on 3GPP's website where different versions of the technical specification TS 36.321 are made available. That location is available at the uniform resource identifier <http://www.3gpp.org/dynareport/36321.htm>, which I refer to in this declaration as "3GPP's public 36.321 specification site." I accessed 3GPP's public 36.321 specification site without any password or any other restriction. Attached as Exhibit 1 is a true and correct copy of a printout of 3GPP's public 36.321 specification site as I accessed it. Exhibit 1 provides links to the different versions of TS 36.321, along with dates on which those versions were made available to the public. For example, Exhibit 1 provides a link to version 8.2.0 of TS 36.321 and shows that this version was made available on June 17, 2008. Based on my 7 years of experience as a 3GPP delegate, having routinely accessed versions of 3GPP technical specifications shortly after they became available to me and members of the public, I understand the June 17, 2008 date on Exhibit 1 to be accurate and have no reason to dispute its accuracy.

7. In preparing this declaration, I selected the link to version 8.2.0, which initiated a download of a ZIP file titled "36321-820.zip." I opened that ZIP file

and found a single Word file titled "36321-820.doc." Attached as Exhibit 2 is a true and correct copy of that Word file. I recognize Exhibit 2 as the version 8.2.0 of 3GPP TS 36.321 that I had access to and had reviewed in June 2008 shortly after it was released.

8. In preparing this declaration, I also accessed the location on 3GPP's website where different versions of the technical specification TS 36.300 are made available. That location is available at the uniform resource identifier <http://www.3gpp.org/dynareport/36300.htm>, which I refer to in this declaration as "3GPP's public 36.300 specification site." I accessed 3GPP's public 36.300 specification site without any password or any other restriction. Attached as Exhibit 3 is a true and correct copy of a printout of 3GPP's public 36.300 specification site as I accessed it. Exhibit 3 provides links to the different versions of TS 36.300, along with dates on which those versions were made available to the public. For example, Exhibit 3 provides a link to version 8.4.0 of TS 36.300 and shows that this version was made available on March 20, 2008. Based on my 7 years of experience as a 3GPP delegate, having routinely accessed versions of 3GPP technical specifications shortly after they became available to me and members of the public, I understand the March 20, 2008 date on Exhibit 3 to be accurate and have no reason to dispute its accuracy.

9. In preparing this declaration, I selected the link to version 8.4.0, which initiated a download of a ZIP file titled "36300-840.zip." I opened that ZIP file and found a single Word file titled "36300-840.doc." Attached as Exhibit 4 is a true and correct copy of that Word file. I recognize Exhibit 4 as the version 8.4.0 of 3GPP TS 36.300 that I had access to and had reviewed in March 2008 shortly after it was released.

10. I attended WG2 Meeting #61bis, which was held on March 31 to April 4, 2008, in Shenzhen, China. Before Meeting #61bis, delegates from companies circulated technical documents for discussion at this meeting. During Meeting #61bis, delegates also collaborated on and generated technical documents. All of these documents were stored to a publicly available location on 3GPP's website that was and remains available at the uniform resource identifier <www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_61bis/Docs/>.

11. In preparing this declaration, I accessed that location without any password or any other restriction. Attached as Exhibit 5 is a true and correct copy of a printout from that website as I accessed it. Exhibit 5 lists several ZIP files, including R2-081764.zip, as shown in the following excerpt.

3/24/2008	7:45	PM	16259	R2-081762.zip
3/25/2008	5:35	AM	34197	R2-081763.zip
3/24/2008	10:39	PM	137378	R2-081764.zip
3/25/2008	5:38	AM	8158	R2-081765.zip
3/24/2008	10:41	PM	39028	R2-081766.zip

(Ex. 5 at 6.) The text "R2-081764.zip" provides a link to a ZIP file titled R1-081764.zip. I downloaded and opened this ZIP file and found that it contains a single Microsoft Word file, a true and correct copy of which is attached as Exhibit 6.

12. In the excerpt from the 3GPP website printout shown above, there is also a date stamp (3/24/2008) to the left of the link to R2-081764.zip. Based on my 7 years of experience as a 3GPP delegate, having uploaded ZIP files to 3GPP's publicly available server, I understand this date stamp to mean that R2-081764.zip was uploaded to 3GPP's publicly available website on March 24, 2008 (before Meeting #61bis), and that any member of the public could have downloaded the ZIP file, extracted the Word document it enclosed, and viewed the contents of that Word document without restriction on March 24, 2008 and thereafter. I have no reason to believe this date stamp is inaccurate.

13. On April 23, 2008, after Meeting #61bis, I received an e-mail message from ETSI employee Joern Krause through WG2's reflector list. Attached as Exhibit 7 is a true and correct copy of Mr. Krause's e-mail message as obtained from 3GPP's public e-mail website, which is available at <https://list.etsi.org/>, with which I have become familiar as a 3GPP delegate. Like all other members of WG2, I received this e-mail message along with an attached ZIP file, which enclosed a Word document, a true and correct copy of which is attached as Exhibit 8.

14. I declare under penalty of perjury that the statements made herein are believed to be true based upon either my personal knowledge or to the best of my knowledge, information, and belief.

Date: March 22, 2016

Ma Wei

Ma Wei

EXHIBIT 1

3GPP Specification detail

Go to spec numbering scheme page
Back to series index

3GPP TS 36.321 (click spec number to see fileserver directory for this spec)

Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification

TSG / WG responsible: R2 (click TSG/WG to see its home page)
Work item which gave rise to this spec: LTE-L23 (click WI code to see Work Item details in the Work Plan)
Work items which may have impacted this spec: **click here**
Rapporteur: **STATTIN, Magnus**
Specification required for: E-UTRAN-based systems
In the table below ...
... click meeting number for meeting details;
... click spec version number to download that version;
... click SDO publication reference to download SDO transposed document.

Release	Freeze meeting	Freeze date	::	remarks	SDO publications
Rel-13	SP-70	2015-12-11	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-70	13.0.0	2016-01-14		-
Rel-12	SP-65	2014-09-17	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-70	12.8.0	2016-01-04		RTS/TSGR-0236321vc80
	RP-69	12.7.0	2015-09-25		RTS/TSGR-0236321vc70
	RP-68	12.6.0	2015-07-08		RTS/TSGR-0236321vc60
	RP-67	12.5.0	2015-03-27		RTS/TSGR-0236321vc50
	RP-66	12.4.0	2015-01-05		RTS/TSGR-0236321vc40
	RP-65	12.3.0	2014-09-23		RTS/TSGR-0236321vc30
	RP-64	12.2.1	2014-07-10	editorial	RTS/TSGR-0236321vc21
	RP-64	12.2.0	2014-07-02		-
	RP-63	12.1.0	2014-03-20		-
	RP-62	12.0.0	2014-01-07		-
Rel-11	SP-57	2012-09-12	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-67	11.6.0	2015-03-27		RTS/TSGR-0236321vb60
	RP-63	11.5.0	2014-03-20		RTS/TSGR-0236321vb50
	RP-62	11.4.0	2014-01-07		RTS/TSGR-[illegible]

	RP-60	11.3.0	2013-07-03		RTS/TSGR-0236321vb30
	RP-59	11.2.0	2013-03-18		RTS/TSGR-0236321vb20
	RP-58	11.1.0	2013-01-03		RTS/TSGR-0236321vb10
	RP-57	11.0.0	2012-09-24		RTS/TSGR-0236321vb00
Rel-10	SP-51	2011-03-23	::	. .	ETSI
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	RP-60	10.9.0	2013-07-03		RTS/TSGR-0236321va90
	RP-59	10.8.0	2013-03-18		RTS/TSGR-0236321va80
	RP-58	10.7.0	2013-01-03		RTS/TSGR-0236321va70
	RP-57	10.6.0	2012-09-21		RTS/TSGR-0236321va60
	RP-55	10.5.0	2012-03-16		RTS/TSGR-0236321va50
	RP-54	10.4.0	2011-12-21		RTS/TSGR-0236321va40
	RP-53	10.3.0	2011-10-03		RTS/TSGR-0236321va30
	RP-52	10.2.0	2011-06-24		RTS/TSGR-0236321va20
	RP-51	10.1.0	2011-04-06		RTS/TSGR-0236321va10
	RP-50	10.0.0	2010-12-21		RTS/TSGR-0236321va00
Rel-9	SP-46	2009-12-10	::	.	ETSI
	event	version	available	remarks	click ref to download
	RP-55	9.6.0	2012-03-16		RTS/TSGR-0236321v960
	RP-54	9.5.0	2011-12-21		RTS/TSGR-0236321v950
	RP-53	9.4.0	2011-10-03		RTS/TSGR-0236321v940
	RP-48	9.3.0	2010-06-18		RTS/TSGR-0236321v930
	RP-47	9.2.0	2010-04-21		RTS/TSGR-0236321v920
	RP-46	9.1.0	2010-01-05		RTS/TSGR-0236321v910
	RP-45	9.0.0	2009-09-28		RTS/TSGR-0236321v900
Rel-8	SP-42	2008-12-11	::	.	ETSI
	event	version	available	remarks	click ref to download
	RP-55	8.12.0	2012-03-16		RTS/TSGR-0236321v8c0
	RP-54	8.11.0	2011-12-21		RTS/TSGR-0236321v8b0
	RP-53	8.10.0	2011-10-03		RTS/TSGR-0236321v8a0
	RP-48	8.9.0	2010-06-18		RTS/TSGR-0236321v890
	RP-46	8.8.0	2010-01-05		RTS/TSGR-0236321v880
	RP-45	8.7.0	2009-09-28		RTS/TSGR-0236321v870
	RP-44	8.6.0	2009-06-18		RTS/TSGR-0236321v860
	RP-43	8.5.0	2009-03-23		RTS/TSGR-0236321v850
	RP-42	8.4.0	2009-01-05		RTS/TSGR-0236321v840
	RP-41	8.3.0	2008-09-23		RTS/TSG[illegible]

	RP-40	8.2.0	2008-06-17		DTS/TSGR-0236321v820
	RP-39	8.1.0	2008-03-20		-
	RP-38	8.0.0	2007-12-20		-
	RP-38	2.0.0	2007-12-11	RP-070917	-
	R2-60	1.3.0	-	R2-075488	-
	R2-60	1.2.0	-	R2-075243	-
	R2-60	1.1.1	-	R2-075093	-
	R2-59b	1.1.0	2014-12-18	R2-074530	-
	RP-37	1.0.0	2007-09-24	RP-070688	-
	R2-59	0.2.1	-	R2-073885	-
	R2-59	0.2.0	-	R2-073715	-
	R2-58b	0.1.1	-	R2-072994	-
	R2-58b	0.1.0	-	R2-072912	-
	R2-58b	0.0.0	-	R2-072710	-

Change Requests for this spec: click here.

Genealogy of this spec:

antecedent(s)	this spec	descendant(s)
	36.321	

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EXHIBIT 2

3GPP TS 36.321 V8.2.0 (2008-05)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Evolved Universal Terrestrial Radio Access (E-UTRA)
Medium Access Control (MAC) protocol specification
(Release 8)

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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the E-UTRA MAC protocol.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer Procedures".

[3] 3GPP TS 36.322: “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification”.

[4] 3GPP TS 36.323: “Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) Specification”.

[5] 3GPP TS 36.212: “Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding”.

[6] 3GPP TS 36.214: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements”.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Active Time: time during which the UE monitors the PDCCH for a PDCCH-subframe. Section 5.7 defines the conditions for which a subframe is included as part of Active Time.

Contention Resolution Timer: Specifies the number of consecutive PDCCH-subframe(s) during which the UE shall monitor the PDCCH after the uplink message containing the C-RNTI MAC control element or the uplink message associated with UE Contention Resolution Identity submitted from higher layer is transmitted.

DRX Cycle: Specifies the periodic repetition of the On Duration followed by a possible period of inactivity (see figure 3.1-1 below).

Figure 3.1-1: DRX Cycle

DRX Inactivity Timer: Specifies the number of consecutive PDCCH-subframe(s) after successfully decoding a PDCCH indicating an initial UL or DL user data transmission for this UE.

DRX Retransmission Timer: Specifies the maximum number of consecutive PDCCH-subframe(s) for as soon as a DL retransmission is expected by the UE.

DRX Short Cycle Timer: This parameter specifies the number of consecutive subframe(s)the UE shall follow the short DRX cycle after the DRX Inactivity Timer has expired.

HARQ RTT Timer: This parameter specifies the minimum amount of subframe(s) before a DL HARQ retransmission is expected by the UE.

On Duration Timer: Specifies the number of consecutive PDCCH-subframe(s) at the beginning of a DRX Cycle.

RA-RNTI: The Random Access RNTI is used on the PDCCH when Random Access Response messages are transmitted. It unambiguously identifies which time-frequency resource was utilized by the UE to transmit the Random Access preamble.

PDCCH-subframe: For FDD UE operation, this represents any subframe; for TDD, only downlink subframes.

NOTE: A timer is running once it is started, until it is stopped or until it expires.

NOTE: When defining On Duration Timer, DRX Inactivity Timer, DRX Retransmission Timer and Contention Resolution Timer, PDCCH-subframes and subframes including DwPTS are considered as subframes where the timer, if running, shall be updated.

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].

BSR	Buffer Status Report
C-RNTI	Cell RNTI
CQI	Channel Quality Indicator
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
MAC	Medium Access Control
PHR	Power Headroom Report
P-RNTI	Paging RNTI
RA-RNTI	Random Access RNTI
RNTI	Radio Network Temporary Identifier
SI-RNTI	System Information RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbols
TB	Transport Block

4 General

4.1 Introduction

The objective is to describe the MAC architecture and the MAC entity from a functional point of view.

4.2 MAC architecture

The description in this sub clause is a model and does not specify or restrict implementations.

RRC is in control of configuration of MAC.

4.2.1 MAC Entities

E-UTRA defines two MAC entities; one in the UE and one in the E-UTRAN. These MAC entities handle the following transport channels:

- Broadcast Channel (BCH);
- Downlink Shared Channel (DL-SCH);
- Paging Channel (PCH);
- Uplink Shared Channel (UL-SCH);
- Random Access Channel(s) (RACH).

The exact functions performed by the MAC entities are different in the UE from those performed in the E-UTRAN.

4.3 Services

4.3.1 Services provided to upper layers

This clause describes the different services provided by MAC sublayer to upper layers.

- data transfer
- radio resource allocation

4.3.2 Services expected from physical layer

The physical layer provides the following services to MAC:

- data transfer services;
- signalling of HARQ feedback;
- signalling of Scheduling Request;
- measurements (e.g. Channel Quality Indication (CQI)).

The access to the data transfer services is through the use of transport channels. The characteristics of a transport channel are defined by its transport format (or format set), specifying the physical layer processing to be applied to the transport channel in question, such as channel coding and interleaving, and any service-specific rate matching as needed.

4.4 Functions

The following functions are supported by MAC sublayer:

- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;
- demultiplexing of MAC SDUs from one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- scheduling information reporting;
- error correction through HARQ;
- priority handling between UEs by means of dynamic scheduling;
- priority handling between logical channels of one UE;
- Logical Channel prioritisation;
- transport format selection.

NOTE: How the multiplexing relates to the QoS of the multiplexed logical channels is FFS.

The location of the different functions and their relevance for uplink and downlink respectively is illustrated in Table 4.4-1.

Table 4.4-1: MAC function location and link direction association.

MAC function	UE	eNB	Downlink	Uplink
Mapping between logical channels and transport channels	X		X	X
		X	X	X
Multiplexing	X			X
		X	X	
Demultiplexing	X		X	
		X		X
Error correction through HARQ	X		X	X
		X	X	X
Transport Format Selection		X	X	X
Priority handling between UEs		X	X	X
Priority handling between logical channels of one UE		X	X	X
Logical Channel prioritisation	X			X
Scheduling information reporting	X			X

4.5 Channel structure

The MAC sublayer operates on the channels defined below; transport channels are SAPs between MAC and Layer 1, logical channels are SAPs between MAC and RLC.

4.5.1 Transport Channels

The transport channels used by MAC are described in Table 4.5.1-1 below.

Table 4.5.1-1: Transport channels used by MAC

Transport channel name	Acronym	Downlink	Uplink
Broadcast Channel	BCH	X	
Downlink Shared Channel	DL-SCH	X	
Paging Channel	PCH	X	
Uplink Shared Channel	UL-SCH		X
Random Access Channel	RACH		X

4.5.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC.

Each logical channel type is defined by what type of information is transferred.

MAC provides the control and traffic channels listed in Table 4.5.2-1 below. When MAC uses the PDCCH to indicate radio resource allocation, the RNTI that is mapped on the PDCCH depends on the logical channel type:

- C-RNTI, Temporary C-RNTI and Semi-Persistent Scheduling C-RNTI for DCCH and DTCH;
- P-RNTI for PCCH;
- RA-RNTI for Random Access Response on DL-SCH;
- Temporary C-RNTI for CCCH during the random access procedure;
- SI-RNTI for BCCH.

Table 4.5.2-1: Logical channels provided by MAC.

Logical channel name	Acronym	Control channel	Traffic channel
Broadcast Control Channel	BCCH	X	
Paging Control Channel	PCCH	X	
Common Control Channel	CCCH	X	
Dedicated Control Channel	DCCH	X	
Dedicated Traffic Channel	DTCH		X

4.5.3 Mapping of Transport Channels to Logical Channels

The mapping of logical channels on transport channels depends on the multiplexing that is configured by RRC.

4.5.3.1 Uplink mapping

The MAC entity is responsible for mapping logical channels for the uplink onto uplink transport channels. The uplink logical channels can be mapped as described in Figure 4.5.3.1-1 and Table 4.5.3.1-1.

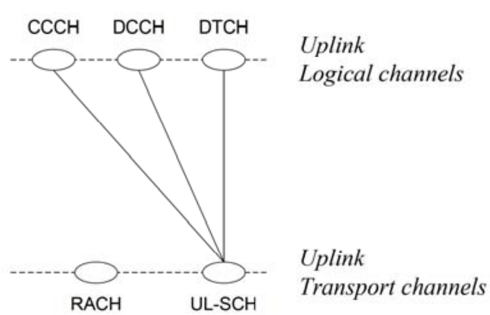

Figure 4.5.3.1-1

Table 4.5.3.1-1: Uplink channel mapping.

Transport channel / Logical channel	UL-SCH	RACH
CCCH	X	
DCCH	X	
DTCH	X	

ZTE/HTC
Exhibit 1017-0023

4.5.3.2 Downlink mapping

The MAC entity is responsible for mapping the downlink logical channels to downlink transport channels. The downlink logical channels can be mapped as described in Figure 4.5.3.2-1 and Table 4.5.3.2-1.

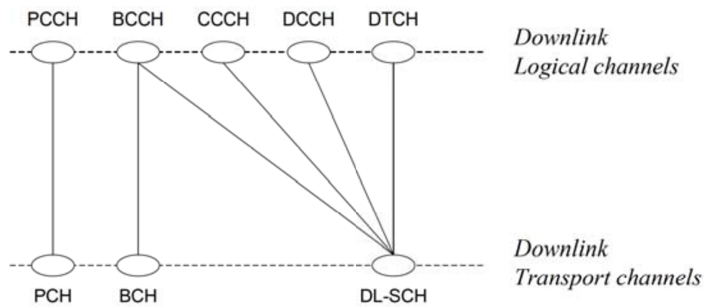

Figure 4.5.3.2-1

Table 4.5.3.2-1: Downlink channel mapping.

Transport channel / Logical channel	BCH	PCH	DL-SCH
BCCH	X		X
PCCH		X	
CCCH			X
DCCH			X
DTCH			X

5 MAC procedures

5.1 Random Access procedure

5.1.1 Random Access Procedure initialization

The Random Access procedure described in this subclause is initiated by a PDCCH order or by the MAC sublayer itself. The PDCCH order or RRC optionally indicate a Random Access Preamble and PRACH resource.

Before the procedure can be initiated, the following information is assumed to be available:

- the available set of PRACH resources for the transmission of the Random Access Preamble and their corresponding RA-RNTIs.
- the groups of Random Access Preambles and the set of available Random Access Preambles in each group.
- the thresholds required for selecting one of the two groups of Random Access Preambles.
- the parameters required to derive the TTI window described in subclause 5.1.4.
- the power-ramping factor POWER_RAMP_STEP.
- the parameter PREAMBLE_TRANS_MAX [integer > 0].
- the initial preamble power PREAMBLE_ INITIAL_RECEIVED_TARGET_POWER.
- the parameter Maximum number of Message3 HARQ transmissions.

[Note that the above parameters may be updated from higher layers before each Random Access procedure is initiated.]

The Random Access procedure shall be performed as follows:

- Flush the [Message3] buffer;
- set the PREAMBLE_TRANSMISSION_COUNTER to 1;
- set the backoff parameter value in the UE to 0 ms;
- proceed to the selection of the Random Access Resource (see subclause 5.1.2).

NOTE: There is only one Random Access procedure ongoing at any point in time. If the UE receives a request for a new Random Access procedure while another is already ongoing, it is up to UE implementation whether to continue with the ongoing procedure or start with the new procedure.

5.1.2 Random Access Resource selection

The Random Access Resource procedure shall be performed as follows:

- If the Random Access Preamble and PRACH resource have been explicitly signalled and the Random Access Preamble expiration time, if configured, has not expired:
  - the UE can directly proceed to the transmission of the Random Access Preamble (see subclause 5.1.3).
- else the Random Access Preamble shall be selected by the UE as follows:
  - If the uplink message containing the C-RNTI MAC control element or the uplink message including the CCCH SDU has not yet been transmitted, the UE shall:
    - depending on the size of the message to be transmitted on the UL or the requested resource blocks [FFS] [the selection also depends on radio conditions], select one of the two groups of Random Access Preambles configured by RRC.
  - else, if the uplink message containing the C-RNTI MAC control element or the uplink message including the CCCH SDU is being retransmitted, the UE shall:
    - select the same group of Random Access Preambles as was used for the preamble transmission attempt corresponding to the first transmission of the uplink message containing the C-RNTI MAC control element or the uplink message including the CCCH SDU.
  - randomly select a Random Access Preamble within the selected group. The random function shall be such that each of the allowed selections can be chosen with equal probability;
  - if more than one PRACH resources are available in the same subframe (TDD), randomly select one. The random function shall be such that each of the allowed selections can be chosen with equal probability;
  - proceed to the transmission of the Random Access Preamble (see subclause 5.1.3).

5.1.3 Random Access Preamble transmission

The random-access procedure shall be performed as follows:

- If PREAMBLE_TRANSMISSION_COUNTER = PREAMBLE_TRANS_MAX + 1:
  - indicate a Random Access problem to upper layers.

[- set the parameter PREAMBLE_RECEIVED_TARGET_POWER to PREAMBLE_INITIAL_RECEIVED_TARGET_POWER + (PREAMBLE_TRANSMISSION_COUNTER-1) * POWER_RAMP_STEP;]

- determine the next available Random Access occasion;
- instruct the physical layer to transmit a preamble using the selected PRACH resource, corresponding RA-RNTI, preamble index and PREAMBLE_RECEIVED_TARGET_POWER.

5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted, the UE shall monitor the PDCCH associated with the RA-RNTI defined below in the TTI window [RA_WINDOW_BEGIN—RA_WINDOW_END] for Random Access Response(s) identified by the RA-RNTI. The RA-RNTI associated with the PRACH resource in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI= t_id+10*f_id

Where t_id is the index of the first subframe of the specified PRACH resource ($0 \le t\_id < 10$), and f_id is the index of the specified PRACH resource within that subframe, in ascending order of frequency domain ($0 \le f\_id < 6$). The UE may stop monitoring for Random Access Response(s) after successful reception of a Random Access Response corresponding to the Random Access Preamble transmission.

- If notification of a reception of the Random Access Response is received from lower layers, the UE shall:
  - if the Random Access Response contains a Backoff Indicator subheader:
    - set the backoff parameter value in the UE as indicated by the BI field of the Backoff Indicator subheader and Table 7.2-1.
  - else, set the backoff parameter value in the UE to 0 ms.
  - if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see subclause 5.1.3), the UE shall:
    - consider this Random Access Response reception successful;
    - process the received Timing Alignment value (see subclause 5.2);
    - process the received UL grant value;
    - if the Random Access Preamble was explicitly signalled (i.e., not selected by MAC):
      - consider the Random Access procedure successfully completed.
    - else, if the Random Access Preamble was selected by UE MAC:
      - set the Temporary C-RNTI to the value received in the Random Access Response message no later than at the time of the first transmission corresponding to the UL grant provided in the Random Access Response message;
      - if this is the first successfully received Random Access Response within this Random Access procedure:
        - if the UE is in RRC_CONNECTED state [except for RLF], indicate to the Multiplexing and assembly entity to include a C-RNTI MAC control element in the subsequent uplink transmission;
        - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity and store it in the [Message3] buffer.

NOTE: When an uplink transmission is required, e.g., for contention resolution, the eNB should not provide a grant smaller than 80 bits in the Random Access Response.

NOTE: If within a Random Access procedure, an uplink grant provided in the Random Access Response for the same group of Random Access Preambles has a different size than the first uplink grant allocated during that Random Access procedure, the UE behavior is not defined.

If no Random Access Response is received within the TTI window [RA_WINDOW_BEGIN—RA_WINDOW_END], or if all received Random Access Responses contain Random Access Preamble identifiers that do not match the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the UE shall:

- if the Random Access procedure was initiated by the MAC sublayer itself; or

- if the Random Access procedure was initiated by a PDCCH order and the PREAMBLE_TRANSMISSION_COUNTER is less than PREAMBLE_TRANS_MAX:
  - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
  - if in this Random Access procedure:
    - the Random Access Preamble was selected by MAC; or
    - the Random Access Preamble and PRACH resource were explicitly signalled and will expire before the next available Random Access occasion:
      - based on the backoff parameter in the UE, compute and apply a backoff value indicating when a new Random Access transmission shall be attempted;
  - proceed to the selection of a Random Access Resource (see subclause 5.1.2).

Editor's note: Whether error conditions are specified is FFS.

5.1.5 Contention Resolution

Contention Resolution is based on C-RNTI on PDCCH and UE Contention Resolution Identity on DL-SCH..

Once the uplink message containing the C-RNTI MAC control element or the uplink message including the CCCH SDU is transmitted, the UE shall:

- start the Contention Resolution Timer;
- monitor the PDCCH until the Contention Resolution Timer expires;
- if notification of a reception of a PDCCH transmission is received from lower layers, the UE shall:
  - if the C-RNTI MAC control element was included in uplink message:
    - if the Random Access procedure was initiated by the MAC sublayer itself and the PDCCH transmission is addressed to the C-RNTI and contains an UL grant; or
    - if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI:
      - consider this Contention Resolution successful;
      - stop the Contention Resolution Timer;
      - discard the Temporary C-RNTI;
      - consider this Random Access procedure successfully completed.
  - else if the uplink message includes the CCCH SDU and the PDCCH transmission is addressed to its Temporary C-RNTI:
    - if the MAC PDU is successfully decoded:
      - stop the Contention Resolution Timer;
      - if the MAC PDU contains a UE Contention Resolution Identity MAC control element; and
      - if the UE Contention Resolution Identity included in the MAC control element matches the CCCH SDU transmitted in the uplink message:
        - consider this Contention Resolution successful and finish the disassembly and demultiplexing of the MAC PDU;
        - set the C-RNTI to the value of the Temporary C-RNTI;
        - consider this Random Access procedure successfully completed.

        - else
            - consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.
        - discard the Temporary C-RNTI.
- if the Contention Resolution Timer expires:
    - consider the Contention Resolution not successful.
- if the Contention Resolution is considered not successful the UE shall:
    - if the Random Access procedure was initiated by the MAC sublayer itself; or
    - if the Random Access procedure was initiated by a PDCCH order and the PREAMBLE_TRANSMISSION_COUNTER is less than PREAMBLE_TRANS_MAX:
        - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
        - based on the backoff parameter in the UE, compute and apply a backoff value indicating when a new Random Access transmission shall be attempted;
        - proceed to the selection of a Random Access Resource (see subclause 5.1.2).
    - discard the Temporary C-RNTI.

5.1.6 Completion of the Random Access procedure

At successful completion of the Random Access procedure, the UE shall:

- if the PREAMBLE_TRANSMISSION_COUNTER is greater than PREAMBLE_TRANS_MAX:
    - indicate recovery from a Random Access problem to upper layers.

5.2 Maintenance of Uplink Time Alignment

The UE has a configurable Time Alignment Timer. The Time Alignment Timer is valid only in the cell for which it was configured and started.

If the Time Alignment Timer has been configured, the UE shall:

- when a Timing Advance MAC control element is received:
    - apply the Timing Advance Command;
    - start the Time Alignment Timer (if not running) or restart the Time Alignment Timer (if already running).
- when a Time Alignment Command is received in a Random Access Response message:
    - if the Random Access Preamble and PRACH resource were explicitly signalled:
        - apply the Time Alignment Command;
        - start the Time Alignment Timer (if not running) or restart the Time Alignment Timer (if already running).
    - else, if the Time Alignment Timer is not running or has expired:
        - apply the Time Alignment Command;
        - start the Time Alignment Timer;
        - when the contention resolution is considered not successful as described in subclause 5.1.5, stop the Time Alignment Timer.
    - else:

- ignore the received Time Alignment Command.

- when the Time Alignment Timer has expired or is not running:
  - prior to any uplink transmission, use the Random Access procedure (see subclause 5.1) in order to obtain uplink Time Alignment.
- when the Time Alignment Timer expires:
  - release all PUCCH resources;
  - release any assigned SRS resources.

5.3 DL-SCH data transfer

Editor's note: Current text applies to, at least, FDD.

5.3.1 DL Assignment reception

Editor's note: A downlink assignment can relate to one or two (MIMO) TBs. It is FFS how this information is presented to MAC.

When the UE has a C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI or RA-RNTI, the UE shall for each TTI during Active Time, for each TTI when a Random Access Response or Contention Resolution is expected and for each TTI for which a DL assignment has been configured:

- if a downlink assignment for this TTI has been received on the PDCCH for the UE's C-RNTI, Temporary C-RNTI or RA-RNTI:
  - indicate a downlink assignment and the associated HARQ information to the HARQ entity for this TTI.
- else, if a downlink assignment for this TTI has been configured:
  - indicate a downlink assignment, for a new transmission, and the associated HARQ information to the HARQ entity for this TTI.

When the UE needs to read BCCH, the UE shall:

- if a downlink assignment for this TTI has been received on the PDCCH for the SI-RNTI;
  - indicate a downlink assignment for the dedicated broadcast HARQ process to the HARQ entity for this TTI.

NOTE: Downlink assignments for both C-RNTI and SI-RNTI can be received in the same TTI.

Editor's note: L1 is configured, as needed, by upper layers or MAC [FFS] to monitor PDCCH for C-RNTI, and by MAC to monitor PDCCH for Temporary C-RNTI and RA-RNTI.

5.3.2 HARQ operation

5.3.2.1 HARQ Entity

There is one HARQ entity at the UE which processes the HARQ process identifiers indicated by the HARQ information associated with TBs received on the DL-SCH and directs the received data to the corresponding HARQ process for reception operations (see subclause 5.3.2.2).

A number of parallel HARQ processes are used in the UE to support the HARQ entity. [The number of HARQ processes is FFS].

If a downlink assignment has been indicated or configured for this TTI, the UE shall:

- allocate the received TB to the HARQ process indicated by the associated HARQ information.

If a downlink assignment has been indicated for the broadcast HARQ process, the UE shall:

- allocate the received TB to the broadcast HARQ process.

NOTE: In case of BCCH a dedicated broadcast HARQ process is used.

5.3.2.2 HARQ process

For each received TB:

- if the NDI, when provided, has been incremented compared to the value of the previous received transmission for this HARQ process; or
- if the HARQ process is equal to the broadcast process and the physical layer indicates a new transmission; or
- if this is the very first received transmission for this HARQ process:
  - a new transmission is indicated for this HARQ process.
- else, a retransmission is indicated for this HARQ process.

The UE then shall:

- if a new transmission is indicated for this HARQ process:
  - replace the data currently in the soft buffer for this HARQ process with the received data.
- if a retransmission is indicated for this HARQ process:
  - if the data has not yet been successfully decoded:
    - combine the received data with the data currently in the soft buffer for this HARQ process.
  - if the TB size is different from the last valid TB size signalled for this HARQ process:
    - the UE may replace the data currently in the soft buffer for this HARQ process with the received data.
- attempt to decode the data in the soft buffer;
- if the data in the soft buffer was successfully decoded:
  - if the HARQ process is equal to the broadcast process, deliver the decoded MAC PDU to RRC.
  - else, deliver the decoded MAC PDU to the disassembly and demultiplexing entity.
  - generate a positive acknowledgement (ACK) of the data in this HARQ process.
- else:
  - generate a negative acknowledgement (NACK) of the data in this HARQ process.
- if the HARQ process is associated with a transmission indicated with an RA-RNTI; or
- if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and a UE Contention Resolution Identity match is not indicated; or
- if the HARQ process is equal to the broadcast process:
  - do not indicate the generated positive or negative acknowledgement to the physical layer.
- else:
  - indicate the generated positive or negative acknowledgement to the physical layer.

5.3.3 Disassembly and demultiplexing

Editor's note: This section describes the disassembly and demultiplexing of MAC PDUs into MAC SDUs.

5.4 UL-SCH data transfer

Editor's note: Current text applies to, at least, FDD.

5.4.1 UL Grant reception

When the UE has a C-RNTI, Semi-Persistent Scheduling C-RNTI, or Temporary C-RNTI, the UE shall for each TTI:

- if an uplink grant for this TTI has been received on the PDCCH for the UE's C-RNTI or Temporary C-RNTI; or
- if an uplink grant for this TTI has been received in a Random Access Response:
  - indicate a valid uplink grant and the associated HARQ information to the HARQ entity for this TTI.
- else, if an uplink grant for this TTI has been configured:
  - indicate an uplink grant, valid for new transmission, and the associated HARQ information to the HARQ entity for this TTI.

NOTE: The period of configured uplink grants is expressed in TTIs.

NOTE: If the UE receives both a grant for its RA-RNTI and a grant for its C-RNTI, the UE may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI.

5.4.2 HARQ operation

5.4.2.1 HARQ entity

There is one HARQ entity at the UE. A number of parallel HARQ processes are used in the UE to support the HARQ entity, allowing transmissions to take place continuously while waiting for the feedback on the successful or unsuccessful reception of previous transmissions.

At a given TTI, if an uplink grant is indicated for the TTI, the HARQ entity identifies the HARQ process for which a transmission should take place. It also routes the receiver feedback (ACK/NACK information), MCS and resource, relayed by the physical layer, to the appropriate HARQ process.

If TTI bundling is configured, the parameter TTI_BUNDLE_SIZE provides the number of TTIs of a TTI bundle. If a transmission is indicated for the TTI, the HARQ entity identifies the HARQ process for which a transmission should take place. The next TTI_BUNDLE_SIZE uplink TTIs are subsequently used for transmissions for the identified HARQ process. HARQ retransmissions within a bundle shall be performed without waiting for feedback from previous transmissions according to TTI_BUNDLE_SIZE. The UE expects feedback only for the last transmission of a bundle.

For transmission of an uplink message containing the C-RNTI MAC control element or an uplink message including a CCCH SDU during Random Access (see section 5.1.5) TTI bundling does not apply.

The number of HARQ processes is equal to [X] [FFS]. Each process is associated with a number from 0 to [X-1].

At the given TTI, the HARQ entity shall:

- if an uplink grant indicating that the NDI has been incremented compared to the value in the previous transmission of this HARQ process is indicated for this TTI or if this is the very first transmission for this HARQ process (i.e. a new transmission takes place for this HARQ process):
  - if there is an ongoing Random Access procedure and there is a MAC PDU in the [Message3] buffer:
    - obtain the MAC PDU to transmit from the [Message3] buffer.
  - else, if the "uplink prioritisation" entity indicates the need for a new transmission:
    - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
    - instruct the HARQ process corresponding to this TTI to trigger a new transmission using the identified parameters.

  - else:
    - flush the HARQ buffer.
- else, if an uplink grant, indicating that the NDI is identical to the value in the previous transmission of this HARQ process (i.e. a retransmission takes place for this HARQ process), is indicated for this TTI:
  - instruct the HARQ process to generate an adaptive retransmission.
- else, if the HARQ buffer of the HARQ process corresponding to this TTI is not empty:
  - instruct the HARQ process to generate a non-adaptive retransmission.

NOTE: A retransmission triggered by the HARQ entity should be cancelled by the corresponding HARQ process if it collides with a measurement gap or if a non-adaptive retransmission is not allowed.

5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

Each HARQ process shall maintain a state variable CURRENT_TX_NB, which indicates the number of transmissions that have taken place for the MAC PDU currently in the buffer. When the HARQ process is established, CURRENT_TX_NB shall be initialized to 0.

The sequence of redundancy versions is defined to be 0, 2, 3, 1. The variable CURRENT_IRV provides a pointer to a redundancy version in the defined set. This variable is up-dated modulo 4.

New transmissions and adaptive retransmisions are performed on the resource and with the MCS indicated on PDCCH, while a non-adaptive retransmission is performed on the same resource and with the same MCS as was used for the last made transmission attempt,

The UE is configured with a Maximum number of HARQ transmissions and a Maximum number of Message3 HARQ transmissions by RRC. For transmissions on all HARQ processes and all logical channels except for transmission of a MAC PDU stored in the [Message3] buffer, maximum number of transmissions shall be set to Maximum number of HARQ transmissions. For transmission of a MAC PDU stored in the [Message3] buffer, maximum number of transmissions shall be set to Maximum number of Message3 HARQ transmissions.

If the HARQ entity requests a new transmission, the HARQ process shall:

- set CURRENT_TX_NB to 0;
- set CURRENT_IRV to 0;
- store the MAC PDU in the associated HARQ buffer;
- generate a transmission as described below.

If the HARQ entity requests a retransmission, the HARQ process shall:

- increment CURRENT_TX_NB by 1;
- if there is no measurement gap at the time of the retransmission:
  - for an adaptive retransmission:
    - set CURRENT_IRV to the value corresponding to the redundancy version indicated on PDCCH;
    - generate a transmission as described below.
  - for a non-adaptive retransmission:
    - if the last feedback for this HARQ process is a HARQ NACK:
      - generate a transmission as described below.

NOTE: When receiving a HARQ ACK alone, the UE keeps the data in the HARQ buffer.

To generate a transmission, the HARQ process shall:

- instruct the physical layer to generate a transmission with the redundancy version corresponding to the CURRENT_IRV value and the transmission timing;
- increment CURRENT_IRV by 1;
- if there is a measurement gap at the time of the feedback for this transmission, consider the feedback coinciding with the measurement gap to be a HARQ ACK.

The HARQ process shall:

- if CURRENT_TX_NB = maximum number of transmissions:
  - flush the HARQ buffer;
  - if the transmission corresponds to a transmission of CCCH; and
    - if the last feedback received (i.e., the feedback received for the last transmission of this process) is a HARQ NACK:
      - notify RRC that the transmission of the corresponding MAC SDU failed.

The HARQ process may:

- if CURRENT_TX_NB = maximum number of transmissions configured; and
  - if the last feedback received (i.e., the feedback received for the last transmission of this process) is a HARQ NACK:
    - notify the relevant ARQ entities in the upper layer that the transmission of the corresponding RLC PDUs failed.

5.4.3 Multiplexing and assembly

Editor's note: This subclause describes the procedure for creation of MAC SDUs including multiplexing of MAC SDUs and creating the MAC header.

5.4.3.1 Logical channel prioritization

The Logical Channel Prioritization procedure is applied when a new transmission is performed.

RRC can control the scheduling of uplink data by giving each logical channel a priority where increasing priority values indicate lower priority levels. In addition, each logical channel is given a Prioritized Bit Rate (PBR).

The UE shall perform the following Logical Channel Prioritization procedure when a new transmission is performed:

- The UE shall allocate resources to the logical channels in the following sequence:
  - all the logical channels are allocated resources in a decreasing priority order up to a value such that on average, the served data rate for radio bearers that have data for transmission equals the configured PBR for the radio bearer. If the PBR of a radio bearer is set to "infinity", the UE shall allocate resources for all the data that is available for transmission on the radio bearer before meeting the PBR of the lower priority radio bearer(s);
  - if any resources remain, all the logical channels are served in a strict decreasing priority order until either the data for that logical channel or the UL grant is exhausted, whichever comes first.
- The UE shall also follow the rules below during the scheduling procedures above:
  - the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources;
  - if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant as much as possible;

- the UE shall serve as much data as it can to fill the grant in general. However, if the remaining resources require the UE to segment an RLC SDU with size smaller than x bytes or smaller than the L2 header size (FFS), the UE may use padding to fill the remaining resources instead of segmenting the RLC SDU and sending the segment.

Logical channels configured with the same priority shall be served equally the by UE.

MAC control elements for BSR, with exception of Padding BSR, have higher priority than U-plane Logical Channels.

At serving cell change, the first UL-DCCH MAC SDU to be transmitted in the new cell has higher priority than MAC control elements for BSR.

5.4.3.2 Multiplexing of MAC SDUs

Editor's note: This subclause describes the construction of MAC PDUs from MAC SDUs as prioritised and selected by the Logical channel prioritisation entity.

5.4.4 Scheduling Request

The Scheduling Request (SR) is for requesting UL-SCH resources.

If an SR has been triggered, the UE shall for each TTI, until UL-SCH resources are granted for a new transmission:

- if no UL-SCH resources are available in this TTI:
  - if a PUCCH is configured for the UE to send an SR in this TTI, instruct the physical layer to signal the SR on PUCCH;
  - if no PUCCH for SR is configured for the UE in any TTI, initiate a Random Access procedure (see subclause 5.1).

NOTE: A triggered SR is considered pending and is repeated until UL-SCH resources are granted for a new transmission.

5.4.5 Buffer Status Reporting

The Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of data in the UL buffers of the UE.

A Buffer Status Report (BSR) shall be triggered if any of the following events occur:

- UL data arrives in the UE transmission buffer and the data belongs to a logical channel with higher priority than those for which data already existed in the UE transmission buffer, in which case the BSR is referred below to as "Regular BSR";
- UL resources are allocated and number of padding bits is larger than the size of the Buffer Status Report MAC control element, in which case the BSR is referred below to as "Padding BSR";
- a serving cell change occurs, in which case the BSR is referred below to as "Regular BSR";
- the PERIODIC BSR TIMER expires, in which case the BSR is referred below to as "Periodic BSR".

For Regular and Periodic BSR:

- if only one LCG has buffered data in the TTI where the BSR is transmitted: report short BSR;
- else if more than one LCG has buffered data in the TTI where the BSR is transmitted: report long BSR.

For padding BSR:

- if the number of padding bits is equal to or larger than the size of the Short BSR but smaller than the size of the Long BSR, report Short BSR of the LCG with the highest priority logical channel with buffered data;
- else if the number of padding bits is equal to or larger than the size of the Long BSR, report Long BSR.

If the Buffer Status reporting procedure determines that a BSR has been triggered since the last transmission of a BSR:

- if the UE has UL resources allocated for new transmission for this TTI:
  - instruct the Multiplexing and Assembly procedure to generate a BSR MAC control element;
  - restart the PERIODIC BSR TIMER.
- else if a Regular BSR has been triggered since the last transmission of a BSR:
  - a Scheduling Request shall be triggered.

NOTE: Even if multiple events occur by the time a BSR can be transmitted, only one BSR will be included in the MAC PDU.

A pending BSR shall be cancelled in case the UL grant can accommodate all pending data but is not sufficient to accommodate the BSR MAC control element in addition.

5.4.6 Power Headroom Reporting

The Power Headroom reporting procedure is used to provide the serving eNB with information about the difference between the UE TX power and the maximum UE TX power (for the positive values of the power headroom) and about the difference between the maximum UE TX power and the calculated UE TX power, according to the UL power control formula, when it exceeds the maximum UE TX power (for the negative values of the power headroom).

A Power Headroom Report (PHR) shall be triggered if any of the following events occur:

- the PROHIBIT_PHR_TIMER expires or has expired and the path loss has changed more than *DL_PathlossChange* dB since the last power headroom report;
- the PERIODIC PHR TIMER expires, in which case the PHR is referred below to as "Periodic PHR".

If the Power Headroom reporting procedure determines that a PHR has been triggered since the last transmission of a PHR:

- if the UE has UL resources allocated for new transmission for this TTI:
  - obtain the value of the power headroom from the physical layer;
  - instruct the Multiplexing and Assembly procedure to generate a PHR MAC control element based on the value reported by the physical layer;
  - if the PHR is a "Periodic PHR", restart the PERIODIC PHR TIMER;
  - restart the PROHIBIT_PHR_TIMER.

NOTE: Even if multiple events occur by the time a PHR can be transmitted, only one PHR is included in the MAC PDU.

Editor's note: When periodic Power Headroom Reporting is configured, the first report should be included immediately when the UE has a grant for a new transmission.

5.5 PCH reception

When in RRC_IDLE, the UE shall at its paging occasions:

- if a PCH assignment has been received on the PDCCH for the P-RNTI:
  - attempt to decode the TB on the PCH as indicated by the PDCCH information.
- if a TB on the PCH has been successfully decoded:
  - deliver the decoded MAC PDU to higher layers.

5.6 BCH reception

When the UE needs to receive BCH, the UE shall:

- receive and attempt to decode the BCH;
- if a TB on the BCH has been successfully decoded:
  - deliver the decoded MAC PDU to higher layers.

5.7 Discontinuous Reception (DRX)

The UE may be configured by RRC with a DRX functionality that allows it to not continuously monitor the PDCCH. The DRX functionality consists of a Long DRX cycle, a DRX Inactivity Timer, a DRX Retransmission Timer and optionally a Short DRX Cycle and a DRX Short Cycle Timer, all defined in subclause 3.1.

When a DRX cycle is configured, the Active Time includes the time while:

- the On Duration Timer or the DRX Inactivity Timer or a DRX Retransmission Timer or the Contention Resolution Timer is running; or
- a Scheduling Request is pending (as described in subclause 5.4.4); or
- an uplink grant for a retransmission can occur; or
- a PDCCH indicating a new transmission addressed to the C-RNTI or Temporary C-RNTI of the UE has not been received after successful reception of a Random Access Response (as described in subclause 5.1.4).

When a DRX cycle is configured, the UE shall for each subframe:

- start the On Duration Timer when [(SFN * 10) + subframe number] modulo (current DRX Cycle) = DRX Start Offset;
- if a HARQ RTT Timer expires in this subframe and the data in the soft buffer of the corresponding HARQ process was not successfully decoded:
  - start the DRX Retransmission Timer for the corresponding HARQ process.
- if a DRX Command MAC control element is received:
  - stop the On Duration Timer;
  - stop the DRX Inactivity Timer.
- if the DRX Inactivity Timer expires or a DRX Command MAC control element is received in this subframe:
  - if the short DRX cycle is configured:
    - start the DRX Short Cycle Timer and use the Short DRX Cycle.
  - else:
    - use the Long DRX cycle.
- if the DRX Short Cycle Timer expires in this subframe:
  - use the long DRX cycle.
- during the Active Time, for a PDCCH-subframe except if the subframe is required for uplink transmission for half-duplex FDD UE operation:
  - monitor the PDCCH;
  - if the PDCCH indicates a DL transmission:
    - start the HARQ RTT Timer for the corresponding HARQ process;

        - stop the DRX Retransmission Timer for the corresponding HARQ process.
    - if the PDCCH indicates a new transmission (DL or UL):
        - start or restart the DRX Inactivity Timer.
    - if a DL assignment has been configured for this subframe and no PDCCH indicating a DL transmission was successfully decoded:
        - start the HARQ RTT Timer for the corresponding HARQ process.
- when not in active time, CQI and SRS shall not be reported.

Regardless of whether the UE is monitoring PDCCH or not the UE receives and transmits HARQ feedback when such is expected.

5.8 MAC reconfiguration

Editor's note: This subclause describes the procedure for handling reconfiguration of MAC parameters during normal operation.

5.9 MAC Reset

Editor's note: This subclause describes the procedure for resetting MAC [FFS]; e.g. at handover.

5.X Handling of unknown, unforeseen and erroneous protocol data

Editor's note: This subclause describes how MAC treats and acts on unexpected data.

Editor's note: The subclause on "Handling of unknown, unforeseen and erroneous protocol data" should be the last subsection of Section "MAC procedures".

6 Protocol Data Units, formats and parameters

6.1 Protocol Data Units

6.1.1 General

A MAC PDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. In the figures in subclause 6.1, bit strings are represented by tables in which the most significant bit is the leftmost bit of the first line of the table, the least significant bit is the rightmost bit on the last line of the table, and more generally the bit string is to be read from left to right and then in the reading order of the lines. The bit order of each parameter field within a MAC PDU is represented with the first and most significant bit in the leftmost bit and the last and least significant bit in the rightmost bit.

MAC SDUs are bit strings that are byte aligned (i.e. multiple of 8 bits) in length. An SDU is included into a MAC PDU from the first bit onward.

6.1.2 MAC PDU (DL-SCH and UL-SCH)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC control elements, and optionally padding; as described in Figure 6.1.2-3.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU sub-headers; each subheader corresponding to either a MAC SDU, a MAC control element or padding.

A MAC PDU subheader consists of the six header fields R/R/E/LCID/F/L but for the last subheader in the MAC PDU and for fixed sized MAC control elements. The last subheader in the MAC PDU and sub-headers for fixed sized MAC control elements consist solely of the four header fields R/R/E/LCID. It follows that a MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

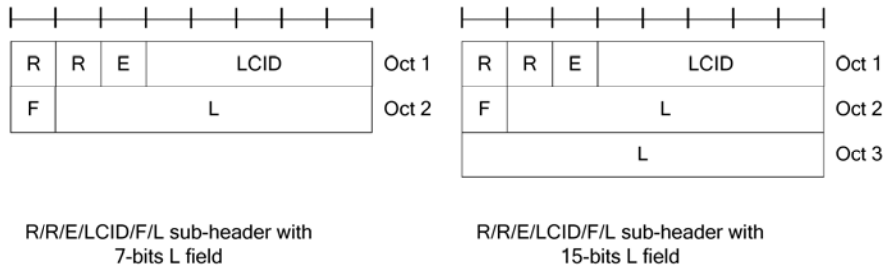

Figure 6.1.2-1: R/R/E/LCID/F/L MAC subheader

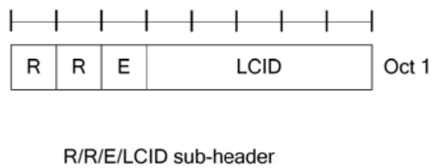

Figure 6.1.2-2: R/R/E/LCID MAC subheader

MAC PDU sub-headers have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements, except Padding BSR, are always placed before any MAC SDU. Padding BSR occurs at the end of the MAC PDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU.

When single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU, one or two MAC PDU sub-headers corresponding to padding are inserted before the first MAC PDU subheader corresponding to a MAC SDU; or if such subheader is not present, before the last MAC PDU subheader corresponding to a MAC control element.

A maximum of one MAC PDU can be transmitted per TB per UE. [Depending on the physical layer category], one or two TBs can be transmitted per TTI per UE.

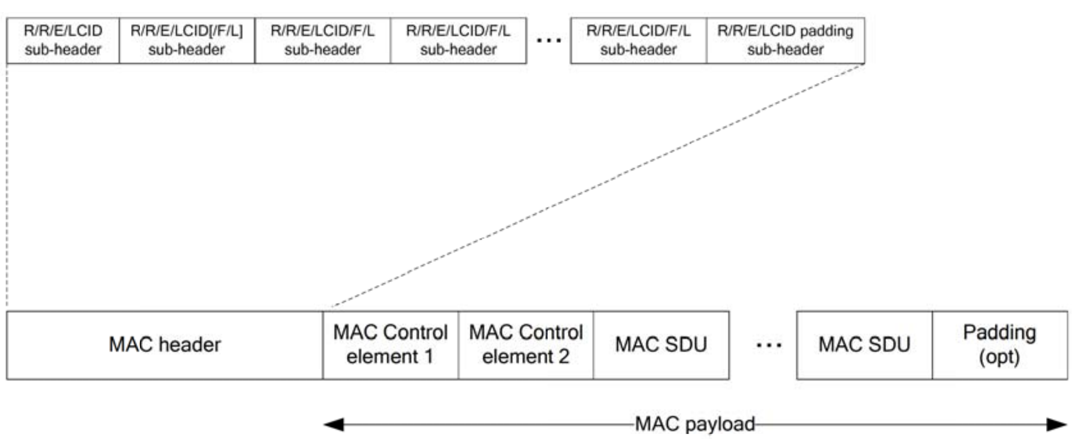

Figure 6.1.2-3: MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding

ZTE/HTC
Exhibit 1017-0038

Editor's note: It is FFS whether this MAC PDU applies only to DL/UL SCH or also to other transport channels

6.1.3 MAC Control Elements

6.1.3.1 Buffer Status Report MAC Control Elements

Buffer Status Report (BSR) MAC control elements consist of either:

- Short BSR format: one LCG ID field and one corresponding BS field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #1 through #4 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1.-1.

The fields LCG ID and BS are defined as follow:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) which buffer status is being reported. The length of the field is 2 bits;
- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a logical channel group after the MAC PDU has been built. The amount of data is indicated in number of bytes. It shall include all data that is available for transmission in the RLC layer and in the PDCP layer; the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively. The size of the RLC and MAC headers are not considered in the buffer size computation. The length of this field is 6 bits. The values taken by the Buffer Size field are shown in [Table 6.1.2.1-1].

LCG ID	Buffer Size	Oct 1

Figure 6.1.3.1-1: Short Buffer Status MAC control element

Buffer Size #1	Buffer Size #2	Oct 1
Buffer Size #2	Buffer Size #3	Oct 2
Buffer Size #3	Buffer Size #4	Oct 3

Figure 6.1.3.1-2: Long Buffer Status MAC control element

6.1.3.2 C-RNTI MAC Control Element

The C-RNTI MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-2.

It has a fixed size and consists of a single field defined as follows (figure 6.1.3.2-1):

- C-RNTI: This field contains the C-RNTI of the UE. The length of the field is 16 bits.

C-RNTI	Oct 1
C-RNTI	Oct 2

Figure 6.1.3.2-1: C-RNTI MAC control element

6.1.3.3 DRX Command MAC Control Element

The DRX Command MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1.

It has a fixed size of zero bits.

6.1.3.4 UE Contention Resolution Identity MAC Control Element

The UE Contention Resolution Identity MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-1. This control element has a fixed 48-bit size and consists of a single field defined as follows (figure 6.1.3.4-1)

- UE Contention Resolution Identity: This field contains the uplink CCCH SDU transmitted by MAC.

UE Contention Resolution Identity	Oct 1
UE Contention Resolution Identity	Oct 2
UE Contention Resolution Identity	Oct 3
UE Contention Resolution Identity	Oct 4
UE Contention Resolution Identity	Oct 5
UE Contention Resolution Identity	Oct 6

Figure 6.1.3.4-1: UE Contention Resolution Identity MAC control element

6.1.3.5 Timing Advance MAC Control Element

The Timing Advance MAC control element is identified by MAC PDU subheader with LCID as specified in table 6.2.1-1.

It has a fixed size and consists of a single field defined as follows (figure 6.1.3.4-1):

- Timing Advance: This field indicates the amount of timing adjustment in 0.5 µs that UE has to apply. The length of the field is [8] bits.

Timing Advance	Oct 1

Figure 6.1.3.5-1: Timing Advance MAC control element

Editor's note: Whether all 8 bits are needed and what the value range is are FFS.

6.1.3.6 Power Headroom MAC Control Element

The Power Headroom MAC control element is identified by a MAC PDU subheader with LCID as specified in table 6.2.1-1. It has a fixed size and consists of a single octet defined as follows (figure 6.1.3.6-1):

- R: reserved bits;

- Power Headroom: this field indicates the power headroom. The length of the field is 6 bits.

R	R	Power Headroom	Oct 1

Figure 6.1.3.5-1: Power Headroom MAC control element

6.1.4 MAC PDU (transparent MAC)

A MAC PDU consists solely of a MAC Service Data Unit (MAC SDU) whose size is aligned to a TB; as described in figure 6.1.4-1.

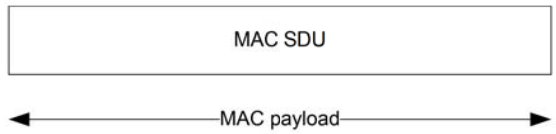

Figure 6.1.4-1: MAC PDU (transparent MAC)

6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of a MAC header and one or more MAC Random Access Responses (MAC RAR) as described in figure 6.1.5-4.

The MAC header is of variable size.

A MAC PDU header consists of one or more MAC PDU sub-headers; each subheader corresponding to a MAC RAR except for the Backoff Indicator sub-header.

A MAC PDU subheader consists of the three header fields E/T/RAPID (as described in figure 6.1.5-1) but for the Backoff Indicator subheader which consists of the five header field E/T/R/R/BI (as described in figure 6.1.5-2).

A MAC RAR consists of the three fields TA/UL Grant/Temporary C-RNTI (as described in figure 6.1.5-3)

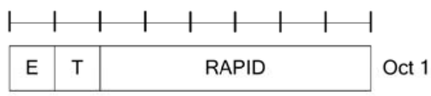

Figure 6.1.5-1: E/T/RAPID MAC sub-header

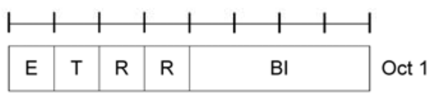

Figure 6.1.5-2: E/T/R/R/BI MAC sub-header

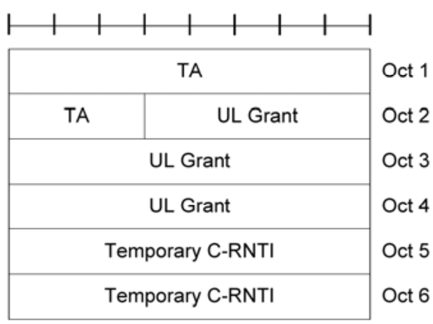

Figure 6.1.5-3: MAC RAR

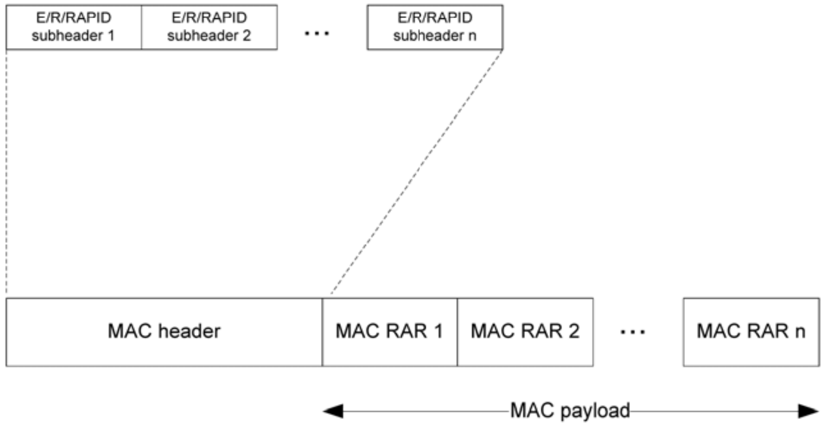

Figure 6.1.5-4: MAC PDU consisting of a MAC header and MAC RARs

6.2 Formats and parameters

6.2.1 MAC header for DL-SCH and UL-SCH

The MAC header is of variable size and consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC control element or padding as described in tables 6.2.1-1 and 6.2.1-2 for the DL and UL-SCH respectively. There is one LCID field for each MAC SDU, MAC control element or padding included in the MAC PDU. The LCID field size is 5 bits;
- L: The Length field indicates the length of the corresponding MAC SDU or MAC control element in bytes. There is one L field per MAC PDU subheader except for the last subheader and sub-headers corresponding to fixed-sized MAC control elements. The size of the L field is indicated by the F field;
- F: The Format field indicates the size of the Length field as indicated in table 6.2.1-3. There is one F field per MAC PDU subheader except for the last subheader and sub-headers corresponding to fixed-sized MAC control elements. The size of the F field is 1 bit. If the size of the MAC SDU or MAC control element is less than 128 bytes, the UE shall set the value of the F field to 0, otherwise the UE shall set it to 1;
- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least R/R/E/LCID fields. The E field is set to "0" to indicate that either a MAC SDU, a MAC control element or padding starts at the next byte;
- R: Reserved bits.

The MAC header and sub-headers are octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

Index	LCID values
00000	CCCH
00001-xxxxx	Identity of the logical channel
xxxxx-11011	Reserved
11100	UE Contention Resolution Identity
11101	Timing Advance
11110	DRX Command
11111	Padding

Table 6.2.1-2 Values of LCID for UL-SCH

Index	LCID values
00000	CCCH
00001-yyyyy	Identity of the logical channel
yyyyy-11010	Reserved
11011	Power Headroom Report
11100	C-RNTI
11101	Short Buffer Status Report
11110	Long Buffer Status Report
11111	Padding

Table 6.2.1-3 Values of F field:

Index	Size of Length field (in bits)
0	7
1	15

Editor's note: It is FFS whether this MAC header applies only to DL/UL SCH or also to other transport channels.

Editor's note: xxxxx and yyyyy are FFS

6.2.2 MAC header for Random Access Response

The MAC header is of variable size and consists of the following fields:

- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least E/T/RAPID or E/T/R/R/BI fields. The E field is set to "0" to indicate that a MAC RAR starts at the next byte;
- T: The Type field is a flag indicating whether the MAC subheader contains a Random Access ID or a Backoff Indicator. The T field is set to "0" to indicate the presence of a Backoff Indicator field in the subheader (BI). The T field is set to "1" to indicate the presence of a Random Access Preamble ID field in the subheader (RAPID);
- R: Reserved bit;
- BI: The Backoff Indicator field identifies the overload condition in the cell. The size of the BI field is 4 bits;
- RAPID: The Random Access Preamble IDentitfier field identifies the transmitted Random Access Preamble (see subclause 5.1.3). The size of the RAPID field is 6 bits.

The MAC header and sub-headers are octet aligned.

6.2.3 MAC payload for Random Access Response

The MAC RAR is of [fixed] size and consists of the following fields:

- TA: The Timing Advance field indicates the required adjustment to the uplink transmission timing to be used for timing synchronisation (see subclause 4.2.4 of [2]). The size of the TA field is [11] bits;
- UL Grant: The UpLink Grant field indicates the resources to be used on the uplink. The size of the UL Grant field is [21] bits;
- Temporary C-RNTI: The Temporary C-RNTI field indicates the temporary identity that is used by the UE during Random Access. The size of the Temporary C-RNTI field is 16 bits.

The MAC RAR is octet aligned.

Editor's note: The size of the TA and UL Grant field is FFS

7 Variables and constants

Editor's note: This subclause defines the variables and constants used by MAC.

7.1 RNTI values

RNTI values are presented in Table 7.1-1.

Table 7.1-1: RNTI values.

Value (hexa-decimal)		RNTI
FDD	TDD	
0000-0009	0000-003B	RA-RNTI
000A-FFF2	003C-FFF2	C-RNTI, Semi-Persistent Scheduling C-RNTI and Temporary C-RNTI
FFF3-FFFC		Reserved for future use
FFFE		P-RNTI
FFFF		SI-RNTI

7.2 Backoff Parameter values

Backoff Parameter values are presented in Table 7.2-1.

Table 7.2-1: Backoff Parameter values.

Index	Backoff Parameter value (ms)
0	0
1	10
2	20
3	30
4	40
5	60
6	80
7	120
8	160
9	240
10	320
11	480
12	960

Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2007-06	RAN2#58 bis	R2-072710			MAC Protocol Specification Baseline	-	
2007-06	RAN2#58 bis	R2-072912			Text Proposal for UL HARQ (Tdoc R2-072708) Text Proposal for DL HARQ (Tdoc R2-072707) Text Proposal for RACH procedure (Tdoc R2-072640) Text Proposal for Logical Channel prioritization (Tdoc R2-072643)		0.1.0
2007-06	RAN2#58 bis	R2-072994			Basic MAC PDU structure (Tdoc R2-072983) with updates Agreements on time-frequency resource configuration (Tdoc R2-072993) Agreement on RA-RNTI association (Tdoc R2-072993) Clarification on RA Response reception (Tdoc R2-072993)	0.1.0	0.1.1
2007-08	RAN2#59	R2-073715			Removed reference to non-existing table (Tdoc R2-073473) Incorrect mapping of logical to transport channel (Tdoc R2-073473) Un-necessary error checking in HARQ process procedure (Tdoc R2-073473) Removal of reference to timing relation for HARQ feedback (Tdoc R2-073473) Correction of Internal variable name (Tdoc R2-073473) Correction of procedure in case of successful HARQ reception (Tdoc R2-073473)	0.1.1	0.2.0
2007-09	RAN2#59	R2-073885			Text proposal for Random Access procedure Text proposal on HARQ clarification for TDD Text proposal on HARQ for grants	0.2.0	0.2.1
2007-09	RAN#37	RP-070688			Clean version for information	0.2.1	1.0.0
2007-10	RAN2#59 bis	R2-074530			Editorial update with Editor's notes (Tdoc R2-074211).	1.0.0	1.1.0
2007-11	RAN2#60	R2-075093			Agreements on MAC PDU format (R2-074536) Corrections on Random Access Procedure (R2-074536)	1.1.0	1.1.1
2007-11	RAN2#60	R2-075243			Endorsement of v1.1.1 Removal of FFS on DL CCCH existence	1.1.1	1.2.0
2007-11	RAN2#60	R2-075488			Agreement on identity used Random Access Response (R2-075038) Agreement on Local Nack1 (R2-074949) PUCCH Resource handling (R2-075432) UL HARQ agreements (R2-075432) Agreements on semi-persistent scheduling (R2-075432, 36.300) Agreements on BSR/SR triggers (R2-075432) Agreements on BSR contents (R2-075432) Agreements on Timing Advance principles (36.300) Agreements on DRX control (36.300) Handling of P-BCH, D-BCH, PCH (R2-075246)	1.2.0	1.3.0
2007-11	RAN #38	RP-070917			Clean version, presented at TSG RAN-38 for approval	1.3.0	2.0.0
2007-12	RAN #38	-			Approved at TSG RAN-38 and placed under change control	2.0.0	8.0.0
2008-03	RAN #39	RP-080162	0001	2	CR to 36.321 with E-UTRA MAC protocol specification update	8.0.0	8.1.0
2008-05	RAN #40	RP-080410	0002	1	36.321 CR covering agreements of RAN2 #61bis and RAN2#62	8.1.0	8.2.0

EXHIBIT 3

3GPP Specification detail

Go to spec numbering scheme page
Back to series index

3GPP TS 36.300 (click spec number to see fileserver directory for this spec)

Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2

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TSG / WG responsible: R2 (click TSG/WG to see its home page)
Work item which gave rise to this spec: LTE-L23 (click WI code to see Work Item details in the Work Plan)
Work items which may have impacted this spec: **click here**
Rapporteur: **SEBIRE, Benoist**
Specification required for: E-UTRAN-based systems
In the table below ...
... click meeting number for meeting details;
... click spec version number to download that version;
... click SDO publication reference to download SDO transposed document.

Release	Freeze meeting	Freeze date	::	remarks	SDO publications
Rel-13	SP-70	2015-12-11	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-70	13.2.0	2016-01-13		RTS/TSGR-0236300vd20
	RP-69	13.1.0	2015-09-24		-
	RP-68	13.0.0	2015-07-08		-
Rel-12	SP-65	2014-09-17	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-70	12.8.0	2016-01-04		RTS/TSGR-0236300vc80
	RP-69	12.7.0	2015-09-24		RTS/TSGR-0236300vc70
	RP-68	12.6.0	2015-07-08		RTS/TSGR-0236300vc60
	RP-67	12.5.0	2015-03-25		RTS/TSGR-0236300vc50
	RP-66	12.4.0	2015-01-07		RTS/TSGR-0236300vc40
	RP-65	12.3.0	2014-09-23		RTS/TSGR-0236300vc30
	RP-64	12.2.0	2014-07-04		-
	RP-63	12.1.0	2014-03-19		-
	RP-62	12.0.0	2014-01-10		-
Rel-11	SP-57	2012-09-12	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-70	11.14.0	2016-01-04		RTS/TSGR-0236300vbe0

	RP-67	11.13.0	2015-03-23		RTS/TSGR-0236300vbd0
	RP-66	11.12.0	2015-01-05		RTS/TSGR-0236300vbc0
	RP-65	11.11.0	2014-09-23		RTS/TSGR-0236300vbb0
	RP-64	11.10.0	2014-07-02		RTS/TSGR-0236300vba0
	RP-63	11.9.0	2014-03-19		RTS/TSGR-0236300vb90
	RP-62	11.8.0	2014-01-07		RTS/TSGR-0236300vb80
	RP-61	11.7.0	2013-09-19		RTS/TSGR-0236300vb70
	RP-60	11.6.0	2013-07-08		RTS/TSGR-0236300vb60
	RP-59	11.5.0	2013-03-18		RTS/TSGR-0236300vb50
	RP-58	11.4.0	2013-01-03		RTS/TSGR-0236300vb40
	RP-57	11.3.0	2012-09-26		RTS/TSGR-0236300vb30
	RP-56	11.2.0	2012-07-02		-
	RP-55	11.1.0	2012-03-14		-
	RP-54	11.0.0	2011-12-22		-
Rel-10	SP-51	2011-03-23	::	. .	ETSI
	event	version	available	remarks	click ref to download
	RP-66	10.12.0	2015-01-05		RTS/TSGR-0236300vac0
	RP-61	10.11.0	2013-09-19		RTS/TSGR-0236300vab0
	RP-60	10.10.0	2013-07-03		RTS/TSGR-0236300vaa0
	RP-58	10.9.0	2013-01-08		RTS/TSGR-0236300va90
	RP-56	10.8.0	2012-07-02		RTS/TSGR-0236300va80
	RP-55	10.7.0	2012-03-14		RTS/TSGR-0236300va70
	RP-54	10.6.0	2011-12-22		RTS/TSGR-0236300va60
	RP-53	10.5.0	2011-10-03		RTS/TSGR-0236300va50
	RP-52	10.4.0	2011-06-24		RTS/TSGR-0236300va40
	RP-51	10.3.0	2011-04-05		RTS/TSGR-0236300va30
	RP-50	10.2.0	2010-12-21		RTS/TSGR-0236300va20
	RP-49	10.1.0	2010-10-04		-
	RP-48	10.0.0	2010-06-18		-
Rel-9	SP-46	2009-12-10	::	.	ETSI
	event	version	available	remarks	click ref to download
	RP-58	9.10.0	2013-01-08		RTS/TSGR-0236300v9a0
	RP-54	9.9.0	2011-12-21		RTS/TSGR-0236300v990
	RP-53	9.8.0	2011-10-03		RTS/TSGR-0236300v980
	RP-51	9.7.0	2011-03-30		RTS/TSGR-0236300v970
	RP-50	9.6.0	2010-12-21		RTS/TSGR-0236300v960
	RP-49	9.5.0	2010-10-04		RTS/TSGR-0236300v950
	RP-48	9.4.0	2010-06-18		RTS/TSGR-0236300v940

	RP-47	9.3.0	2010-04-28		RTS/TSGR-0236300v930
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	RP-44	9.0.0	2009-06-18		-
Rel-8	SP-42	2008-12-11	::	.	ETSI
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	RP-46	8.11.0	2010-01-06		RTS/TSGR-0236300v8b0
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	RP-44	8.9.0	2009-06-18		RTS/TSGR-0236300v890
	RP-43	8.8.0	2009-04-03		RTS/TSGR-0236300v880
	RP-42	8.7.0	2009-01-05		RTS/TSGR-0236300v870
	RP-41	8.6.0	2008-09-23		RTS/TSGR-0236300v860
	RP-40	8.5.0	2008-06-25		RTS/TSGR-0236300v850
	RP-39	8.4.0	2008-03-20		RTS/TSGR-0236300v840
	RP-38	8.3.0	2008-01-03		RTS/TSGR-0236300v830
	RP-37	8.2.0	2007-10-05		RTS/TSGR-0236300v820
	RP-36	8.1.0	2007-07-17		RTS/TSGR-0236300v810
	RP-35	8.0.0	2007-04-06		DTS/TSGR-0236300v800
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Foreword

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1 Scope

The present document provides an overview and overall description of the E-UTRAN radio interface protocol architecture. Details of the radio interface protocols will be specified in companion specifications of the 36 series.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TR 25.913: "Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)"

[3] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; General description".

[4] 3GPP TS 36.211:"Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation "

[5] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding"

[6] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures"

[7] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements"

[8] IETF RFC 2960 (10/2000): "Stream Control Transmission Protocol"

[9] 3GPP TS 36.302: "Evolved Universal Terrestrial Radio Access (E-UTRA); Services provided by the physical layer"

[11] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode"

[12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities"

[13] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Acces Control (MAC) protocol specification"

[14] 3GPP TS 36.322: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification"

[15] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification"

[16] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[17] 3GPP TS 23.401: "Technical Specification Group Services and System Aspects; GPRS enhancements for E-UTRAN access".

[18] 3GPP TR 24.801: "3GPP System Architecture Evolution (SAE); CT WG1 aspects".

[19] 3GPP TS 23.402: "3GPP System Architecture Evolution: Architecture Enhancements for non-3GPP accesses".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Carrier frequency: center frequency of the cell.

MBMS-dedicated cell: cell dedicated to MBMS transmission.

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

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

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

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	Acknowledge Mode
AMBR	Aggregate Maximum Bit Rate
ARQ	Automatic Repeat Request
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BSR	Buffer Status Reports
C/I	Carrier-to-Interference Power Ratio
CAZAC	Constant Amplitude Zero Auto-Correlation
CMC	Connection Mobility Control
CP	Cyclic Prefix
C-plane	Control Plane
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
DCCH	Dedicated Control Channel
DL	Downlink
DFTS	DFT Spread OFDM
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
ECM	EPS Connection Management
EMM	EPS Mobility Management
eNB	E-UTRAN NodeB
EPC	Evolved Packet Core
EPS	Evolved Packet 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
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
LCR	Low Chip Rate
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
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
MTCH	MBMS Traffic Channel
MSAP	MCH Subframe Allocation Pattern
NACK	Negative Acknowledgement
NAS	Non-Access Stratum
NCL	Neighbour Cell List
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
P-GW	PDN Gateway
PA	Power Amplifier
PAPR	Peak-to-Average Power Ratio
PBCH	Physical Broadcast CHannel
PBR	Prioritised Bit Rate
PCCH	Paging Control Channel
PCFICH	Physical Control Format Indicator CHannel
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
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAC	Radio Admission Control
RACH	Random Access Channel
RAT	Radio Access Technology
RB	Radio Bearer
RBC	Radio Bearer Control
RBG	Radio Bearer Group
RF	Radio Frequency
RLC	Radio Link Control
RNC	Radio Network Controller
RNL	Radio Network Layer
ROHC	Robust Header Compression

RRC	Radio Resource Control
RRM	Radio Resource Management
RU	Resource Unit
SDF	Service Data Flow
S-GW	Serving Gateway
S1-MME	S1 for the control plane
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
SDMA	Spatial Division Multiple Access
SDU	Service Data Unit
SFN	System Frame Number
SPID	Subscriber Profile ID for RAT/Frequency Priority
SR	Scheduling Request
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	Un-acknowledge Mode
UMTS	Universal Mobile Telecommunication System
U-plane	User plane
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
VRB	Virtual Resource Block
X2-C	X2-Control plane
X2-U	X2-User plane

4 Overall architecture

The E-UTRAN consists of eNBs, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other by means of the X2 interface. The eNBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), more specifically to the MME (Mobility Management Entity) by means of the S1-MME and to the Serving Gateway (S-GW) by means of the S1-U. The S1 interface supports a many-to-many relation between MMEs / Serving Gateways and eNBs.

The E-UTRAN architecture is illustrated in Figure 4 below.

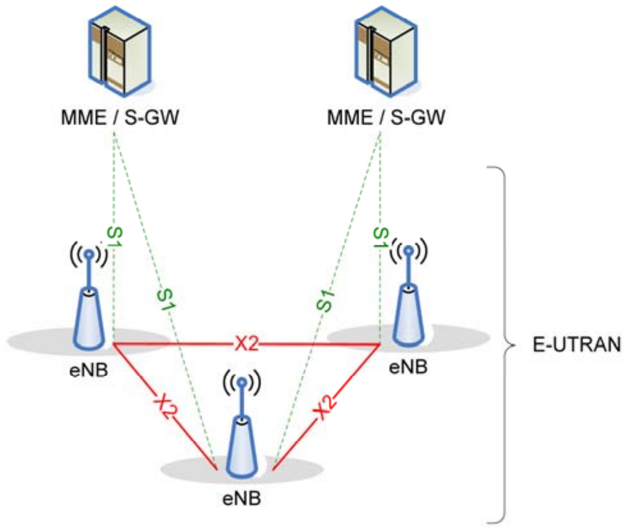

Figure 4-1: Overall Architecture

4.1 Functional Split

The eNB hosts the following functions:

- Functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling);
- IP header compression and encryption of user data stream;
- Selection of an MME at UE attachment when no routing to an MME can be determined from the information provided by the UE;
- Routing of User Plane data towards Serving Gateway;
- Scheduling and transmission of paging messages (originated from the MME);
- Scheduling and transmission of broadcast information (originated from the MME or O&M);
- Measurement and measurement reporting configuration for mobility and scheduling.

The MME hosts the following functions (see 3GPP TS 23.401 [17]):

- NAS signalling;
- NAS signalling security;
- AS Security control;
- Inter CN node signalling for mobility between 3GPP access networks;
- Idle mode UE Reachability (including control and execution of paging retransmission);
- Tracking Area list management (for UE in idle and active mode);
- PDN GW and Serving GW selection;
- MME selection for handovers with MME change;
- SGSN selection for handovers to 2G or 3G 3GPP access networks;
- Roaming;
- Authentication;

- Bearer management functions including dedicated bearer establishment.

The Serving Gateway (S-GW) hosts the following functions (see 3GPP TS 23.401 [17]):

- The local Mobility Anchor point for inter-eNB handover;
- Mobility anchoring for inter-3GPP mobility;
- E-UTRAN idle mode downlink packet buffering and initiation of network triggered service request procedure;
- Lawful Interception;
- Packet routeing and forwarding;
- Transport level packet marking in the uplink and the downlink;
- Accounting on user and QCI granularity for inter-operator charging;
- UL and DL charging per UE, PDN, and QCI.

The PDN Gateway (P-GW) hosts the following functions (see 3GPP TS 23.401 [17]):

- Per-user based packet filtering (by e.g. deep packet inspection);
- Lawful Interception;
- UE IP address allocation;
- Transport level packet marking in the downlink;
- UL and DL service level charging, gating and rate enforcement;
- DL rate enforcement based on AMBR;

This is summarized on the figure below where yellow boxes depict the logical nodes, white boxes depict the functional entities of the control plane and blue boxes depict the radio protocol layers.

NOTE: it is assumed that no other logical E-UTRAN node than the eNB is needed for RRM purposes. Moreover, due to the different usage of inter-cell RRM functionalities, each inter-cell RRM functionality should be considered separately in order to assess whether it should be handled in a centralised manner or in a distributed manner.

NOTE: MBMS related functions in E-UTRAN are described separately in subclause 15.

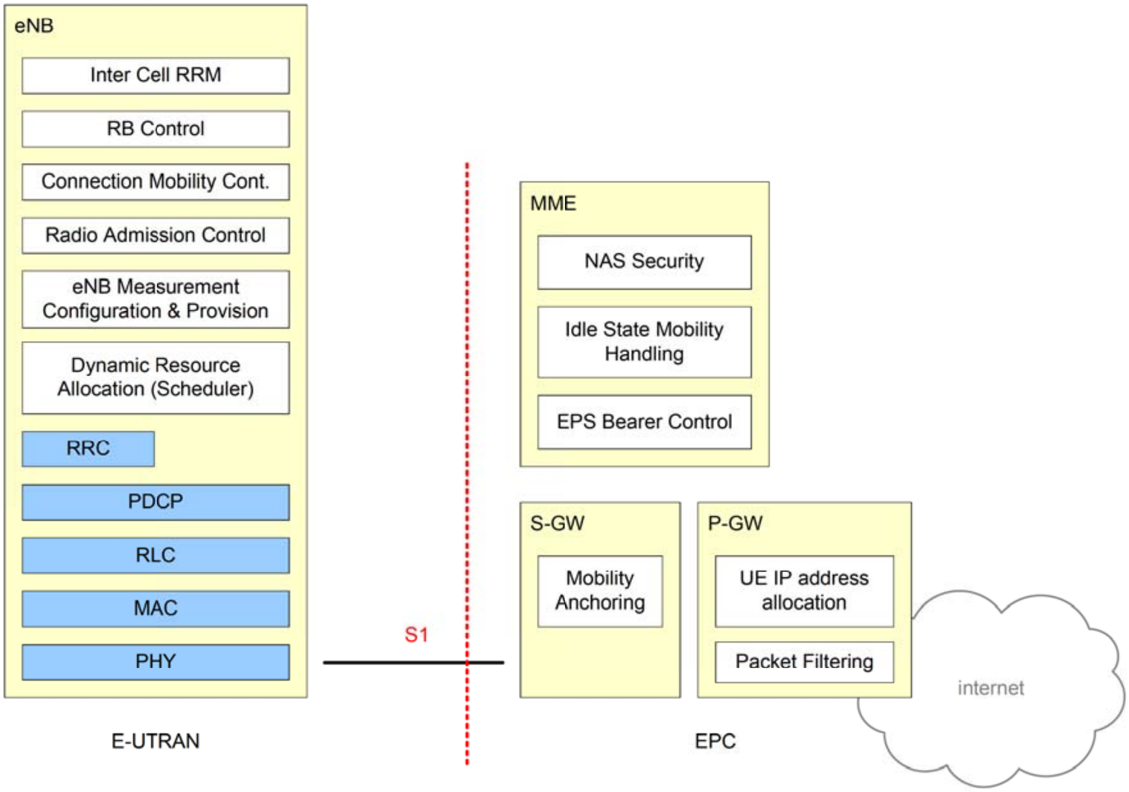

Figure 4.1-1: Functional Split between E-UTRAN and EPC

4.2 Interfaces

4.2.1 S1 Interface

4.2.2 X2 Interface

4.3 Radio Protocol architecture

In this subclause, the radio protocol architecture of E-UTRAN is given for the user plane and the control plane.

4.3.1 User plane

The figure below shows the protocol stack for the user-plane, where PDCP, RLC and MAC sublayers (terminated in eNB on the network side) perform the functions listed for the user plane in subclause 6, e.g. header compression, ciphering, scheduling, ARQ and HARQ;

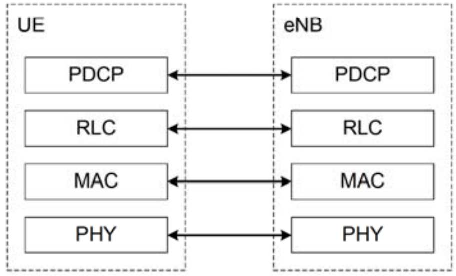

Figure 4.3.1-1: User-plane protocol stack

4.3.2 Control plane

The figure below shows the protocol stack for the control-plane, where:

- PDCP sublayer (terminated in eNB on the network side) performs the functions listed for the control plane in subclause 6, e.g. ciphering and integrity protection;
- RLC and MAC sublayers (terminated in eNB on the network side) perform the same functions as for the user plane;
- RRC (terminated in eNB on the network side) performs the functions listed in subclause 7, e.g.:
    - Broadcast;
    - Paging;
    - RRC connection management;
    - RB control;
    - Mobility functions;
    - UE measurement reporting and control.
- NAS control protocol (terminated in MME on the network side) performs among other things:
    - EPS bearer management;
    - Authentication;
    - ECM-IDLE mobility handling;
    - Paging origination in ECM-IDLE;
    - Security control.

NOTE: the NAS control protocol is not covered by the scope of this TS and is only mentioned for information.

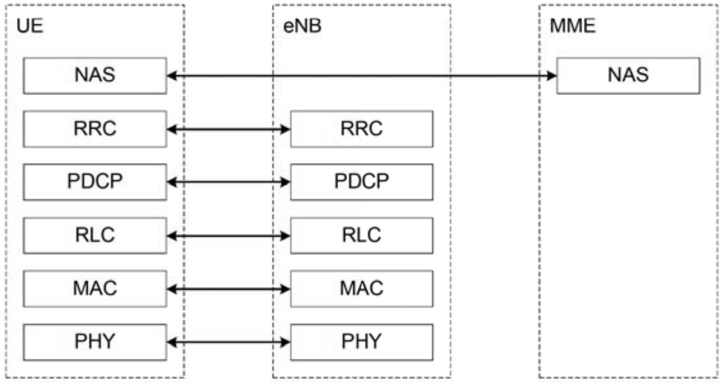

Figure 4.3.2-1: Control-plane protocol stack

4.4 Synchronization

Diverse methods and techniques are preferred depending on synchronization requirements. As no single method can cover all E-UTRAN applications a logical port at eNB may be used for reception of timing and/or frequency and/or phase inputs pending to the synchronization method chosen.

4.5 IP fragmentation

Fragmentation function in IP layer on S1 and X2 shall be supported.

Configuration of S1-U (X2-U) link MTU in the eNB/ S-GW according to the MTU of the network domain the node belongs to shall be considered as a choice at network deployment. The network may employ various methods to handle IP fragmentation, but the specific methods to use are implementation dependant.

At the establishment/modification of an EPS bearer, the network may signal a value that is to be used as MTU by the UE IP stack (it is FFS how the requirement on the UE should be formulated). It is also FFS if the MTU is signalled by the MME or the eNB.

5 Physical Layer for E-UTRA

The generic frame structure is illustrated in Figure 5-1. Each 10 ms radio frame is divided into ten equally sized sub-frames. Each sub-frame consists of two equally sized slots. Each sub-frame can be assigned for either downlink or uplink transmission [*there are certain restrictions in the assignment as the first and sixth sub-frame of each frame include the downlink synchronization signals*]

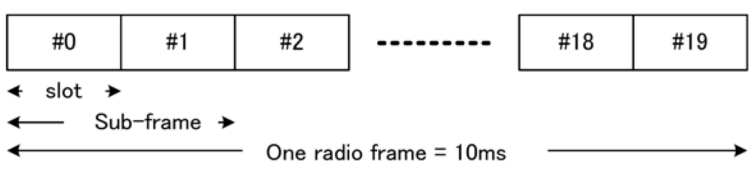

Figure 5-1: Generic frame structure

In addition, for coexistence with LCR-TDD, an alternative frame structure illustrated in Figure 5-2 is also supported when operating E-UTRA in TDD mode.

ZTE/HTC
Exhibit 1017-0071

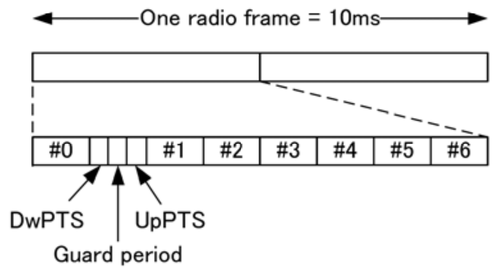

Figure 5-2: alternative frame structure

The physical channels of E-UTRA are:

Physical broadcast channel (PBCH)

- The coded BCH transport block is mapped to four subframes within a 40 ms interval;
- 40 ms timing is blindly detected, i.e. there is no explicit signalling indicating 40 ms timing;
- Each subframe is assumed to be self-decodable, i.e. the BCH can be decoded from a single reception, assuming sufficiently good channel conditions.

Physical control format indicator channel (PCFICH)

- Informs the UE about the number of OFDM symbols used for the PDCCHs;
- Transmitted in every subframe.

Physical downlink control channel (PDCCH)

- Informs the UE about the resource allocation of PCH and DL-SCH, and Hybrid ARQ information related to DL-SCH;
- Carries the uplink scheduling grant.

Physical Hybrid ARQ Indicator Channel (PHICH)

- Carries Hybrid ARQ ACK/NAKs in response to uplink transmissions.

Physical downlink shared channel (PDSCH)

- Carries the DL-SCH and PCH.

Physical multicast channel (PMCH)

- Carries the MCH.

Physical uplink control channel (PUCCH)

- Carries Hybrid ARQ ACK/NAKs in response to downlink transmission;
- Carries Scheduling Request (SR);
- Carries CQI reports.

Physical uplink shared channel (PUSCH)

- Carries the UL-SCH.

Physical random access channel (PRACH)

- Carries the random access preamble.

5.1 Downlink Transmission Scheme

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 Δf = 15 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 $N_{RB\text{-}min}$ = 6 to $N_{RB\text{-}max}$ = [110].

In addition there is also a reduced sub-carrier spacing Δf_{low} = 7.5 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: $T_{CP} = 160 \times Ts$ (OFDM symbol #0) , $T_{CP} = 144 \times Ts$ (OFDM symbol #1 to #6)
- Extended cyclic prefix: $T_{CP\text{-}e} = 512 \times Ts$ (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 $T_{CP\text{-}low} = 1024 \times Ts$, corresponding to 3 OFDM symbols per slot.

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

For operation in unpaired spectrum with generic frame structure, DL/UL switching points are generated by not transmitting in certain symbols while idle periods, required by the Node B at UL/DL switching points are created using time advance mechanism. For the alternative frame structure, the cyclic prefix length, in case of 15 kHz sub-carrier spacing, is

- Normal cyclic prefix: $T_{CP} = 224 \times Ts$ (OFDM symbol #0 to #8)
- Extended cyclic prefix: $T_{CP\text{-}e} = 512 \times Ts$ (OFDM symbol #0 to #7)

5.1.2 Physical-layer processing

The downlink physical-layer processing of transport channels consists of the following steps:

- CRC insertion: 24 bit CRC is the baseline for PDSCH;
- Channel coding: Turbo coding based on QPP inner interleaving with trellis termination;
- Physical-layer hybrid-ARQ processing;
- Channel interleaving;
- Scrambling: transport-channel specific scrambling on DL-SCH, BCH, and PCH. Common MCH scrambling for all cells involved in a specific MBSFN transmission;
- Modulation: QPSK, 16QAM, and 64QAM;
- Layer mapping and pre-coding;
- Mapping to assigned resources and antenna ports.

5.1.3 Physical downlink control channel

The downlink control signalling (PDCCH) is located in the first n OFDM symbols where $n \leq 3$ and consists of:

- Transport format, resource allocation, and hybrid-ARQ information related to DL-SCH, and PCH;
- Transport format, resource allocation, and hybrid-ARQ information related to UL-SCH;

Transmission of control signalling from these groups is mutually independent.

Multiple physical downlink control channels are supported and a UE monitors a set of control channels.

Control channels are formed by aggregation of control channel elements, each control channel element consisting of a set of resource elements. Different code rates for the control channels are realized by aggregating different numbers of control channel elements.

QPSK modulation is used for all control channels.

Each separate control channel has its own set of x-RNTI.

There is an implicit relation between the uplink resources used for dynamically scheduled data transmission, or the DL control channel used for assignment, and the downlink ACK/NAK resource used for feedback

5.1.4 Downlink Reference signal

The downlink reference signals consist of known reference symbols inserted in the first and third last OFDM symbol of each slot. There is one reference signal transmitted per downlink antenna port. The number of downlink antenna ports equals 1, 2, or 4. The two-dimensional reference signal sequence is generated as the symbol-by-symbol product of a two-dimensional orthogonal sequence and a two-dimensional pseudo-random sequence. There are 3 different two-dimensional orthogonal sequences and 170 different two-dimensional pseudo-random sequences. Each cell identity corresponds to a unique combination of one orthogonal sequence and one pseudo-random sequence, thus allowing for 510 unique cell identities 170 cell identity groups with 3 cell identities in each group).

Frequency hopping can be applied to the downlink reference signals. The frequency hopping pattern has a period of one frame (10 ms). Each frequency hopping pattern corresponds to one cell identity group.

The downlink MBSFN reference signals consist of known reference symbols inserted every other sub-carrier in the 3rd, 7th and 11th OFDM symbol of sub-frame in case of 15kHz sub-carrier spacing and extended cyclic prefix

5.1.5 Downlink multi-antenna transmission

Multi-antenna transmission with 2 and 4 transmit antennas is supported. The maximum number of codeword is two irrespective to the number of antennas with fixed mapping between code words to layers.

Spatial division multiplexing (SDM) of multiple modulation symbol streams to a single UE using the same time-frequency (-code) resource, also referred to as Single-User MIMO (SU-MIMO) is supported. When a MIMO channel is solely assigned to a single UE, it is known as SU-MIMO. Spatial division multiplexing of modulation symbol streams to different UEs using the same time-frequency resource, also referred to as MU-MIMO, is also supported. There is semi-static switching between SU-MIMO and MU-MIMO per UE.

In addition, the following techniques are supported:

- Code-book-based pre-coding with a single pre-coding feedback per full system bandwidth when the system bandwidth (or subset of resource blocks) is smaller or equal to12RB and per 5 adjacent resource blocks or the full system bandwidth (or subset of resource blocks) when the system bandwidth is larger than 12RB.

- Rank adaptation with single rank feedback referring to full system bandwidth. Node B can override rank report.

5.1.6 MBSFN transmission

MBSFN is supported for the MCH transport channel. Multiplexing of transport channels using MBSFN and non-MBSFN transmission is done on a per-sub-frame basis. Additional reference symbols, transmitted using MBSFN are transmitted within MBSFN subframes.

5.1.7 Physical layer procedure

5.1.7.1 Link adaptation

Link adaptation (AMC: adaptive modulation and coding) with various modulation schemes and channel coding rates is applied to the shared data channel. The same coding and modulation is applied to all groups of resource blocks belonging to the same L2 PDU scheduled to one user within one TTI and within a single stream.

5.1.7.2 Power Control

Downlink power control can be used.

5.1.7.3 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 72 sub-carriers and upwards.

E-UTRA cell search is based on following signals transmitted in the downlink: the primary and secondary synchronization signals, the downlink reference signals.

The primary and secondary synchronization signals are transmitted over the centre 72 sub-carriers in the first and sixth subframe of each frame.

Neighbour-cell search is based on the same downlink signals as initial cell search.

5.1.8 Physical layer measurements definition

The physical layer measurements to support mobility are classified as:

- within E-UTRAN (intra-frequency, inter-frequency);
- between E-UTRAN and GERAN/UTRAN (inter-RAT);
- between E-UTRAN and non-3GPP RAT (Inter 3GPP access system mobility).

For measurements within E-UTRAN at least two basic UE measurement quantities shall be supported:

- Reference symbol received power (RSRP);
- E-UTRA carrier received signal strength indicator (RSSI).

5.2 Uplink Transmission Scheme

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.

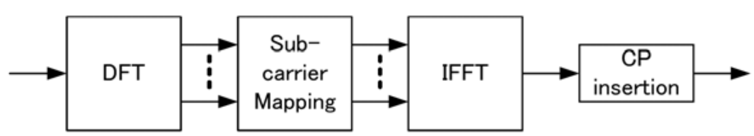

Figure 5.2.1-1: Transmitter scheme of SC-FDMA

The uplink sub-carrier spacing Δf = 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 $N_{RB\text{-}min}$ = 6 to $N_{RB\text{-}max}$ = [110].

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

Correspondingly, for the alternative frame structure, the cyclic prefix length is listed in table 5.2.1-1.

ZTE/HTC
Exhibit 1017-0075

Table 5.2.1-1: Cyclic prefix length for alternative frame structure

<table>
<tr><th rowspan="3">l</th><th colspan="4">Normal cyclic prefix</th><th colspan="4">Extended cyclic prefix</th></tr>
<tr><th colspan="2">$N_{BW}^{UL} \le 300$</th><th colspan="2">$300 < N_{BW}^{UL}$</th><th colspan="2">$N_{BW}^{UL} \le 300$</th><th colspan="2">$300 < N_{BW}^{UL}$</th></tr>
<tr><th>$N_{CP,l}$</th><th>N_d</th><th>$N_{CP,l}$</th><th>N_d</th><th>$N_{CP,l}$</th><th>N_d</th><th>$N_{CP,l}$</th><th>N_d</th></tr>
<tr><td>0</td><td>320</td><td>2048</td><td>224</td><td>2048</td><td>560</td><td>2048</td><td>472</td><td>2048</td></tr>
<tr><td>1</td><td rowspan="9">192</td><td>1024</td><td rowspan="9">204</td><td>1024</td><td rowspan="8">423</td><td>1024</td><td rowspan="8">456</td><td>1024</td></tr>
<tr><td>2</td><td rowspan="6">2048</td><td rowspan="6">2048</td><td rowspan="5">2048</td><td rowspan="5">2048</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td>1024</td><td>1024</td></tr>
<tr><td>8</td><td>1024</td><td>1024</td><td>2048</td><td>2048</td></tr>
<tr><td>9</td><td>2048</td><td>2048</td><td></td><td></td><td></td><td></td></tr>
</table>

5.2.2 Physical-layer processing

The uplink physical layer processing of transport channels consists of the following steps:

- CRC insertion: 24 bit CRC is the baseline for PUSCH;
- Channel coding: turbo coding based on QPP inner interleaving with trellis termination;
- Physical-layer hybrid-ARQ processing;
- Scrambling: UE-specific scrambling;
- Modulation: QPSK, 16QAM, and 64QAM (64 QAM optional in UE);
- Mapping to assigned resources [*and antennas*].

5.2.3 Physical uplink control channel

The PUCCH shall be mapped to a control channel resource in the uplink. A control channel resource is defined by a code and two resource blocks, consecutive in time, with hopping at the slot boundary.

Depending on presence or absence of uplink timing synchronization, the uplink physical control signalling can differ.

In the case of time synchronization being present, the outband control signalling consists of:

- CQI;
- ACK/NAK;
- Scheduling Request (SR).

The CQI informs the scheduler about the current channel conditions as seen by the UE. If MIMO transmission is used, the CQI includes necessary MIMO-related feedback.

The HARQ feedback in response to downlink data transmission consists of a single ACK/NAK bit per HARQ process.

PUCCH resources for SR and CQI reporting are assigned and can be revoked through RRC signalling. An SR is not necessarily assigned to UEs acquiring synchronization through the RACH (i.e. synchronised UEs may or may not have a dedicated SR channel). PUCCH resources for SR and CQI are lost when the UE is no longer synchronized.

5.2.4 Uplink Reference signal

Uplink reference signals [for channel estimation for coherent demodulation] are transmitted in the 4-th block of the slot [*assumed normal CP*]. The uplink reference signals sequence length equals the size (number of sub-carriers) of the assigned resource.

The uplink reference signals are based on [*prime-length*] Zadoff-chu sequences that are either truncated or cyclically extended to the desired length

Multiple reference signals can be created:

- Based on different Zadoff-Chu sequence from the same set of Zadoff-Chu sequences;
- Different shifts of the same sequence.

5.2.5 Random access preamble

The physical layer random access burst consists of a cyclic prefix, a preamble, and a guard time during which nothing is transmitted.

The random access preambles are generated from Zadoff-Chu sequences with zero correlation zone, ZC-ZCZ, generated from one or several root Zadoff-Chu sequences.

5.2.6 Uplink multi-antenna transmission

The baseline antenna configuration for uplink MIMO is MU-MIMO. To allow for MU-MIMO reception at the Node B, allocation of the same time and frequency resource to several UEs, each of which transmitting on a single antenna, is supported.

Closed loop type adaptive antenna selection transmit diversity shall be supported for FDD (optional in UE).

5.2.7 Physical channel procedure

5.2.7.1 Link adaptation

Uplink link adaptation is used in order to guarantee the required minimum transmission performance of each UE such as the user data rate, packet error rate, and latency, while maximizing the system throughput.

Three types of link adaptation are performed according to the channel conditions, the UE capability such as the maximum transmission power and maximum transmission bandwidth etc., and the required QoS such as the data rate, latency, and packet error rate etc. Three link adaptation methods are as follows.

- Adaptive transmission bandwidth;
- Transmission power control;
- Adaptive modulation and channel coding rate.

5.2.7.2 Uplink Power control

Intra-cell power control: the power spectral density of the uplink transmissions can be influenced by the eNB.

5.2.7.3 Uplink timing control

The timing advance is derived from the UL received timing and sent by the eNB to the UE which the UE uses to advance/delay its timings of transmissions to the eNB so as to compensate for propagation delay and thus time align the transmissions from different UEs with the receiver window of the eNB.

The timing advance command is on a per need basis with a granularity in the step size of 0.52 μs ($16 \times T_s$).

5.3 Transport Channels

The physical layer offers information transfer services to MAC and higher layers. The physical layer transport services are described by *how* and with what characteristics data are transferred over the radio interface. An adequate term for this is "Transport Channel".

NOTE: This should be clearly separated from the classification of *what* is transported, which relates to the concept of logical channels at MAC sublayer.

Downlink transport channel types are:

1. **Broadcast Channel (BCH)** characterised by:
   - fixed, pre-defined transport format;
   - requirement to be broadcast in the entire coverage area of the cell.
2. **Downlink Shared Channel (DL-SCH)** characterised by:
   - support for HARQ;
   - support for dynamic link adaptation by varying the modulation, coding and transmit power;
   - possibility to be broadcast in the entire cell;
   - possibility to use beamforming;
   - support for both dynamic and semi-static resource allocation;
   - support for UE discontinuous reception (DRX) to enable UE power saving;
   - support for MBMS transmission.

NOTE: the possibility to use slow power control depends on the physical layer.

3. **Paging Channel (PCH)** characterised by:
   - support for UE discontinuous reception (DRX) to enable UE power saving (DRX cycle is indicated by the network to the UE);
   - requirement to be broadcast in the entire coverage area of the cell;
   - mapped to physical resources which can be used dynamically also for traffic/other control channels.
4. **Multicast Channel (MCH)** characterised by:
   - requirement to be broadcast in the entire coverage area of the cell;
   - support for MBSFN combining of MBMS transmission on multiple cells;
   - support for semi-static resource allocation e.g. with a time frame of a long cyclic prefix.

Uplink transport channel types are:

1. **Uplink Shared Channel (UL-SCH)** characterised by:
   - possibility to use beamforming; (likely no impact on specifications)
   - support for dynamic link adaptation by varying the transmit power and potentially modulation and coding;
   - support for HARQ;
   - support for both dynamic and semi-static resource allocation.

NOTE: the possibility to use uplink synchronisation and timing advance depend on the physical layer.

2. **Random Access Channel(s) (RACH)** characterised by:
   - limited control information;
   - collision risk;

NOTE: the possibility to use open loop power control depends on the physical layer solution.

5.3.1 Mapping between transport channels and physical channels

The figures below depict the mapping between transport and physical channels:

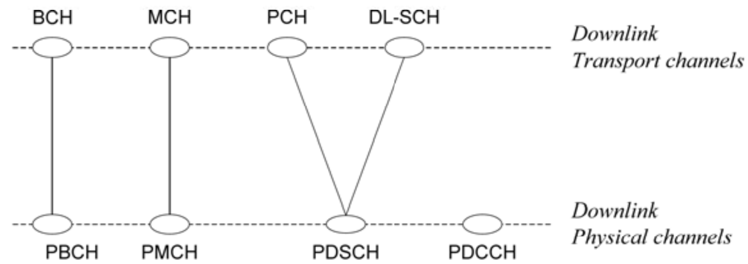

Figure 5.3.1-1: Mapping between downlink transport channels and downlink physical channels

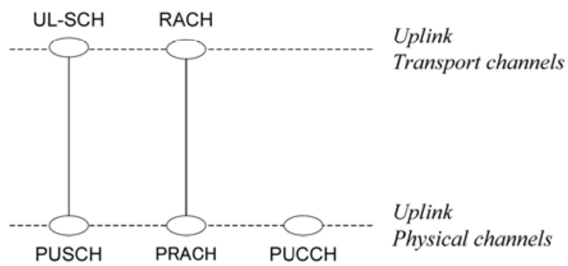

Figure 5.3.1-2: Mapping between uplink transport channels and uplink physical channels

5.4 E-UTRA physical layer model

The E-UTRAN physical layer model is captured in TS 36.302 [9].

5.4.1 Void

5.4.2 Void

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, only one transport block is generated per TTI in the non-MIMO case.

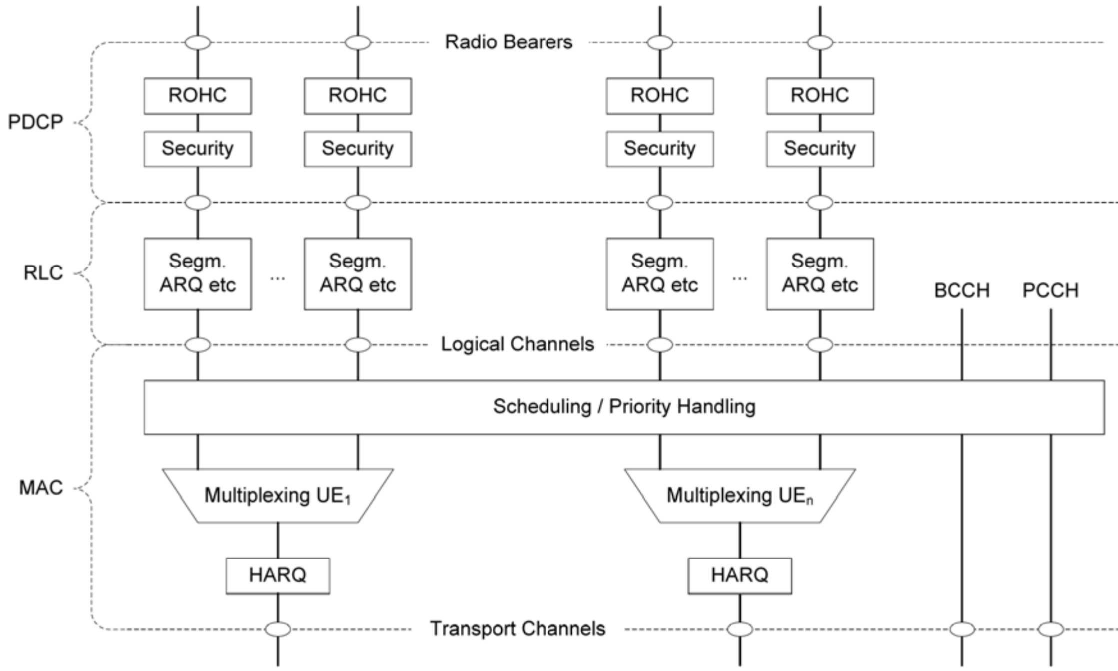

Figure 6-1: Layer 2 Structure for DL

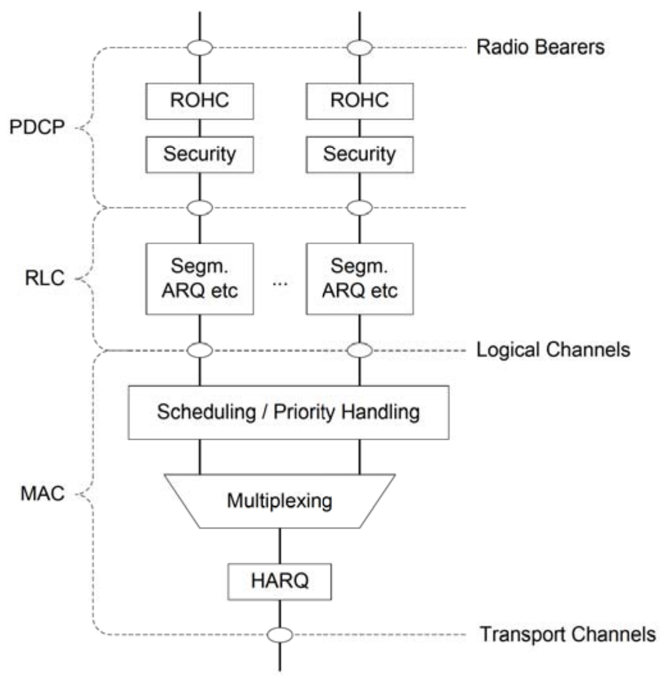

Figure 6-2: Layer 2 Structure for UL

6.1 MAC Sublayer

This subclause provides an overview on services and functions provided by the MAC sublayer.

6.1.1 Services and Functions

The main services and functions of the MAC sublayer include:

- Mapping between logical channels and transport channels;
- Multiplexing/demultiplexing of RLC PDUs belonging to one or different radio bearers into/from transport blocks (TB) delivered to/from the physical layer on transport channels;
- Traffic volume measurement reporting;
- Error correction through HARQ;
- Priority handling between logical channels of one UE;
- Priority handling between UEs by means of dynamic scheduling;
- Transport format selection;
- Padding.

6.1.2 Logical Channels

Different kinds of data transfer services as offered by MAC. Each logical channel type is defined by what type of information is transferred.

A general classification of logical channels is into two groups:

- Control Channels (for the transfer of control plane information);
- Traffic Channels (for the transfer of user plane information).

There is one MAC entity per cell. MAC generally consists of several function blocks (transmission scheduling functions, per UE functions, MBMS functions, MAC control functions, transport block generation…). Transparent Mode is only applied to BCCH, CCCH and PCCH.

6.1.2.1 Control Channels

Control channels are used for transfer of control plane information only. The control channels offered by MAC are:

- **Broadcast Control Channel (BCCH)**

  A downlink channel for broadcasting system control information.

- **Paging Control Channel (PCCH)**

  A downlink channel that transfers paging information. This channel is used when the network does not know the location cell of the UE.

- **Common Control Channel (CCCH)**

  Channel for transmitting control information between UEs and network. This channel is used for UEs having no RRC connection with the network.

- **Multicast Control Channel (MCCH)**

  A point-to-multipoint downlink channel used for transmitting MBMS control information from the network to the UE, for one or several MTCHs. This channel is only used by UEs that receive MBMS.

NOTE: It is FFS how MBMS scheduling is transmitted by either L2/3 signalling on MCCH or L1 signalling.

- **Dedicated Control Channel (DCCH)**

  A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. Used by UEs having an RRC connection.

6.1.2.2 Traffic Channels

Traffic channels are used for the transfer of user plane information only. The traffic channels offered by MAC are:

- **Dedicated Traffic Channel (DTCH)**

  A Dedicated Traffic Channel (DTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.

- **Multicast Traffic Channel (MTCH)**

  A point-to-multipoint downlink channel for transmitting traffic data from the network to the UE. This channel is only used by UEs that receive MBMS.

6.1.3 Mapping between logical channels and transport channels

6.1.3.1 Mapping in Uplink

The figure below depicts the mapping between uplink logical channels and uplink transport channels:

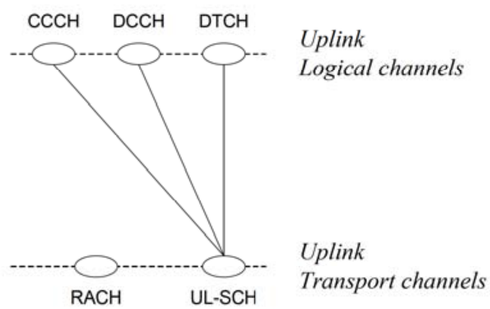

Figure 6.1.3.1-1: Mapping between uplink logical channels and uplink transport channels

In Uplink, the following connections between logical channels and transport channels exist:

- CCCH can be mapped to UL-SCH;
- DCCH can be mapped to UL- SCH;
- DTCH can be mapped to UL-SCH.

6.1.3.2 Mapping in Downlink

The figure below depicts the mapping between downlink logical channels and downlink transport channels:

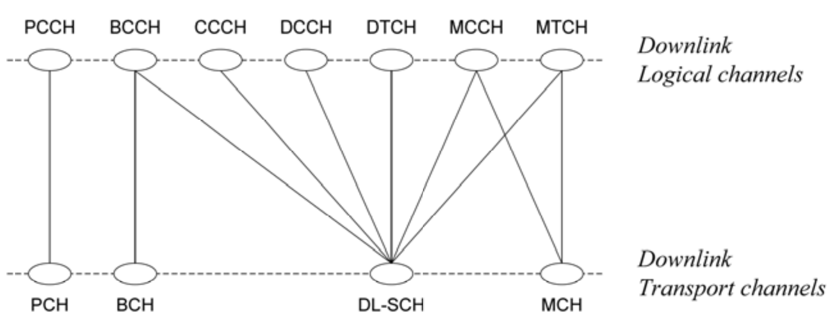

Figure 6.1.3.2-1: Mapping between downlink logical channels and downlink transport channels

In Downlink, the following connections between logical channels and transport channels exist:

- BCCH can be mapped to BCH;
- BCCH can be mapped to DL-SCH;
- PCCH can be mapped to PCH;
- CCCH can be mapped to DL-SCH;
- DCCH can be mapped to DL-SCH;
- DTCH can be mapped to DL-SCH;
- MTCH can be mapped to DL-SCH;
- MTCH can be mapped to MCH;
- MCCH can be mapped to DL-SCH;
- MCCH can be mapped to MCH.

6.2 RLC Sublayer

This subclause provides an overview on services, functions and PDU structure provided by the RLC sublayer. Note that:

- The reliability of RLC is configurable: some radio bearers may tolerate rare losses (e.g. TCP traffic);
- Radio Bearers are not characterized by a fixed sized data unit (e.g. a fixed sized RLC PDU).

6.2.1 Services and Functions

The main services and functions of the RLC sublayer include:

- Transfer of upper layer PDUs supporting AM or UM;
- TM data transfer;
- Error Correction through ARQ (CRC check provided by the physical layer, in other words no CRC needed at RLC level);
- Segmentation according to the size of the TB: only if an RLC SDU does not fit entirely into the TB then the RLC SDU is segmented into variable sized RLC PDUs, which do not include any padding;
- Re-segmentation of PDUs that need to be retransmitted: if a retransmitted PDU does not fit entirely into the new TB used for retransmission then the RLC PDU is re-segmented;
- The number of re-segmentations is not limited;
- Concatenation of SDUs for the same radio bearer;
- In-sequence delivery of upper layer PDUs except at HO;
- Duplicate Detection;
- Protocol error detection and recovery;
- SDU discard;
- Reset.

6.2.2 PDU Structure

Figure 6.2.2-1 below depicts the RLC PDU structure where:

- The PDU sequence number carried by the RLC header is independent of the SDU sequence number (i.e. PDCP sequence number);
- A red dotted line indicates the occurrence of segmentation;
- Because segmentation only occurs when needed and concatenation is done in sequence, the content of an RLC PDU can generally be described by the following relations:
  - {0; 1} last segment of SDU_i + [0; n] complete SDUs + {0; 1} first segment of SDU_{i+n+1} ; or
  - 1 segment of SDU_i .

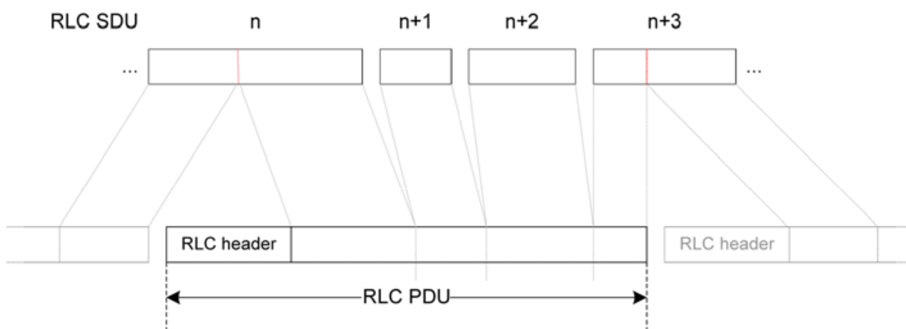

Figure 6.2.2-1: RLC PDU Structure

6.3 PDCP Sublayer

This subclause provides an overview on services, functions and PDU structure provided by the PDCP sublayer.

6.3.1 Services and Functions

The main services and functions of the PDCP sublayer for the user plane include:

- Header compression and decompression: ROHC only;
- Transfer of user data: transmission of user data means that PDCP receives PDCP SDU from the NAS and forwards it to the RLC layer and vice versa;
- In-sequence delivery of upper layer PDUs at handover for RLC AM;
- Duplicate detection of lower layer SDUs at handover for RLC AM;
- Retransmission of PDCP SDUs at handover for RLC AM;
- Ciphering;
- Timer-based SDU discard in uplink.

NOTE: When compared to UTRAN, the *lossless DL RLC PDU size change* is not required.

The main services and functions of the PDCP for the control plane include:

- Ciphering and Integrity Protection;
- Transfer of control plane data: transmission of control plane data means that PDCP receives PDCP SDUs from RRC and forwards it to the RLC layer and vice versa.

6.3.2 PDU Structure

Figure 6.3.2-1 below depicts the PDCP PDU structure where:

- PDCP PDU and PDCP header are octet-aligned;
- PDCP header can be either 1 or 2 bytes long.

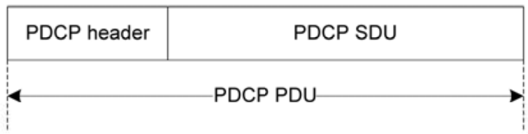

Figure 6.3.2-1: PDCP PDU Structure

6.4 Data flows through Layer 2

7 RRC

This subclause provides an overview on services and functions provided by the RRC sublayer.

7.1 Services and Functions

The main services and functions of the RRC sublayer include:

- Broadcast of System Information related to the non-access stratum (NAS);
- Broadcast of System Information related to the access stratum (AS);
- Paging;
- Establishment, maintenance and release of an RRC connection between the UE and E-UTRAN including:
  - Allocation of temporary identifiers between UE and E-UTRAN;
  - Configuration of signalling radio bearer(s) for RRC connection:
    - Low priority SRB and high priority SRB.
- Security functions including key management;
- Establishment, configuration, maintenance and release of point to point Radio Bearers;
- Mobility functions including:
  - UE measurement reporting and control of the reporting for inter-cell and inter-RAT mobility;
  - Inter-cell handover;
  - UE cell selection and reselection and control of cell selection and reselection;
  - Context transfer between eNBs.
- Notification for MBMS services;
- Establishment, configuration, maintenance and release of Radio Bearers for MBMS services;
- QoS management functions;

- UE measurement reporting and control of the reporting;
- NAS direct message transfer to/from NAS from/to UE.

7.2 RRC protocol states & state transitions

RRC uses the following states:

- **RRC_IDLE**:
  - PLMN selection;
  - DRX configured by NAS (Option to have UE specific DRX is FFS);
  - Broadcast of system information;
  - Paging;
  - Cell re-selection mobility;
  - The UE shall have been allocated an id which uniquely identifies the UE in a tracking area;
  - No RRC context stored in the eNB.
- **RRC_CONNECTED**:
  - UE has an E-UTRAN-RRC connection;
  - UE has context in E-UTRAN;
  - E-UTRAN knows the cell which the UE belongs to;
  - Network can transmit and/or receive data to/from UE;
  - Network controlled mobility (handover and inter-RAT cell change order to GERAN with NACC);
  - Neighbour cell measurements;
  - At PDCP/RLC/MAC level:
    - UE can transmit and/or receive data to/from network;
    - UE monitors control signalling channel for shared data channel to see if any transmission over the shared data channel has been allocated to the UE;
    - UE also reports channel quality information and feedback information to eNB;
    - DRX period can be configured according to UE activity level for UE power saving and efficient resource utilization. This is under control of the eNB.

7.3 Transport of NAS messages

In E-UTRAN, NAS messages are either concatenated with RRC messages or carried in RRC without concatenation. Initial Direct Transfer is not used in E-UTRAN and no NAS message is concatenated with RRC connection request.

NOTE: NAS messages are integrity protected and ciphered by PDCP, in addition to the integrity protection and ciphering performed by NAS.

7.4 System Information

Scheduling information (indicating starting times) is provided for a group of system information blocks (SIBs) that have the same scheduling requirements (i.e. periodicity). RRC concatenates such a group of SIBs into a Scheduling Unit (SU) message. It is expected that typically 3 or 4 SUs will be used. The mapping of SIBs on to SUs may be configurable or fixed in the specification (FFS). When multiple SUs are sent in the same TTI, they are mapped on the same downlink transport block.

The following system information is carried on the BCH:

- Physical layer parameters:
  - Downlink system bandwidth [4 bits];
  - Number of transmit antennas [1..2 bits];
  - Reference-Signal transmit power [0..6 bits];
- System Frame Number (SFN [10 bits], unless provided otherwise);
- Scheduling information of the most frequently repeated Scheduling Unit (SU-1) (FFS) [1 bit];

The system information carried on BCH is contained in a System Information Block called the Master Information Block (MIB).

All system information other than contained in the MIB is carried on DL-SCH. The following system information is carried within the most frequently repeated Scheduling Unit (SU-1):

- One or more PLMN identities;
- Tracking Area Code;
- Cell identity;
- One bit for "cell barring" common for all sharing PLMNs;
- One bit for "cell reserved for operator use" per sharing PLMN (up to 6);
- One bit for "cell reservation extension" common for all sharing PLMNs;
- Value_tag (Common for all SUs);
- Scheduling information i.e. the periodicity of the other Scheduling Units (other than SU-1);
- SIB mapping information i.e. indication in which SU the SIB is included (FFS).

The scheduling information, as contained within SU-1, is carried in a System Information Block called the Scheduling Block (SB). Besides this SB, SU-1 includes one or more other SIBs. SU-1 should include all access restriction related parameters. SU-1 is carried on the DL-SCH and uses a fixed schedule with a periodicity of 80 ms.

In the case of TDD, BCCH indicates the frame configuration.

SU-1 is scheduled in the subframe #5 for frame structure Type 1 (FDD and TDD). For frame structure Type 2, SU-1 is scheduled in subframe #0 of the second half frame. Different frame structure types are described in TS 36.211 [4]. It is FFS if further SUs are scheduled in subsequent consecutive subframes. 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. It is FFS if the eNB may schedule more than one SU in a subframe.

During RRC_IDLE state, the UE can identify changes in system information through paging message, so that the UE is not required to do any additional reception activities except from time instants when the UE receives paging channel.

During RRC_CONNECTED state, the UEs checks periodically to identify changes in system information. Whenever a change is detected, all SUs that are relevant to the UE are refreshed.

For very dynamic SI change handling (e.g. similar to SIB7 of UTRAN) UE timer based approach is used.

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

7.5 RRC Procedures

8 E-UTRAN identities

8.1 E-UTRAN related UE identities

The following E-UTRAN related UE identities are used:

a) C-RNTI:

- The C-RNTI provides a unique UE identification at the cell level identifying RRC Connection;
- It is assumed that this identity is used for scheduling unless the cost would turn out to be too high and the introduction of a separate MAC identity would be required.

b) Random value for contention resolution:

- During some transient states, the UE is temporarily identified with a random value for contention resolution purposes.

8.2 Network entity related Identities

The following identities are used in E-UTRAN for identifying a specific network entity:

a) MME identity:

- a UE in ECM-IDLE establishing an RRC connection has to provide a unique identification of its current MME to the eNB in order for the eNB to fetch the UE context from the MME;
- Within the S-TMSI, one field contains the identifier of the MME that allocated the S-TMSI. The identifier of MME is needed to ensure that the S-TMSI remains unique in a tracking area shared by multiple MMEs.

b) eNB identity or cell identity (FFS):

- The signalling sequence to be followed in case a UE in ECM-CONNECTED accesses a cell in which no UE context has been established yet (kind of "cell update") is currently not agreed. Identified options are:
  1) In order to obtain the UE context/data from the old eNB, the new eNB directly contacts the old eNB without consulting the MME;
  2) In order to obtain the UE context/data from the old eNB, the new eNB consults the MME to obtain the identity of the old eNB;
  3) In order to obtain a UE context, the new eNB contacts the MME.
- If it is required for the new eNB to be able to contact the old eNB without involving the MME (case 1 above), the UE has to provide a network entity related identification that enables the new eNB to contact the old eNB, and that enables the old eNB to uniquely identify the UE for retrieving the correct UE context. For this purpose either an eNB identity or cell identity could be used.

c) Tracking Area identity (TAI):

- This is the identity used to identify tracking areas. The Tracking Area Identity is constructed from the MCC (Mobile Country Code), MNC (Mobile Network Code) and TAC (Tracking Area Code).

The following identities are broadcast in every E-UTRAN cell:

a) Cell identity:

- Uniquely identifying the cell in the area (size of area is FFS).

b) Tracking Area identity:

  - Tracking Area this cell belongs to.

c) One or more PLMNs:

  - PLMN (s) for which this cell is providing radio access.

9 ARQ and HARQ

E-UTRAN provides ARQ and HARQ functionalities. The ARQ functionality provides error correction by retransmissions in acknowledged mode at Layer 2. The HARQ functionality ensures delivery between peer entities at Layer 1.

9.1 HARQ principles

The HARQ within the MAC sublayer has the following characteristics:

- N-process Stop-And-Wait;
- HARQ transmits and retransmits transport blocks;
- In the downlink:
  - Asynchronous adaptive HARQ;
  - Uplink ACK/NAKs in response to downlink (re)transmissions are sent on PUCCH or PUSCH;
  - PDCCH signals the HARQ process number and if it is a transmission or retransmission;
  - Retransmissions are always scheduled through PDCCH.
- In the uplink:
  - Synchronous HARQ;
  - Maximum number of retransmissions configured per UE (as opposed to per radio bearer);
  - Downlink ACK/NAKs in response to uplink (re)transmissions are sent on PHICH;
  - Non-adaptive retransmissions (compared to the previous (re)transmission) are triggered by a NACK on PHICH only, while adaptive retransmissions are scheduled through PDCCH;
- Measurement gaps are of higher priority than HARQ retransmissions: whenever an HARQ retransmission collides with a measurement gap, the HARQ retransmission does not take place.

9.2 ARQ principles

The ARQ within the RLC sublayer has the following characteristics:

- ARQ retransmits RLC PDUs or RLC PDU segments;
  - ARQ retransmissions are based on RLC status reports, and optionally can also be based on HARQ/ARQ interactions (see subclause 9.3).
- Polling for RLC status report is used when needed by RLC;
- Status reports can be triggered by upper layers.

9.3 HARQ/ARQ interactions

In HARQ assisted ARQ operation, ARQ uses knowledge obtained from the HARQ about the transmission status of a TB: if the HARQ transmitter detects a failed delivery of a TB due to e.g. maximum retransmission limit is reached, the relevant transmitting ARQ entities are notified and potential retransmissions and re-segmentation can be initiated.

10 Mobility

Load balancing is achieved in E-UTRAN with redirection mechanisms (upon RRC establishment, in RRC_CONNECTED and upon RRC release) and through the usage of inter-frequency and inter-RAT Qoffset.

Measurements to be performed by a UE for mobility are classified in at least three measurement types:

- Intra-frequency E-UTRAN measurements;
- Inter-frequency E-UTRAN measurements;
- Inter-RAT measurements for UTRAN and GERAN.

For each measurement type a measurement identity is used by E-UTRAN when configuring measurements as well as by the UE when reporting results of the measurements. Measurement quantities and reporting events are considered separately for each measurement type. Measurement commands are used by E-UTRAN to order the UE to start measurements, modify measurements or stop measurements. Three reporting criteria are used: event triggered reporting, periodic reporting and event triggered periodic reporting.

10.1 Intra E-UTRAN

In E-UTRAN RRC_CONNECTED state, network-controlled UE-assisted handovers are performed and various DRX cycles are supported.

In E-UTRAN RRC_IDLE state, cell reselections are performed and DRX is supported.

10.1.1 Mobility Management in ECM-IDLE

10.1.1.1 Cell selection

The principles of PLMN selection in E-UTRA are based on the 3GPP PLMN selection principles. Cell selection is required on transition from EMM_DETACHED to EMM-REGISTERED and from ECM-IDLE or ECM-CONNECTED.

Cell selection:

- The UE NAS identifies a selected PLMN and equivalent PLMNs;
- The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s):
    - The UE may search each carrier in turn ("initial cell selection") or make use of stored information to shorten the search ("stored information cell selection").
- The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure:
    - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of "forbidden tracking areas for roaming";
    - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred;

Transition to RRC_IDLE:

On transition from RRC_CONNECTED to RRC_IDLE, a UE should camp on the last cell for which it was in RRC_CONNECTED or a cell/any cell of set of cells or frequency be assigned by RRC in the state transition message.

Recovery from out of coverage:

The UE should attempt to find a suitable cell in the manner described for stored information or initial cell selection above. If no suitable cell is found on any frequency or RAT the UE should attempt to find an acceptable cell.

10.1.1.2 Cell reselection

UE in RRC_IDLE performs cell reselection. The principles of the procedure are the following:

- The UE makes measurements of attributes of the serving and neighbour cells to enable the reselection process:
  - There is no need to indicate neighbouring cell in the serving cell system information to enable the UE to search and measure a cell i.e. E-UTRAN relies on the UE to detect the neighbouring cells;
  - For the search and measurement of inter-frequency neighbouring cells, only the carrier frequencies need to be indicated;
  - Measurements may be omitted if the serving cell attribute fulfils particular search or measurement criteria.
- Cell reselection identifies the cell that the UE should camp on. It is based on cell reselection criteria which involves measurements of the serving and neighbour cells:
  - Intra-frequency reselection is based on ranking of cells;
  - Inter-frequency reselection is based on absolute priorities where UE tries to camp on highest priority frequency available. Absolute priorities for reselection are provided only by the RPLMN and valid only within the RPLMN; priorities are given by the system information and valid for all UEs in a cell, specific priorities per UE can be signalled in the RRC Connection Release message. A validity time can be associated with UE specific priorities.
  - For inter-frequency neighbouring cells, it is possible to indicate layer-specific cell reselection parameters (e.g., layer specific offset). These parameters are common to all neighbouring cells on a frequency;
  - An NCL can optionally be provided by the serving cell to handle specific cases for intra- and inter-frequency neighbouring cells. This NCL can contain cell specific cell reselection parameters (e.g., cell specific offset) for specific neighbouring cells;
  - It should be possible to prevent the UE from reselecting to specific detected neighbouring cells;
  - Cell reselection can be speed dependent (speed detection based on UTRAN solution);
  - Cell reselection parameters are applicable for all UEs in a cell, but it is possible to configure specific reselection parameters per UE group or per UE.

Cell access restrictions apply as for UTRAN, which consist of access class (AC) barring and cell reservation (e.g. for cells "reserved for operator use") applicable for mobiles in RRC_IDLE mode.

10.1.1.3 Handling in eNB

10.1.1.4 Handling above eNB

10.1.1.5 Mobility Management Entity (MME)

10.1.2 Mobility Management in ECM-CONNECTED

The Intra-E-UTRAN-Access Mobility Support for UEs in ECM-CONNECTED handles all necessary steps for relocation/handover procedures, like processes that precede the final HO decision on the source network side (control and evaluation of UE and eNB measurements taking into account certain UE specific area restrictions), preparation of resources on the target network side, commanding the UE to the new radio resources and finally releasing resources on the (old) source network side. It contains mechanisms to transfer context data between evolved nodes, and to update node relations on C-plane and U-plane.

In E-UTRAN RRC_CONNECTED state, network-controlled UE-assisted handovers are performed and various DRX cycles are supported:

The UE makes measurements of attributes of the serving and neighbour cells to enable the process:

- There is no need to indicate neighbouring cell to enable the UE to search and measure a cell i.e. E-UTRAN relies on the UE to detect the neighbouring cells;
- For the search and measurement of inter-frequency neighbouring cells, only the carrier frequencies need to be indicated (other information FFS);
- Network signals reporting criteria for event-triggered and periodical reporting;
- An NCL can optionally be provided by the serving cell to handle specific cases. This NCL can contain cell specific cell reselection parameters (e.g. cell specific offset) for specific neighbouring cells.

Depending on whether the UE needs transmission/reception gaps to perform the relevant measurements, measurements are classified as gap assisted or non-gap assisted. A non-gap assisted measurement is a measurement on a cell that does not require transmission/reception gaps to allow the measurement to be performed. A gap assisted measurement is a measurement on a cell that does require transmission/reception gaps to allow the measurement to be performed. Gap patterns (as opposed to individual gaps) are configured and activated by RRC.

10.1.2.1 Handover

The intra E-UTRAN HO in RRC_CONNECTED state is UE assisted NW controlled HO, with HO preparation signalling in E-UTRAN:

- Part of the HO command comes from the target eNB and is transparently forwarded to the UE by the source eNB;
- The QoS profiles in use by the UE (EPS bearer attributes) are sent to the target eNB by the source eNB, and it is FFS if also the currently used AS configuration is sent (intra-MME case);
- Both the source eNB and UE keep some context (e.g. C-RNTI) to enable the return of the UE in case of HO failure;
- UE accesses the target cell via RACH following a contention-free procedure using a dedicated RACH preamble or following a contention-based procedure if dedicated RACH preambles are not available:
    - If an end-time is associated to the dedicated preamble, the UE follows a contention-based procedure after reaching the end time;
    - If an end-time is not associated to the dedicated preamble, the UE uses the dedicated preamble until the handover procedure is finished (successfully or unsuccessfully);
- If the RACH procedure towards the target cell is not successful within a certain time, the UE initiates radio link failure recovery using the best cell;

- No ROHC context is transferred during inter eNB mobility.

10.1.2.1.1 C-plane handling

The HO procedure is performed without EPC involvement, i.e. preparation messages are directly exchanged between the eNBs. The release of the resources at the source side during the HO completion phase is triggered by the eNB. The figure below depicts the basic handover scenario where neither MME nor Serving Gateway changes:

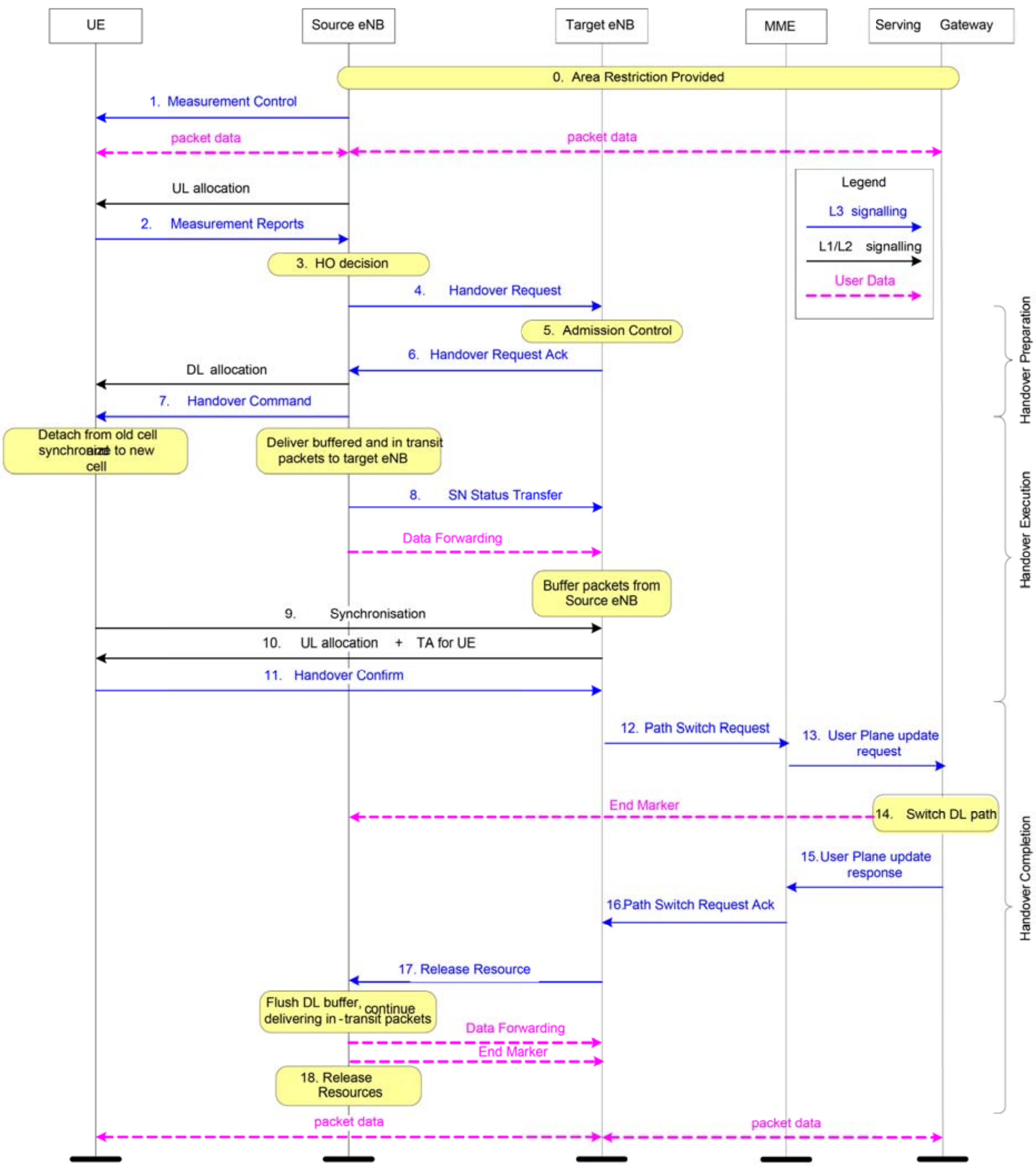

Figure 10.1.2.1.1-1: Intra-MME/Serving Gateway HO

Below is a more detailed description of the intra-MME/Serving Gateway HO procedure:

ZTE/HTC
Exhibit 1017-0093

0 The UE context within the source eNB contains information regarding roaming restrictions which where provided either at connection establishment or at the last TA update.

1 The source eNB configures the UE measurement procedures according to the area restriction information. Measurements provided by the source eNB may assist the function controlling the UE's connection mobility.

2 UE is triggered to send MEASUREMENT REPORT by the rules set by i.e. system information, specification etc.

3 Source eNB makes decision based on MEASUREMENT REPORT and RRM information to hand off UE.

4 The source eNB issues a HANDOVER REQUEST message to the target eNB passing necessary information to prepare the HO at the target side (UE X2 signalling context reference at source eNB, UE S1 EPC signalling context reference, target cell ID, K_{eNB^*}, RRC context including the C-RNTI of the UE in the source eNB, AS-configuration (excluding physical layer configuration), EPS bearer context and physical layer ID of the source cell + MAC for possible RLF recovery). UE X2 / UE S1 signalling references enable the target eNB to address the source eNB and the EPC. The EPS bearer context includes necessary RNL and TNL addressing information, and QoS profiles of the EPS bearers.

5 Admission Control may be performed by the target eNB dependent on the received EPS bearer QoS information to increase the likelihood of a successful HO, if the resources can be granted by target eNB. The target eNB configures the required resources according to the received EPS bearer QoS information and reserves a C-RNTI and optionally a RACH preamble. The AS-configuration to be used in the target cell can either be specified independently (i.e. an "establishment") or as a delta compared to the AS-configuration used in the source cell (i.e. a "reconfiguration").

6 Target eNB prepares HO with L1/L2 and sends the HANDOVER REQUEST ACKNOWLEDGE to the source eNB. The HANDOVER REQUEST ACKNOWLEDGE message includes a transparent container to be sent to the UE as part of the Handover Command. The container includes a new C-RNTI, target eNB security algorithm identifiers for the selected security algorithms, may include a dedicated RACH preamble, indication of the expiry time of the dedicated RACH preamble, and possibly some other parameters i.e. access parameters, SIBs, etc. The HANDOVER REQUEST ACKNOWLEDGE message may also include RNL/TNL information for the forwarding tunnels, if necessary.

NOTE: As soon as the source eNB receives the HANDOVER REQUEST ACKNOWLEDGE, or as soon as the transmission of the handover command is initiated in the downlink, data forwarding may be initiated.

Steps 7 to 16 provide means to avoid data loss during HO and are further detailed in 10.1.2.1.2 and 10.1.2.3.

7 The source eNB generates the HANDOVER COMMAND (RRC message) towards the UE. The HANDOVER COMMAND includes the transparent container, which has been received from the target eNB. The source eNodeB performs the necessary integrity protection and ciphering of the message. The UE receives the HANDOVER COMMAND with necessary parameters (i.e. new C-RNTI, target eNB security algorithm identifiers, and optionally dedicated RACH preamble, possible expiry time of the dedicated RACH preamble, target eNB SIBs etc) and is commanded by the source eNB to perform the HO. The UE does not need to delay the handover execution for delivering the HARQ/ARQ responses to source eNB.

8 The source eNB sends the SN STATUS TRANSFER message to the target eNB to convey the uplink PDCP SN receiver status and the downlink PDCP SN transmitter status of SAE bearers for which PDCP status preservation applies. The uplink PDCP SN receiver status includes at least the PDCP SN of the last in-sequence received UL SDU and may include a bit map of the receive status of the out of sequence missing (FFS) UL SDUs that the UE may need to retransmit in the target cell, if there are any such SDUs. The downlink PDCP SN transmitter status indicates the next PDCP SN that the target eNB shall assign to new SDUs, not having a PDCP SN yet. The source eNB may omit sending this message if none of the SAE bearers of the UE shall be treated with PDCP status preservation.

9 After receiving the HANDOVER COMMAND, UE performs synchronisation to target eNB and accesses the target cell via RACH following a contention-free procedure if a dedicated RACH preamble was allocated in HANDOVER COMMAND or following a contention-based procedure if no dedicated preamble was allocated. UE derives target eNB specific keys and configures the selected security algorithms to be used in the target cell.

10 Network responds with UL allocation and timing advance.

11 When the UE has successfully accessed the target cell, the UE sends the HANDOVER CONFIRM message (C-RNTI) along with an uplink Buffer Status Report when required to the target eNB to indicate that the handover

procedure is completed for the UE. The target eNB verifies the C-RNTI sent in the HANDOVER CONFIRM message. The target eNB can now begin sending data to the UE. Based on further optimizations, the downlink data transmission can begin as early as after step 8.

12 The target eNB sends a PATH SWITCH message to MME to inform that the UE has changed cell.

13 The MME sends a USER PLANE UPDATE REQUEST message to the Serving Gateway.

14 The Serving Gateway switches the downlink data path to the target side. The Serving gateway sends one or more "end marker" packets on the old path to the source eNB and then can release any U-plane/TNL resources towards the source eNB.

15 Serving Gateway sends a USER PLANE UPDATE RESPONSE message to MME.

16 The MME confirms the PATH SWITCH message with the PATH SWITCH ACK message.

17 By sending RELEASE RESOURCE the target eNB informs success of HO to source eNB and triggers the release of resources. The target eNB sends this message after the PATH SWITCH ACK message is received from the MME.

18 Upon reception of the RELEASE RESOURCE message, the source eNB can release radio and C-plane related resources associated to the UE context.

NOTE: Details on updating of roaming/area restriction information within E-UTRAN in the course of the HO procedure are FFS

With respect to SRBs, the following principles apply:

- No forwarding or retransmissions of RRC messages in the target;
- The PDCP SN and HFN are reset in the target eNB.

10.1.2.1.2 U-plane handling

The U-plane handling during the Intra-E-UTRAN-Access mobility activity for UEs in ECM-CONNECTED takes the following principles into account to avoid data loss during HO:

- During HO preparation U-plane tunnels can be established between the source eNB and the target eNB. There is one tunnel established for uplink data forwarding and another one for downlink data forwarding for each SAE bearer for which data forwarding is applied.
- During HO execution, user data can be forwarded from the source eNB to the target eNB. The forwarding may take place in a service and deployment dependent and implementation specific way.
  - Forwarding of downlink user data from the source to the target eNB should take place in order as long as packets are received at the source eNB from the EPC or the source eNB buffer has not been emptied.
- During HO completion:
  - The target eNB sends a PATH SWITCH message to MME to inform that the UE has gained access and MME sends a USER PLANE UPDATE REQUEST message to the Serving Gateway, the U-plane path is switched by the Serving Gateway from the source eNB to the target eNB.
  - The source eNB should continue forwarding of U-plane data as long as packets are received at the source eNB from the Serving Gateway or the source eNB buffer has not been emptied.

For **RLC-AM bearers**:

- For in-sequence delivery and duplication avoidance, PDCP SN is maintained on a bearer basis and the source eNB informs the target eNB about the next DL PDCP SN to allocate to a packet which does not have a PDCP sequence number yet (either from source eNB or from the Serving Gateway).
- For security synchronisation, HFN is also maintained and the source eNB provides to the target one reference HFN for the UL and one for the DL i.e. HFN and corresponding SN.
- In both the UE and the target eNB, a window-based mechanism is needed for duplication detection.

- The occurrence of duplicates over the air interface in the target eNB is minimised by means of PDCP SN based reporting at the target eNB by the UE. In uplink, the reporting is optionally configured on a bearer basis by the eNB and the UE should first start by transmitting those reports when granted resources in the target eNB. In downlink, the eNB is free to decide when and for which bearers a report is sent and the UE does not wait for the report to resume uplink transmission.
- The target eNB re-transmits and prioritizes all downlink PDCP SDUs forwarded by the source eNB (i.e. the target eNB should send data with PDCP SNs from X2 before sending data from S1), with the exception of PDCP SDUs of which the reception was acknowledged through PDCP SN based reporting by the UE.
- The UE re-transmits in the target eNB all uplink PDCP SDUs starting from the first PDCP SDU following the last consecutively confirmed PDCP SDU i.e. the oldest PDCP SDU that has not been acknowledged at RLC in the source, excluding the PDCP SDUs of which the reception was acknowledged through PDCP SN based reporting by the target.

For **RLC-UM bearers**:

- The PDCP SN and HFN are reset in the target eNB.
- No PDCP SDUs are retransmitted in the target eNB.
- The target eNB prioritize all downlink PDCP SDUs forwarded by the source eNB if any (i.e. the target eNB should send data with PDCP SNs from X2 before sending data from S1),.
- The UE PDCP entity does not attempt to retransmit any PDCP SDU in the target cell for which transmission had been completed in the source cell. Instead UE PDCP entity starts the transmission with other PDCP SDUs.

10.1.2.2 Path Switch

After the downlink path is switched at the Serving GW downlink packets on the forwarding path and on the new direct path may arrive interchanged at the target eNB. The target eNodeB should first deliver all forwarded packets to the UE before delivering any of the packets received on the new direct path. The method employed in the target eNB to enforce the correct delivery order of packets is outside the scope of the standard.

In order to assist the reordering function in the target eNB, the Serving GW shall send one or more "end marker" packets on the old path immediately after switching the path for each SAE bearer of the UE. The "end marker" packet shall not contain user data. The "end marker" is indicated in the GTP header. After completing the sending of the tagged packets the GW shall not send any further user data packets via the old path.

Upon receiving the "end marker" packets, the source eNB shall, if forwarding is activated for that bearer, forward the packet toward the target eNB.

On detection of an "end marker" the target eNB shall discard the end marker packet and initiate any necessary processing to maintain in sequence delivery of user data forwarded over X2 interface and user data received from the serving GW over S1 as a result of the path switch.

10.1.2.3 Data forwarding

10.1.2.3.1 For RLC-AM bearers

Upon handover, the source eNB forwards in order to the target eNB all downlink PDCP SDUs with their SN that have not been acknowledged by the UE. In addition, the source eNB may forward without a PDCP SN fresh data arriving over S1 to the target eNB. In addition, the source eNB may forward fresh data arriving over S1 to the target eNB.

NOTE: Target eNB does not have to wait for the completion of forwarding from the source eNB before it begins transmitting packets to the UE.

The source eNB discards any remaining downlink RLC PDUs. Correspondingly, the source eNB does not forward the downlink RLC context to the target eNB.

NOTE: Source eNB does not need to abort on going RLC transmissions with the UE as it starts data forwarding to the target eNB.

Upon handover, the source eNB forwards uplink PDCP SDUs successfully received in-sequence to the Serving Gateway, may forward uplink PDCP SDUs with their SN received out-of-sequence to the target eNB and shall discard any remaining uplink RLC PDUs. Correspondingly, the source eNB does not forward the uplink RLC context to the target eNB.

The PDCP SN of forwarded SDUs is carried in the "PDCP PDU number" field of the GTP-U extension header. The target eNB shall use the PDCP SN if it is available in the forwarded GTP-U packet.

In-sequence delivery of upper layer PDUs during handover is based on a continuous PDCP SN and is provided by the re-ordering function at the PDCP layer, which can be activated at least during inter-eNB mobility:

- in the downlink, the re-ordering function at the UE PDCP layer guarantees in-sequence delivery of downlink PDCP SDUs;
- in the uplink, the re-ordering function at the target eNB PDCP layer guarantees in-sequence delivery of uplink PDCP SDUs.

After handover, when the UE receives a PDCP SDU from the target eNB, it can deliver it to higher layer together with all PDCP SDUs with lower SNs regardless of possible gaps.

10.1.2.3.2 For RLC-UM bearers

Upon handover, the source eNB does not forward to the target eNB downlink PDCP SDUs for which transmission had been completed in the source cell. PDCP SDUs that have not been transmitted may be forwarded. In addition, the source eNB may forward fresh data arriving over S1 to the target eNB. The source eNB discards any remaining downlink RLC PDUs. Correspondingly, the source eNB does not forward the downlink RLC context to the target eNB.

Upon handover, the source eNB forwards all uplink PDCP SDUs successfully received to the Serving Gateway and discards any remaining uplink RLC PDUs. Correspondingly, the source eNB does not forward the uplink RLC context to the target eNB.

10.1.2.4 Handling in eNB

10.1.2.5 Handling above eNB

10.1.2.6 Mobility Management Entity (MME)

10.1.2.7 Timing Advance

In RRC_CONNECTED, the eNB is responsible for maintaining the timing advance. In some cases (e.g. during DRX), the timing advance is not necessarily always maintained and the MAC sublayer knows if the L1 is synchronised and which procedure to use to start transmitting in the uplink:

- as long as the L1 is non-synchronised, uplink transmission can only take place on PRACH.

For one UE, cases where the UL synchronisation status moves from "synchronised" to "non-synchronised" include:

- Expiration of a timer;
- Non-synchronised handover;
- Explicit request by MAC or RRC in the eNB (FFS);

The value of the timer is either UE specific and managed through dedicated signalling between the UE and the eNB, or cell specific and indicated via broadcast information. In both cases, the timer is always restarted whenever a new timing advance is given by the eNB:

- restarted to a UE specific value if any; or
- restarted to a cell specific value otherwise.

Upon DL data arrival, dedicated signature on PRACH can be allocated by the eNB to UE. When a dedicated signature on PRACH is allocated, the UE shall perform the corresponding random access procedure regardless of its L1 synchronisation status.

TA updates are signalled by the eNB to the UE in MAC PDUs addressed via C-RNTI, and embedded with user data or alone.

10.1.3 Measurements

Measurements to be performed by a UE for intra/inter-frequency mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control for RRC_IDLE state is FFS. In RRC_CONNECTED state, a UE shall follow the measurement configurations specified by RRC directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

Intra-frequency neighbour (cell) measurements and inter-frequency neighbour (cell) measurements are defined as follows:

- Intra-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are intra-frequency measurements when the current and target cell operates on the same carrier frequency. The UE shall be able to carry out such measurements without measurement gaps.

- Inter-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the neighbour cell operates on a different carrier frequency, compared to the current cell. The UE should not be assumed to be able to carry out such measurements without measurement gaps.

Whether a measurement is non gap assisted or gap assisted depends on the UE's capability and current operating frequency. The UE determines whether a particular cell measurement needs to be performed in a transmission/reception gap and the scheduler needs to know whether gaps are needed:

- Same carrier frequency and cell bandwidths (Scenario A): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell smaller than the bandwidth of the current cell (Scenario B): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell larger than the bandwidth of the current cell (Scenario C): FFS.

- Different carrier frequencies, bandwidth of the target cell smaller than the bandwidth of the current cell and bandwidth of the target cell within bandwidth of the current cell (Scenario D): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies, bandwidth of the target cell larger than the bandwidth of the current cell and bandwidth of the current cell within bandwidth of the target cell (Scenario E): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies and non-overlapping bandwidth, (Scenario F): an inter-frequency scenario; measurement gap-assisted scenario.

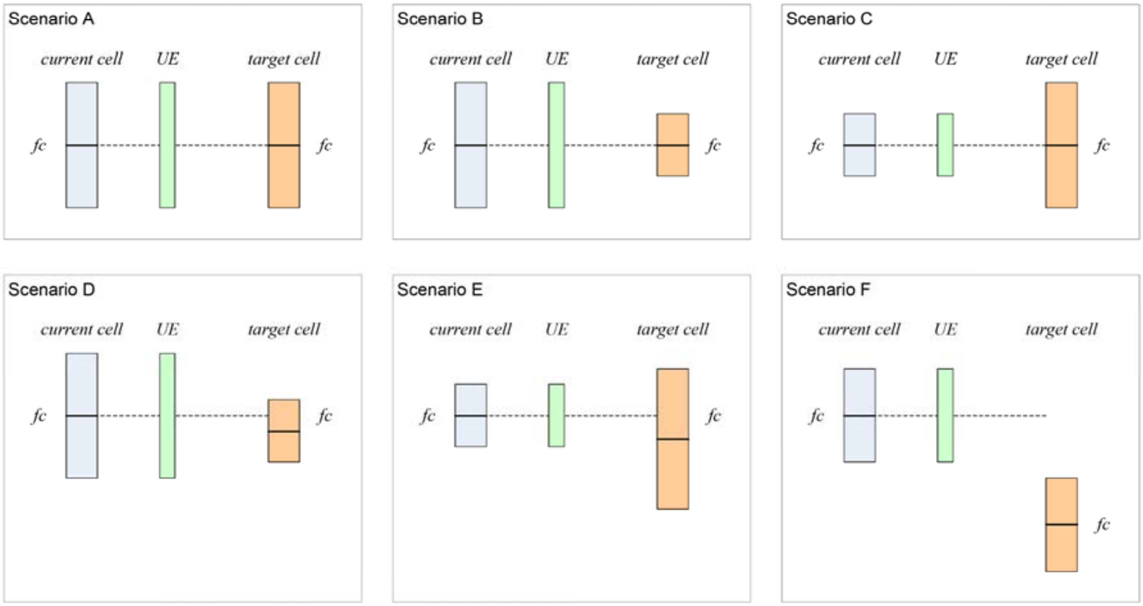

Figure 10.1.3-1: Inter and Intra-frequency measurements scenarios

Measurement gaps patterns are configured and activated by RRC. Measurement gaps are of higher priority than HARQ retransmissions i.e. if an HARQ retransmissions collides with a measurement gap, the HARQ retransmission does not take place.

10.1.3.1 Intra-frequency neighbour (cell) measurements

In a system with frequency reuse = 1, mobility within the same frequency layer (i.e. between cells with the same carrier frequency) is predominant. Good neighbour cell measurements are needed for cells that have the same carrier frequency as the serving cell in order to ensure good mobility support and easy network deployment. Search for neighbour cells with the same carrier frequency as the serving cell, and measurements of the relevant quantities for identified cells are needed.

NOTE: To avoid UE activity outside the DRX cycle, the reporting criteria for neighbour cell measurements should match the used DRX cycle.

10.1.3.2 Inter-frequency neighbour (cell) measurements

Regarding mobility between different frequency layers (i.e. between cells with a different carrier frequency), UE may need to perform neighbour cell measurements during DL/UL idle periods that are provided by DRX or packet scheduling (i.e. gap assisted measurements).

10.1.4 Paging and C-plane establishment

Paging groups (where multiple UEs can be addressed) are used on L1/L2 signalling channel:

- Precise UE identity is found on PCH;
- DRX configurable via BCCH (UE specific DRX is FFS);
- Only one subframe allocated per paging interval per UE;
- The network may divide UEs to different paging occasions in time;
- There is no grouping within paging occasion;
- One paging RNTI for PCH.

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;

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

- Initial access from RRC_IDLE;
- Initial access after radio link failure;
- Handover requiring random access procedure;
- 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.

Furthermore, the random access procedure takes two distinct forms:

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

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:

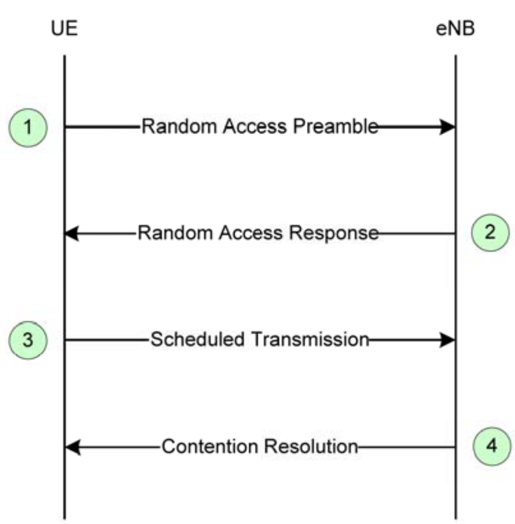

Figure 10.1.5.1-1: Contention based Random Access Procedure

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

1) Random Access Preamble on RACH in uplink:
    - 6 bits to carry: a 5 bit random ID, and 1 bit to indicate information on size of message 3 or requested resource blocks (FFS) limited by radio conditions. The groups of signatures that are used for indicating the 1 bit information, as well as necessary thresholds are broadcast on system information.