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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	UT09-1365
	Application Number	
Title of Invention	SI PROVIDING FOR CA	

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Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Seung June		YI	

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Citizenship under 37 CFR 1.41(b)[i] KR

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Applicant 2 Remove

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Prefix	Given Name	Middle Name	Family Name	Suffix
	Young Dae		LEE	

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Applicant 3 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Sung Duck		CHUN	

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	Sung Jun		PARK	

Residence Information (Select One) ( ) US Residency (•) Non US Residency ( ) Active US Military Service

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Citizenship under 37 CFR 1.41(b) i	KR		

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Prefix	Given Name	Middle Name	Family Name	Suffix
	Sung Hoon		JUNG	

Residence Information (Select One) ( ) US Residency (•) Non US Residency ( ) Active US Military Service

City	Anyang	**Country Of Residence**i	KR
Citizenship under 37 CFR 1.41(b) i	KR		

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City	Anyang	**State/Province**		
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Prefix	Given Name	Middle Name	Family Name	Suffix
	Sung Min		LEE	

Residence Information (Select One) ( ) US Residency (•) Non US Residency ( ) Active US Military Service

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Prefix	Given Name	Middle Name	Family Name	Suffix
	Sun Hee		KIM	

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Citizenship under 37 CFR 1.41(b)[i]	KR		

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Postal Code	431-080	Country[i]	KR

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Applicant Authority (•) Inventor ( ) Legal Representative under 35 U.S.C. 117 ( ) Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kyung Jun		LEE	

Residence Information (Select One) ( ) US Residency (•) Non US Residency ( ) Active US Military Service

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Citizenship under 37 CFR 1.41(b)[i]	KR		

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Postal Code	431-080	Country[i]	KR

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	67487		
Email Address	info@kpatent.com	Add Email	Email

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Title of Invention	SI PROVIDING FOR CA	

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Application Information:

Title of the Invention	SI PROVIDING FOR CA		
Attorney Docket Number	UT09-1365	**Small Entity Status Claimed**	☐
Application Type	Provisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recongnition (37 CFR 11.9)
Customer Number	67487		

Domestic Benefit Information:

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)

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Foreign Priority Information:

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	UT09-1365
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This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

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Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◉ Yes ○ No

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Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. ☒

Organization Name	LG Electronics Inc.		
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Country [i] KR		Postal Code	150-721
Phone Number		Fax Number	
Email Address			

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Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Andrew S. Park/			Date (YYYY-MM-DD)	2009-11-02
First Name	Andrew	Last Name	Park	Registration Number	47841

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PROVISIONAL APPLICATION FOR UNITED STATES PATENT
IN THE NAMES OF

Seung June YI, Young Dae LEE, Sung Duck CHUN, Sung Jun PARK,
Sung Hoon JUNG, Sung Min LEE, Sun Hee KIM and Kyung Jun LEE

for

SI PROVIDING FOR CA

prepared by:

KBK & Associates

Customer Number: 67487

Attorney Docket Number: UT09-1365

Total Number of Pages : 106 (including cover)

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00007

Title: **Measurement procedure on DC-HSUPA**
Agenda item: **x.x.x**
Document for: **Discussion and decision**

1 Introduction

RAN2#67bis meeting에서 [1]이 baseline으로 승인되었다. 이 baseline에서, Network 이 한 UE에서 사용되는 두 개의 Frequency에 대한 intra-frequency measurement를 configuration 할 때, 하나의 Measurement ID를 Primary 와 Secondary carrier가 공유할지 혹은 각각의 carrier 마다 하나의 Measurement ID를 사용할지는 아직 결정되지 않았다. 또한, Network가 CELL_PCH상태에서 CELL Update Confirm 메시지로 UE의 Primary와 Secondary Carrier를 Configuration 할 때, UE가 어떻게 Secondary carrier의 measurement results를 network에게 알려주는지에 관한 것이 논의 되지 않았다.

따라서, 이 문서에서는 네트워크가 dual cell operation을 사용하는 UE를 위하여 measurement ID를 어떻게 사용할 지를 define하고, UE가 CELL_PCH state 에서의 SIB 11 혹은 SIB12 수신시의 어떻게 동작하고, UE가 CELL_PCH 상태에서 어떻게 secondary carrier의 measurement results를 네트워크에게 전송할지에 대하여 논의하고자 한다.

2 Discussion

2.1 The number of Measurement Identity

Normally, one intra-frequency measurement identity corresponds to one intra-frequency event. So, in order to allow two intra-frequency events, two intra-frequency measurement identities are needed. It means that two MEASUREMENT CONTROL messages should be sent in DC-HSUPA (because one measurement identity corresponds to a MEASUREMENT CONTROL message).

Sending two MEASUREMENT CONTROL messages in DC-HSUPA has a good aspect that it provides measurement configuration flexibility to network. However, considering that the number of measurement identity is limited, it would be preferable to use only one measurement identity for both carriers. Since the geography of primary E-DCH serving cell is same as that of secondary E-DCH serving cell, it is expected that the measurement objects or measurement quantity per carrier would be almost same, so it might be enough to have same measurement identity for both carriers.

Proposal 1: It is asked to discuss how many measurement identities should be used for intra-frequency measurement of dual carriers.

From our point of view, only one measurement identity is sufficient.

2.2 Intra-frequency measurement system information

RRC Baseline CR로 승인된 [1]에 따르면, UE가 전송하는 Measurement Report의 intra-frequency cell info list IE 내에 주파수 정보가 추가 되었다. 이는 Network와 UE사이에 Measurement configuration 시, 어떤 carrier (Primary carrier/secondary carrier)에 관한 것 인지를 구별하기 위해서이다. 이와 마찬가지로 Measurement Control message내부의 intra-frequency measurement reporting criteria 내에도 주파수 정보가 추가되었다.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00008

하지만, 한 셀 내에서 사용할 measurement control 정보를 알려주는 SIB 11 혹은 SIB 12 가 frequency info를 포함하는 지에 대한 여부는 아직 정의되지 않았다.

SIB11 은 Cell내에 모든 UE가 수신되는 값이므로, 해당 Cell 내에 Dual cell operation을 수행하는 UE뿐만 아니라 Single cell operation을 수행하는 UE도 같은 SIB11을 수신한다. 그런데, Dual Cell Operation을 수행하는 UE와는 달리 Single Cell Operation을 수행하는 UE는 frequency 정보가 필요 없다. 따라서 네트워크가 intra-frequency measurement를 위하여 SIB11 에 해당 frequency정보를 포함해야 하는지에 대해 논의할 필요가 있다.

SIB11에 frequency 정보가 없을 때 문제점? 있을 때 문제점? 둘의 비교.. 비교 결과 있는게 낫다.

Proposal 2: SIB11 should contain the IE "frequency info".

2.3 Measured Results on RACH for intra-frequency measurement

RRC Baseline CR로 승인된 [1]에 따르면, network은 RB control message 뿐 아니라 CELL Update Confirm을 통하여서도 Dual Cell을 supporting 하는 UE에게 두 frequency를 Configuration 하는 것이 가능하다. 그런데, 이를 위해서는 Dual Cell을 supporting하는 Cell_PCH 상태의 UE는 Cell_DCH 상태의 UE와 마찬가지로 두 frequency에 대한 measurement result를 전송해야 한다.

Proposal 3: The UE in CELL_PCH state should report measurement results on two frequencies to network.

Cell_PCH 상태의 UE가 measurement result를 전송할 때에는 Measured Results on RACH IE를 Measurement Report에 포함시켜 전송한다. 그런데, 현재 표준에 따르면 Measured Results on RACH IE에는 frequency 정보가 포함되지 않는다. 따라서, 두 frequency에 대한 measurement result를 구분하기 위해 Measured Results on RACH IE에 frequency 정보가 포함되어야 한다.

Proposal 4: Frequency information should be included in Measured Results on RACH IE.

Measured Results on RACH IE는 최대한 작은 message를 전송하여야 한다. 본 메시지는 CCCH 메시지로 전송할 수 있으며, 이는 Size restrict하기 때문에, 최대한 작은 Size로 전송하여야 한다. 기존 intra-frequency measurement는 최대 "Maximum number of reported cells on RACH" 개수만큼의 Cell을 measure하여 알려준다. Secondary carrier에 대하여 최대 몇 개의 cell을 measure해야 하는지는 남아있는 이슈이다.

1. Primary와 같이 Maximum number of reported cells on RACH 개수의 cell을 measure하여 알려준다.
2. 네트워크가 먼저 Secondary carrier에 대한 Threshold 값을 준다.

1) 이후, Secondary frequency에 할당된 CELL들을 measure하여 그 measure된 값이 네트워크로부터 수신받은 Threshold을 초과하면, threshold를 초과한 CELL에 대하여 Frequency와 measurement 결과를 알려준다. 해당 measurement 결과는 Ec/No 등으로 알려준다.

3 Conclusion

We would like to suggest following proposals with appendix in the section 4:

Proposal 1: It is asked to discuss how many measurement identities should be used for intra-frequency measurement of dual carriers.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00009

Proposal 2: SIB11 should contain the IE "frequency info".

Proposal 3: The UE in CELL_PCH state should report measurement results on two frequencies to network.

Proposal 4: Frequency information should be included in Measured Results on RACH IE.

4 Appendix

8.1.1.6.11 System Information Block type 11

If the cell is not operating in MBSFN mode according to subclause 8.1.1.6.3 the UE should store all relevant IEs included in this system information block. If the cell is not operating in MBSFN mode according to subclause 8.1.1.6.3 the UE shall:

1> if in idle mode:

2> clear the variable MEASUREMENT_IDENTITY.

1> if IE "FACH measurement occasion info" is included:

2> act as specified in subclause 8.6.7.

1> else:

2> may perform inter-frequency/inter-RAT measurements or inter-frequency/inter-RAT cell re-selection evaluation, if the UE capabilities permit such measurements while simultaneously receiving the S-CCPCH of the serving cell.

1> clear the variable CELL_INFO_LIST;

1> act upon the received IE "Intra-frequency cell info list"/"Inter-frequency cell info list"/"Inter-RAT cell info list" as described in subclause 8.6.7.3;

1> if the IE "Inter-frequency RACH reporting information" is included in the system information block:

2> read the IE and use that information for the inter-frequency measurements as specified in subclause 8.5.23.

1> if in idle mode; or

1> if in connected mode and if System Information Block type 12 is not broadcast in the cell:

2> if no intra-frequency measurement stored in the variable MEASUREMENT_IDENTITY was set up or modified through a MEASUREMENT CONTROL message:

3> if included, store the IE "Intra-frequency reporting quantity" and the IE "Intra-frequency measurement reporting criteria" or "Periodical reporting criteria" in order to activate reporting when state CELL_DCH is entered in the variable MEASUREMENT_IDENTITY. The IE "Cells for measurement" is absent for this measurement. The IE "Measurement Validity" is absent for this measurement after a state transition to CELL_DCH;

1> if in connected mode and if System Information Block type 12 is not broadcast in the cell:

2> read the IE "Traffic volume measurement system information";

2> if no traffic volume measurement with the measurement identity indicated in the IE "Traffic volume measurement system information" was set up or modified through a MEASUREMENT CONTROL message:

3> update the variable MEASUREMENT_IDENTITY with the measurement information received in that IE.

1> if the IE "Cell selection and reselection info" is not included for a new neighbouring cell in the IE "intra-frequency cell info list", the IE "inter-frequency cell info list" or the IE "inter-RAT cell info list" in System Information Block type 11:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00010

2> use the default values specified for the IE "Cell selection and reselection info" for that cell except for the IE "HCS neighbouring cell information".

1> if the IE "Use of HCS" is set to "used", indicating that HCS is used, do the following:

2> if IE "HCS neighbouring cell information" is not included for the first new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 11:

3> use the default values specified for the IE "HCS neighbouring cell information" for that cell.

2> if IE "HCS neighbouring cell information" is not included for any other new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 11:

3> for that cell use the same parameter values as used for the preceding cell in the same cell info list in System Information Block type 11.

1> if the value of the IE "Cell selection and reselection quality measure" is different from the value of the IE "Cell selection and reselection quality measure" obtained from System Information Block type 3 or System Information Block type 4:

2> use the value of the IE from this System Information Block and ignore the value obtained from System Information Block type 3 or System Information Block type 4.

1> if in connected mode, and System Information Block type 12 is indicated as used in the cell:

2> read and act on information sent in System Information Block type 12 as indicated in subclause 8.1.1.6.12.

1> if IE "MBSFN frequency list" is included:

2> act as specified in subclause 8.6.9.9ac.

For 1.28 Mcps TDD if the cell is operating in MBSFN only mode according to subclause 8.1.1.6.3 the UE shall:

1> store the frequencies and their corresponding "cell parameter ID" indicated in the IE "MBSFN LCR TDD frequency list" included in the IE "MBSFN frequency list".

If the cell is operating in MBSFN mode according to subclause 8.1.1.6.3 the UE may:

1> for FDD and 3.84/7.68 Mcps TDD consider the cells indicated in the IE "Intra-frequency cell info list" in the IE "Intra-frequency measurement system information" as candidates for the selection of the MBSFN cluster;

1> for 1.28 Mcps TDD consider there exist MBSFN clusters deployed with the frequencies and their corresponding "cell parameter ID" stored.

For 1.28 Mcps TDD if the cell is not operating in MBSFN only mode but associated with one or more MBSFN clusters the UE shall:

1> store the frequencies and their corresponding "cell parameter ID" indicated in the IE "MBSFN LCR TDD frequency list" included in the IE "MBSFN frequency list";

1> consider there exist MBSFN clusters deployed with the frequencies and their corresponding "cell parameter ID" stored;

1> search an MBSFN cluster in MBSFN only mode with its frequency and corresponding "cell parameter ID" for monitoring the MBMS services delivered in dedicated MBSFN frequency layer.

NOTE: The IE "Intra-frequency cell info list" may not include information about all neighbouring MBSFN clusters

For FDD, the UE shall:

1> When the IE "frequency info" is included in the IE "Intra-frequency measurement system information" from System Information Block type 11,

2> if UE does not support multi cell E-DCH operation,

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00011

3>ignore the received IE and the UE behaviour is undefined.

2> else

3> measure the frequency adjacent to frequency of the current cell among the frequencies in the IE "Frequency Info"

8.1.1.6.12 System Information Block type 12

If in connected mode, the UE should store all relevant IEs included in this system information block. The UE shall:

1> after reception of System Information Block type 11; and

1> after reception of System Information Block type 11bis, if broadcast in the cell:

2> update the variable MEASUREMENT_IDENTITY with the measurement information in the received IEs unless specified otherwise.

1> if IE "FACH measurement occasion info" is included:

2> act as specified in subclause 8.6.7.

1> else:

2> may perform inter-frequency/inter-RAT measurements or inter-frequency/inter-RAT cell re-selection evaluation, if the UE capabilities permit such measurements while simultaneously receiving the S-CCPCH of the serving cell.

1> act upon the received IE "Intra-frequency cell info list"/"Inter-frequency cell info list"/"Inter-RAT cell info list" as described in subclause 8.6.7.3;

1> if any of the IEs "Intra-frequency measurement quantity", "Intra-frequency reporting quantity for RACH reporting", "Maximum number of reported cells on RACH" or "Reporting information for state CELL_DCH" are not included in the system information block:

2> read the corresponding IE(s) in system information block type 11 and use that information for the intra-frequency measurement.

1> if the IE "Inter-frequency RACH reporting information" is included in this system information block or in System Information Block type 11:

2> if the IE is not included in the system information block, read the corresponding IE(s) in System Information Block type 11;

2> use the received information for the inter-frequency measurements as specified in subclause 8.5.23.

1> if included in this system information block or in System Information Block type 11:

2> if no intra-frequency measurement in the variable MEASUREMENT_IDENTITY was set up or modified through a MEASUREMENT CONTROL message:

3> store the IE "Intra-frequency reporting quantity" and the IE "Intra-frequency measurement reporting criteria" or "Periodical reporting criteria" in order to activate reporting when state CELL_DCH is entered in the variable MEASUREMENT_IDENTITY. The IE "Cells for measurement" is absent for this measurement. The IE "Measurement Validity" is absent for this measurement after a state transition to CELL_DCH;

1> if the IE "Traffic volume measurement system information" is not included in this system information block:

2> read the corresponding IE in System Information Block type 11.

1> if the IE "Traffic volume measurement system information" was received either in this system information block or in System Information Block type 11:

2> if no traffic volume measurement with the measurement identity indicated in the IE "Traffic volume measurement system information" was set up or modified through a MEASUREMENT CONTROL message:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00012

3> update the variable MEASUREMENT_IDENTITY with the measurement information received in that IE.

1> if in CELL_FACH state:

2> start or continue the traffic volume measurements stored in the variable MEASUREMENT_IDENTITY that are valid in CELL_FACH state.

1> if the IE "Cell selection and reselection info" is not included for a new neighbouring cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

2> use the default values specified for the IE "Cell selection and reselection info" for that cell except for the IE "HCS neighbouring cell information".

1> if the IE "Use of HCS" is set to "used", indicating that HCS is used, do the following:

2> if IE "HCS neighbouring cell information" is not included for the first new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

3> use the default values specified for the IE "HCS neighbouring cell information" for that cell.

2> if IE "HCS neighbouring cell information" is not included for any other new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

3> for that cell use the same parameter values as used for the preceding cell in the same cell info list in System Information Block type 12.

1> if the value of the IE "Cell selection and reselection quality measure" is different from the value of the IE "Cell selection and reselection quality measure" obtained from System Information Block type 3 or System Information Block type 4:

2> use the value of the IE from this System Information Block and ignore the value obtained from System Information Block type 3 or System Information Block type 4.

If in idle mode, the UE shall not use the values of the IEs in this system information block.

For FDD, the UE shall:

1> When the IE "frequency info" is included in the IE "Intra-frequency measurement system information" from System Information Block type 12,

2> if UE does not support multi cell E-DCH operation,

3>ignore the received IE and the UE behaviour is undefined.

2> else

3> measure the frequency adjacent to frequency of the current cell among the frequencies in the IE "Frequency Info"

8.5.23 Measured results on RACH

When transmitting an uplink RRC message and System Information Block type 11, System Information Block type 11bis and System Information Block type 12, if transmitted, have been received, the UE shall:

1> if the uplink RRC message is an RRC CONNECTION REQUEST message:

2> if the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" are included in System Information Block type 11:

3> include a measurement report in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" in System Information Block type 11.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00013

2> if the IE "Inter-frequency RACH reporting information" is included in System Information Block type 11:

3> if, at the time the message is to be sent, valid measurements are available; and

3> there is one or more cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold":

4> include a measurement report in the IE "Measured results on RACH";

4> include the cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold";

4> set the IE "Inter-frequency cell indication- SIB11" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 11;

4> set the IE "Inter-frequency cell indication- SIB12" to any value.

1> for any other uplink RRC message which optionally includes the IE "Measured results on RACH":

2> if the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" are included in System Information Block type 12 (or "System Information Block Type 11", if these IEs are not included in the broadcast "System Information Block Type 12" or "System Information Block Type 12" is not being broadcast).

3> include a measurement report in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" in System Information Block type 12 (or "System Information Block Type 11" if these IEs are not included in the broadcast "System Information Block Type 12" or "System Information Block Type 12" is not being broadcast).3> if the UE supports multi cell E-DCH operation:

4> if one frequency among the IE "Frequency info" of the "New intra-frequency cells" in the IE "Intra-frequency measurement system information" is adjacent frequency of the current cell;

5> include a measurement report corresponding to adjacent frequency of the current cell in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting".

2> if the IE "Inter-frequency RACH reporting information" is included in "System Information Block type 12" (or "System Information Block Type 11" if this IE is not included in the "System Information Block Type 12" or if "System Information Block Type 12" is not being broadcast):

3> if, at the time the message is to be sent, valid measurements are available; and

3> there is one or more cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold":

4> include a measurement report in the IE "Measured results on RACH";

4> include the cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold";

4> set the IE "Inter-frequency cell indication- SIB11" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 11;

4> if "System Information Block Type 12" is being broadcast:

5> set the IE "Inter-frequency cell indication- SIB12" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 12.

4> else:

5> set the IE "Inter-frequency cell indication- SIB12" to any value.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00014

1> include in the IE "Measured results on RACH" all requested reporting quantities for cells for which measurements are reported.

NOTE: The UE only includes measurement results for neighbour cells for which valid measurements are available at the time the message is sent. At cell access following selection or reselection to a cell, the UE may not have had sufficient time to obtain valid measurement results for neighbour cells.

1> for messages transmitted on CCCH, take care that the maximum allowed message size is not exceeded when forming the IE "Measured results on RACH", i.e. limit the number of included neighbour cells or if required omit the IE "Measured results on RACH" altogether. When limiting the number of included neighbouring cells, the number of inter-frequency cells should be limited first i.e. inter-frequency cells should be omitted before limiting the number of intra- frequency cells.

When transmitting an uplink RRC message and the System Information Block type 11, System Information Block type 11bis and System Information Block type 12, if transmitted, have not been received, the UE shall:

1> for any uplink RRC message which optionally includes the IE "Measured results on RACH", include a measurement report in the IE "Measured results on RACH" according to the following rules:

2> if the IE "Intra-frequency reporting quantity" was not present in System Information Block type 3:

3> include a measurement report for the serving cell using CPICH RSCP as a measurement quantity;

3> include measurement reports for cells on the used frequency for which measured results are available, using CPICH RSCP as measurement quantity for each cell;

3> omit the IE "Measurement results for monitored cells on non-used frequencies".

2> if the IE "Intra-frequency reporting quantity" was present in System Information Block type 3:

3> include a measurement report for the serving cell using as a measurement quantity given in IE "Intra-frequency reporting quantity";

3> include measurement reports for cells on the used frequency for which measured results are available, using as a measurement quantity given in IE "Intra-frequency reporting quantity" for each cell;

3> omit the IE "Measurement results for monitored cells on non-used frequencies".

2> for TDD, include measurement reports using the measurement quantities specified in the IE "Reporting quantity list".

If the IE "Measured results on RACH" is present in the message, the UTRAN should extract the contents to be used for radio resource control.

10.3.7.45 Measured results on RACH

For measurements on used frequency, this IE contains the measured results on RACH of the quantity indicated by Reporting quantity in the IE "Intra-frequency reporting quantity for RACH Reporting" in system information broadcast on BCH. The list, measurement results for monitored cells (not including the current cell) shall be in the order of the value of the measurement quantity as indicated by Reporting Quantity in the IE "Intra-frequency reporting quantity for RACH Reporting" (the first cell shall be the best cell).

For measurements on non-used frequencies, this IE includes the best cell on each non- used frequency, in order of decreasing quality and up to a maximum number as specified by the IE "Maximum number of inter-frequency RACH reporting cells".

The "best" FDD cell has the largest value when the measurement quantity is "Ec/No" or "RSCP". On the other hand, the "best" cell has the smallest value when the measurement quantity is "Pathloss". The "best" TDD cell has the largest value when measurement quantity is "Primary CCPCH RSCP".

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00015

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version
Measurement result for current cell	MP				
>CHOICE *mode*	MP				
>>FDD					
>>>CHOICE *measurement quantity*	MP			One spare value is needed.	
>>>>CPICH Ec/N0			Integer(0..49)	In dB. According to CPICH_Ec/No in [19]. Fourteen spare values are needed.	
>>>>CPICH RSCP			Integer(0..91)	In dBm. According to CPICH_RSCP_LEV in [19]. Thirty-six spare values are needed.	
>>>>Pathloss			Integer(46..158)	In dB. Fifteen spare values are needed.	
>>TDD					
>>>CHOICE *TDD option*	MP				REL-4
>>>>3.84 Mcps TDD					REL-4
>>>>>Timeslot List	OP	1 to 14			
>>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	
>>>7.68 Mcps TDD					REL-7
>>>>Timeslot List	OP	1 to 14			REL-7
>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	REL-7
>>>>1.28 Mcps TDD					REL-4
>>>>>Timeslot List	OP	1 to 6			REL-4
>>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	REL-4
>>>Primary CCPCH RSCP	OP		Primary CCPCH RSCP info 10.3.7.54		
Measurement results for monitored cells on used frequency	OP	1 to 12			
>SFN-SFN observed time difference	OP		SFN-SFN observed time difference 10.3.7.63		
>CHOICE *mode*	MP				
>>FDD					
>>>Primary CPICH info	MP		Primary CPICH info		

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00016

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version
			10.3.6.60		
>>>Frequency info	OP		Enumerated (TRUE)	Absence of this IE means it is the primary UL frequency.	REL-9
>>>CHOICE *measurement quantity*	OP			One spare value is needed.	
>>>>CPICH Ec/N0			Integer(0..49)	In dB. According to CPICH_Ec/No in [19]. Fourteen spare values are needed.	
>>>>CPICH RSCP			Integer(0..91)	In dBm. According to CPICH_RSCP_LEV in [19]. Thirty-six spare values are needed.	
>>>>Pathloss			Integer(46..158)	In dB. Fifteen spare values are needed.	
>>TDD					
>>>Cell parameters Id	MP		Cell parameters Id 10.3.6.9		
>>>Primary CCPCH RSCP	MP		Primary CCPCH RSCP info 10.3.7.54		
Measurement results for monitored cells on non-used frequencies	OP				REL-6
>Inter-frequency cell indication-SIB11	MP		Integer (0..1)		REL-6
>Inter-frequency cell indication-SIB12	MP		Integer (0..1)		REL-6
>Inter-frequency cell list	MP	1 to <maxFreq>			REL-6
>>Inter-frequency cell id	MP		Integer(0 .. <maxCellMeas>-1)		REL-6

NOTE: Monitored cells consist of neighbouring cells.

14.1.2 Intra-frequency reporting events for FDD

Within the measurement reporting criteria field in the Measurement Control message the UTRAN notifies the UE which events should trigger a measurement report. The listed events are the toolbox from which the UTRAN can choose the reporting events that are needed for the implemented handover evaluation function, or other radio network functions.

All the specified events are measured with respect to any of the measurement quantities given in subclause 14.1.1. The measurement quantities are measured on the monitored primary common pilot channels (CPICH) of the cell defined in the measurement object.

Special mechanisms for the events are illustrated in subclause 14.1.4 and 14.1.5.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00017

NOTE: The events below are numbered 1A, 1B, 1C,... since all intra-frequency reporting events would be labelled 1X, inter-frequency reporting events would be labelled 2X, and so on for the other measurement types.

When one intra-frequency measurement identity corresponds to multiple intra-frequency events with identical event identities, the UE behaviour is not specified, excpet that SECONDARY_E_DCH_TRANSMISSION is set to TRUE.

NOTE: A intra-frequency measurement identity corresponds to two intra-frequency event when DC-HSUPA is configured.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00018

Title: **De-activation/Re-activation of Secondary Carrier**
Agenda item: **x.x.x**
Document for: **Discussion and decision**

1 Introduction

In Dual Cell E-DCH operation, unlike the primary carrier, the secondary carrier is dynamically activated/de-activated by Node B. The UE behaviour when the secondary carrier deactivated is re-activated has not been discussed.

Therefore, this paper discusses what the UE does when secondary carrier is de-activated and re-activated.

2 Discussion

2.1 Flush of HARQ process buffer on secondary carrier

When the secondary carrier is de-activated, the data to be transmitted on the carrier might be remained in the HARQ process buffer on the UE. Assuming that Node B receives data on the secondary carrier from the UE then transmits the HARQ ACK to the UE and de-activates the secondary carrier. If ACK-to-NACK error occurs at the UE side, the UE will not flush HARQ process buffer on the secondary carrier. Moments later if the secondary carrier is re-activated by Node B, the UE might try to re-transmit the data in the HARQ process buffer since the buffer is not empty. In order to prevent this problem, the UE should flush HARQ process buffer on the secondary carrier when the carrier is de-activated (or re-activated).

Proposal 1: The UE shall flush HARQ process buffer corresponding to the secondary carrier when secondary carrier is de-activated (or re-activated).

2.2 Initial variables on secondary carrier

When the secondary carrier is de-activated, the UE does not initialize the variable and timers related to Serving Grant Update function. Therefore, when the secondary carrier is re-activated, the UE might use the value calculated at deactivation. It leads that after the secondary carrier is re-activated the UE may start to transmit data even if the UE has not received the Serving Grant from Node B.

Hence, the UE needs to initialize variables and timers related to Serving Grant Update Function when the secondary carrier is re-activated (or de-activated) similarly to initialization of them when Dual Cell E-DCH operation is configured.

Proposal 2: The UE shall initialize variables and timers related to Serving Grant Update function when the secondary carrier is re-activated (or de-activated).

3 Conclusion

For the correct operation of secondary carrier, the followings are proposed at secondary carrier de-activation or re-activation:

Proposal 1: The UE shall flush HARQ process buffer corresponding to the secondary carrier.

Proposal 2: The UE shall initialize variables and timers for Serving Grant Update function when the secondary carrier is re-activated (or de-activated).

A text proposal is attached in section 4.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00019

4 Appendix

11.8.1.3.2 Handling at start of E-DCH transmission

In CELL_DCH state when E-DCH transmission is started or Secondary Uplink Frequency is re-activated by lower layer, the UE shall on that carrier:

- activate all HARQ processes;
- if the IE's "Serving Grant value" and "Primary/Secondary Grant Selector" are provided by higher layers:
  - update the state variables and timers according to subclause 11.8.1.3.5.
- else:
  - initialise the state variable Serving_Grant to Zero_Grant;
  - initialise the state variable Primary_Grant_Available to "False";
  - initialise the state variable Stored_Secondary_Grant to "Zero_Grant".
- initialise the state variables reference_ETPR and reference_ETPR2 to "Minimum_Grant";
- initialise the state variable Maximum_Serving_Grant to the highest possible value (i.e. index 37 in table 9.2.5.2.1.1 or 9.2.5.2.1.2 as configured by higher layers).

Next Modified Section

11.8.1.10 De-activation on Secondary Uplink Frequency

If Secondary Uplink Frequency is de-activated by lower layer, the UE shall on the secondary carrier:

- deactivate all HARQ processes and flush all buffers;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00020

Title:	⌘	Agreements on Carrier Aggregation

Reason for change:	⌘	RAN2 has agreed some control plane aspects related to carrier aggregation
Summary of change:	⌘	In subclause 5.3.2.1 (new), transmission of CC specific system information on the BCCH of the CC is explained. In subclause 5.3.2.2 (new), details of the "special cell" are included. Usage of *RRCConnectionReconfiguration* message is also explained for the reconfiguration, addition and removal of CCs. Triggers agreed for re-establishment are also listed. In addition, editorial corrections are also included to subclause 5.1.
Consequences if not approved:	⌘	RAN2 agreements on Carrier Aggregation are not captured in 36.912.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00021

5 Support of wider bandwidth

5.1 General

LTE-Advanced extends LTE Rel.-8 with support for *Carrier Aggregation*, where two or more *component carriers* (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz and for spectrum aggregation.

It shall be possible to configure all component carriers which are LTE Rel-8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are the same. Not all component carriers may necessarily be LTE Rel-8 compatible.

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.
- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.

Carrier aggregation is supported for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks in the frequency domain using the LTE Rel-8 numerology

It is possible to configure a UE to aggregate a different number of component carriers originating from the same eNB and of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same.

Component carriers originating from the same eNB need not to provide the same coverage.

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

5.2 User Plane

5.2.1 Structure

Compared to the Layer 2 structure of LTE Rel-8, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per CC. The Layer 2 structure for the downlink is depicted on Figured 5.2.1-1 below.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00022

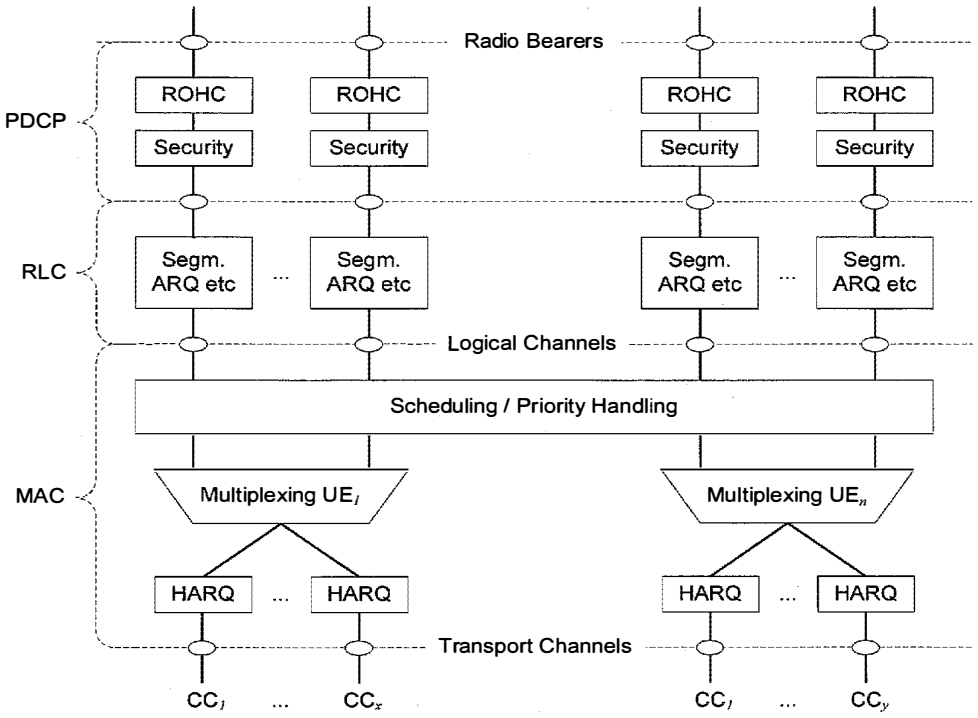


Figure 5.2.1-1: Layer 2 Structure for the DL

The Layer 2 structure for the uplink is depicted on Figured 5.2.1-2 below.

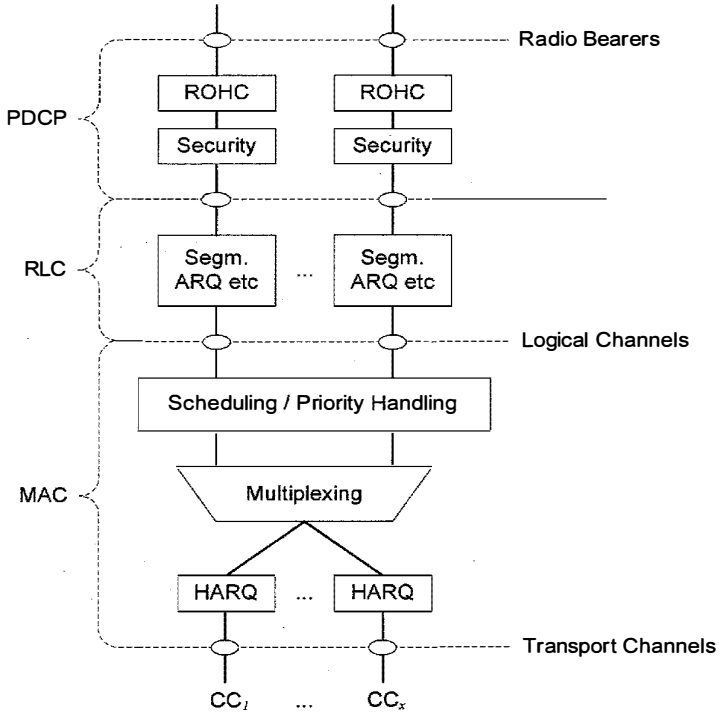


Figure 5.2.1-2: Layer 2 Structure for the UL

5.2.2 MAC

From a UE perspective, the Layer 2 aspects of HARQ are kept Rel-8 compliant unless modifications provide significant gains. There is one transport block (in absence of spatial multiplexing, up to two transport blocks in case of spatial

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00023

multiplexing) and one independent hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only where all possible HARQ retransmissions also take place. A UE may be scheduled over multiple component carriers simultaneously but at most one random access procedure shall be ongoing at any time.

5.2.3 RLC

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

5.2.4 PDCP

The PDCP protocol of LTE Rel-8 also applies to carrier aggregation.

5.3 Control plane

5.3.1 Structure

The C-Plane architecture of LTE Rel-8 also applies to carrier aggregation.

5.3.2 RRC procedures

5.3.2.1 System Information

Each CC provides on BCCH the system information which is specific to it. The handling of system information for extension carriers is FFS.

5.3.2.2 Connection Control

As in LTE Rel-8, the UE only has one RRC connection with the network. One cell - the "special cell" - provides the security input and the NAS mobility information (one ECGI, one PCI and one ARFCN). There is only one "special cell" per UE in connected mode.

After RRC connection establishment to the "special cell", the reconfiguration, addition and removal of CCs can be performed by *RRCConnectionReconfiguration* including *mobilityControlInfo* (i.e. "intra-cell handover"). *RRCConnectionReconfiguration* without *mobilityControlInfo* can also be used for the addition of CCs, and for the removal of CCs with the exception of the CC corresponding to the "special cell".

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

Detection of failure of one CC by the UE does not necessarily trigger a connection re-establishment. RRC connection re-establishment triggers at the UE include:

1) The failure of all CCs on which the UE is configured to receive PDCCH;

NOTE: FFS if re-establishment is triggered under more restrictive conditions.

2) The loss of all UL communication;

3) The indication from RLC that the maximum number of retransmissions has been reached (as in Rel-8).

5.3.3 Idle mode procedures

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00024

1 Introduction

At RAN2#67bis it was discussed whether the intention of the Rel-8 specification is to include, in the UEs Active Time, the time between triggering of an SR until the actual transmission of the SR; i.e., whether UE shall monitor PDCCH from the moment a SR is triggered or from the moment an SR is transmitted.

Some companies understood that to improve UE battery performance the UE need not monitor the PDCCH until the SR is transmitted. Others understood the Rel-8 intent is to have UE monitoring PDCCH also before the SR is transmitted and that this would be beneficial for latency reduction by means of 'pre-allocation'.

RAN2#67bis concluded that the Rel-8 intent was to have the UE monitor the PDCCH from the moment SR is triggered. However, it has been identified that this behaviour will severely impact UE DRX opportunity, in particular for VoIP traffic. This contribution highlights the DRX issue resulting from the Rel-8 Active Time definition w r t D-SR and proposes to clarify that the UE monitors PDCCH due to D-SR from the time the D-SR is transmitted on PUCCH.

2 DRX and D-SR induced PDCCH monitoring

It is understood that before the D-SR has been transmitted on PUCCH the eNB is not aware that new (higher priority) data has become available for transmission in the UE. Thus, assuming that UE is not in Active Time due to some other reason, an uplink grant would typically not be provided on PDCCH before D-SR has been transmitted. One exception to the rule would be the application of 'pre-allocation' of uplink resources blindly to the UE to optimize uplink latency. For pre-allocation the early PDCCH monitoring enables the UE to receive the 'unsolicited' uplink grants and reduces uplink latency. Thus, when the UE should start PDCCH monitoring (w r t D-SR) would appear to be a tradeoff between UE battery efficiency and pre-allocation efficiency.

2.1 UE battery efficiency

For traffic with periodic uplink transmissions where the data inter-arrival time is on the same order as the SR-trigger to UL-transmission latency, the behaviour confirmed at RAN2#67bis severely limits DRX opportunity and performance. In the following we consider the DRX performance for VoIP.

We assume an SR periodicity of 20ms, packet arrival uncorrelated to the SR opportunity and a constant packet inter-arrival time of 20ms. Because the size of the VoIP packet is rather small, the UE buffer becomes empty between the packets and each VoIP packet triggers a regular BSR and SR.

2.1.1 UE monitors PDCCH from SR trigger

With the 'confirmed' behaviour, the UE will monitor PDCCH

1. 0 – 20 ms from SR trigger until D-SR opportunity
2. at least 6 ms from D-SR opportunity until the SR is cancelled (transmission of SR, detection by eNB, immediate issue of uplink grant and UE pre-PUSCH-transmission processing)

Thus, for each VoIP packet, the minimum UE Active Time varies between 6 – 26 ms and is 16.8 ms on average if averaged over many sessions. This corresponds to a DRX potential of less than 25%. Note that during a session packets arrive in a very regular fashion and averaging per UE and session does not occur. We further note that this minimum Active Time does not include PDCCH monitoring for retransmissions, nor does it account for associated downlink traffic. Thus DRX opportunity may in practice be even more limited; possibly non-existent during the talk period of the UE .

The Active Time can be reduced by configuring the UE with a shorter D-SR periodicity. However, this requires more uplink resources to be allocated to PUCCH and is not always justified from a delay budget

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00025

point of view. Less resources will be available for PUSCH and capacity may be limited due to DRX considerations. To ensure that Active Time due to D-SR is less than half the VoIP packet inter-arrival time (i.e., below 10 ms), D-SR periodicity would need to be less than 5 ms.

2.1.2 UE monitors PDCCH from SR transmission

If UEs' monitoring of PDCCH would start at D-SR transmission, the waiting time for D-SR opportunity is eliminated and UEs' D-SR induced monitoring of PDCCH is independent of the D-SR periodicity. The decoupling of Active Time from the D-SR periodicity is a nice property, but more important is that the D-SR induced PDCCH monitoring becomes significantly reduced and UEs' DRX opportunity significantly improved. DRX potential is nearly 75% compared to less than 25% with PDCCH monitoring from SR trigger.

2.2 Pre-allocation efficiency

W r t pre-allocation it is envisioned that UEs' lesser availability between SR trigger and D-SR transmission can be compensated with a shorter DRX cycle. Efficient pre-allocation can be achieved by configuring a shorter DRX cycle.

3 Alternative approach

An alternative approach to changing the definition of the D-SR induced Active Time, as proposed in Subsection 2.1.1, would be to provide the eNB with detailed timing information about when the SR was triggered. This would allow the eNB to adjust the timing of periodic uplink grants so that they can be provided shortly after SR trigger and minimize the time until SR cancellation. The information could be provided with an uplink MAC Control element.

While this is a feasible alternative, it seems a little more complex than redefining the start of PDCCH monitoring w r t D-SR on PUCCH.

Another alterlative is for eNB to indicate whether the UE is allowed not to monitor PDCCH during the period from the trigger of D-SR to actual transmission of D-SR. For example, sr_drx_indicator can be defined. Thus, when eNB set sr_drx_indicator to allowed through RRC signaling, the UE can start monitoring of PDCCH only after transmission of D-SR and this means that active time does not include the time period from the trigger of D-SR to actual transmission of D-SR. Thus, when eNB set sr_drx_indicator to not-allowed through RRC signaling, the UE should start monitoring of PDCCH as soon as the triggering of D-SR and this means that active time include the time period from the trigger of D-SR to actual transmission of D-SR.

Or alternatively, skipping of monitoring during the period from the trigger of D-SR to actual transmission of D-SR.can be done if there is any configured VoIP service. Otherwise, the UE should monitor as soon as the triggering of D-SR.

Or alternatively, skipping of monitoring during the period from the trigger of D-SR to actual transmission of D-SR.can be done if there is any configured SPS(semi persistent scheduling or configured resources). Otherwise, the UE should monitor as soon as the triggering of D-SR.

4 Summary and conclusion

For traffic with periodic uplink transmissions the behaviour confirmed at RAN2#67bis severely limits DRX opportunity and performance. The problem is evident especially for VoIP traffic and when data inter-arrival time is on the same order as the latency between SR-trigger and actual uplink transmission. Unless a mechanism is introduced, which provides the eNB with accurate timing information about voice data arrival in the UE, DRX becomes virtually disabled. To achieve acceptable DRX performance, it is proposed to

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00026

revisit the assumption that UEs monitor PDCCH from SR trigger and discuss whether UEs should rather monitor PDCCH from D-SR transmission or a mechanism should be introduced to enable eNB to minimize UE Active Time due to D-SR. Based on our analysis updating the Active Time due to D-SR is simpler and preferred, but introducing an uplink MAC Control element with SR delay information is also doable.

Proposal 1: It is proposed to discuss whether the poor DRX performance for, e.g., VoIP is acceptable.

Proposal 2: It is proposed to clarify that, w r t D-SR, UE Active Time begins at D-SR transmission.

Proposal 3: If proposal 2 is not agreeable, it is proposed to introduce an uplink MAC Control element with SR delay information in Rel-9.

CRs corresponding to proposal 2 are provided in [1] and [2]. A CR corresponding to proposal 3 can be provided by Ericsson if proposal 3 is agreed.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00027

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00028

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".

[7] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[9] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

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 related to DRX operation, as defined in subclause 5.7, during which the UE monitors the PDCCH in PDCCH-subframes.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00029

mac-ContentionResolutionTimer: Specifies the number of consecutive subframe(s) during which the UE shall monitor the PDCCH after Msg3 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).

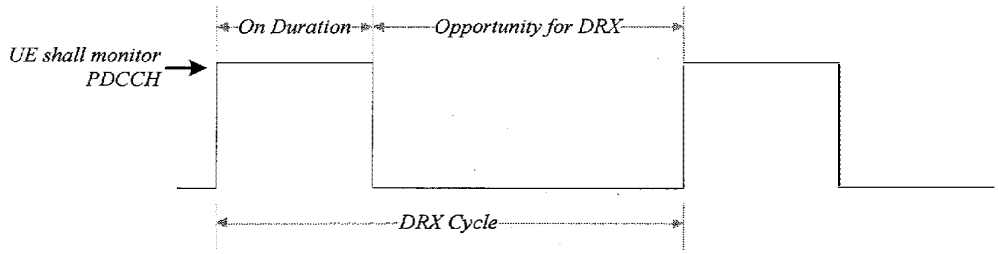


Figure 3.1-1: DRX Cycle

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

drxShortCycleTimer: Specifies the number of consecutive subframe(s) the UE shall follow the Short DRX cycle.

drxStartOffset: Specifies the subframe where the DRX Cycle starts.

HARQ information: HARQ information consists of New Data Indicator (NDI), Transport Block (TB) size. For DL-SCH transmissions the HARQ information also includes HARQ process ID. For UL-SCH transmission the HARQ info also includes Redundancy Version (RV). In case of spatial multiplexing on DL-SCH the HARQ information comprises a set of NDI and TB size for each transport block.

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

Msg3: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a random access procedure.

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

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

PRACH Resource Index: The index of a PRACH within a system frame [7]

***ra-PRACH-MaskIndex*:** Defines in which PRACHs within a system frame the UE can transmit a Random Access Preamble (see subclause 7.3).

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.

NOTE: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value.

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00030

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
LCG	Logical Channel Group
PHR	Power Headroom Report
PMI	Precoding Matrix Index
P-RNTI	Paging RNTI
RA-RNTI	Random Access RNTI
RI	Rank Indicator
RNTI	Radio Network Temporary Identifier
SI-RNTI	System Information RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbols
TB	Transport Block
TPC-PUCCH-RNTI	Transmit Power Control-Physical Uplink Control Channel-RNTI
TPC-PUSCH-RNTI	Transmit Power Control-Physical Uplink Shared Channel-RNTI

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.

Figure 4.2.1.1 illustrates one possible structure for the UE side MAC entity, and it should not restrict implementation.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00031

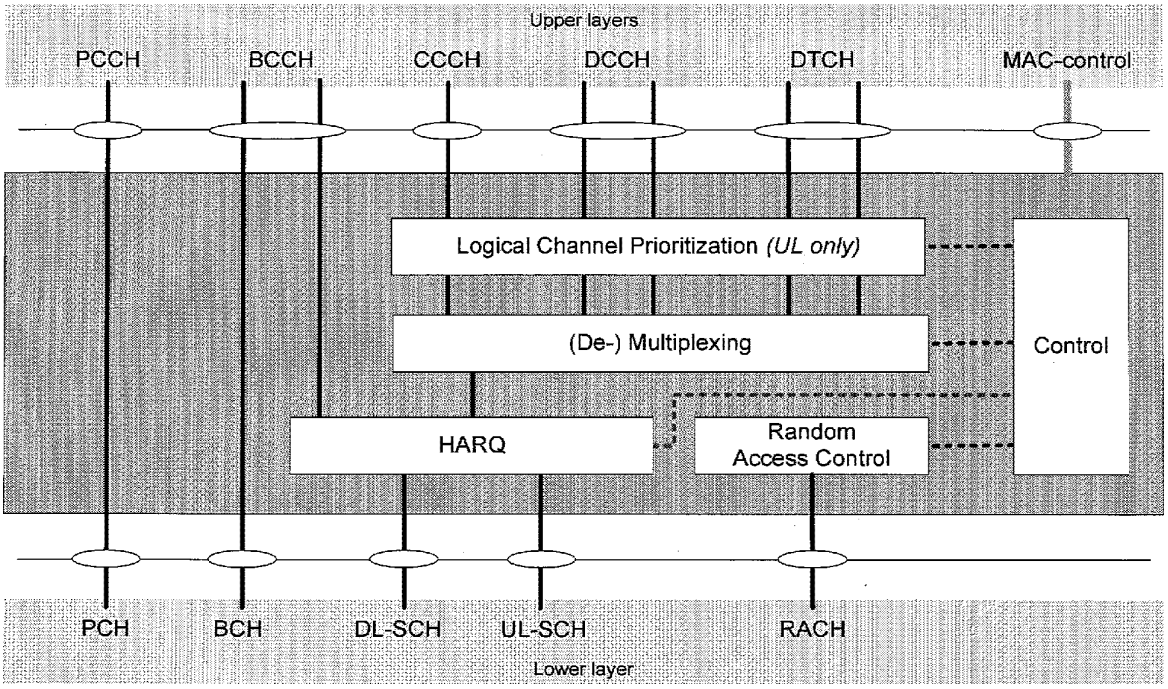


Figure 4.2.1.1: MAC structure overview, UE side

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;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00032

- 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.

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00033

MAC provides the control and traffic channels listed in Table 4.5.2-1 below.

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.

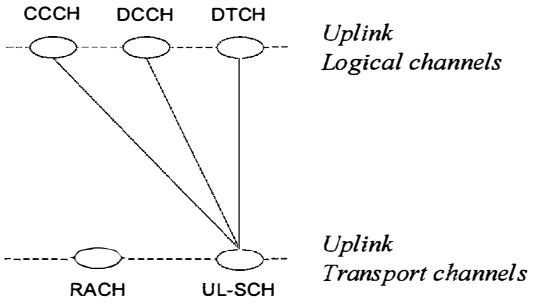


Figure 4.5.3.1-1

Table 4.5.3.1-1: Uplink channel mapping.

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

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00034

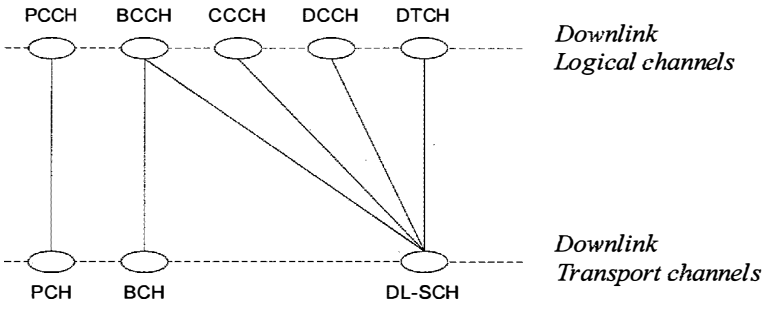


Figure 4.5.3.2-1

Table 4.5.3.2-1: Downlink channel mapping.

Logical channel \ Transport 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. If a UE receives a PDCCH transmission consistent with a PDCCH order [5] masked with its C-RNTI, it shall initiate a Random Access procedure. The PDCCH order or RRC optionally indicate *ra-PreambleIndex* and *ra-PRACH-MaskIndex*.

Before the procedure can be initiated, the following information is assumed to be available [8]:

- the available set of PRACH resources for the transmission of the Random Access Preamble, *prach-ConfigIndex*.
- the groups of Random Access Preambles and the set of available Random Access Preambles in each group:

  The preambles that are contained in Random Access Preambles group A and Random Access Preambles group B are calculated from the parameters *numberOfRA-Preambles* and *sizeOfRA-PreamblesGroupA*:

  If *sizeOfRA-PreamblesGroupA* is equal to *numberOfRA-Preambles* then there is no Random Access Preambles group B. The preambles in Random Access Preamble group A are the preambles 0 to *sizeOfRA-PreamblesGroupA* – 1 and, if it exists, the preambles in Random Access Preamble group B are the preambles *sizeOfRA-PreamblesGroupA* to *numberOfRA-Preambles* – 1 from the set of 64 preambles as defined in [7].
- if Random Access Preambles group B exists, the thresholds, *messagePowerOffsetGroupB* and *messageSizeGroupA*, the configured UE transmitted power, P_{CMAX} [10], and the offset between the preamble and Msg3, *deltaPreambleMsg3*, that are required for selecting one of the two groups of Random Access Preambles.
- the RA response window size *ra-ResponseWindowSize*.
- the power-ramping factor *powerRampingStep*.
- the maximum number of preamble transmission *preambleTransMax*.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00035

- the initial preamble power *preambleInitialReceivedTargetPower*.
- the preamble format based offset DELTA_PREAMBLE (see subclause 7.6).
- the maximum number of Msg3 HARQ transmissions *maxHARQ-Msg3Tx*.
- the Contention Resolution Timer *mac-ContentionResolutionTimer*.

NOTE: The above parameters may be updated from upper layers before each Random Access procedure is initiated.

The Random Access procedure shall be performed as follows:

- Flush the Msg3 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 selection procedure shall be performed as follows:

- If *ra-PreambleIndex* (Random Access Preamble) and *ra-PRACH-MaskIndex* (PRACH Mask Index) have been explicitly signalled and *ra-PreambleIndex* is not 000000:
  - the Random Access Preamble and the PRACH Mask Index are those explicitly signalled.
- else the Random Access Preamble shall be selected by the UE as follows:
  - If Msg3 has not yet been transmitted, the UE shall:
    - if Random Access Preambles group B exists and if the potential message size (data available for transmission plus MAC header and, where required, MAC control elements) is greater than *messageSizeGroupA* and if the pathloss is less than $P_{CMAX} - preambleInitialReceivedTargetPower - deltaPreambleMsg3 - messagePowerOffsetGroupB$, then:
      - select the Random Access Preambles group B;
    - else:
      - select the Random Access Preambles group A.
  - else, if Msg3 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 Msg3.
  - 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;
  - set PRACH Mask Index to 0.
- determine the next available subframe containing PRACH permitted by the restrictions given by the *prach-ConfigIndex*, the PRACH Mask Index (see subclause 7.3) and physical layer timing requirements [2] (a UE may take into account the possible occurrence of measurement gaps when determining the next available PRACH subframe);
- if the transmission mode is TDD and the PRACH Mask Index is equal to zero:
  - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00036

- randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe.

- else:

  - randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe and the next two consecutive subframes.

- else:

  - determine a PRACH within the determined subframe in accordance with the requirements of the PRACH Mask Index.

- 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:

- set PREAMBLE_RECEIVED_TARGET_POWER to *preambleInitialReceivedTargetPower* + DELTA_PREAMBLE + (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*;

- instruct the physical layer to transmit a preamble using the selected PRACH, corresponding RA-RNTI, preamble index and PREAMBLE_RECEIVED_TARGET_POWER.

5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap, the UE shall monitor the PDCCH for Random Access Response(s) identified by the RA-RNTI defined below, in the RA Response window which starts at the subframe that contains the end of the preamble transmission [7] plus three subframes and has length *ra-ResponseWindowSize* subframes. The RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

$$RA\text{-}RNTI = 1 + t\_id + 10 * f\_id$$

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

- If a downlink assignment for this TTI has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded, the UE shall regardless of the possible occurrence of a measurement gap:

  - 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 Advance Command (see subclause 5.2);

    - indicate the *preambleInitialReceivedTargetPower* and the amount of power ramping applied to the latest preamble transmission to lower layers (i.e., (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*);

    - process the received UL grant value and indicate it to the lower layers;

    - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00037

- 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 transmission is not being made for the CCCH logical channel, 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 Msg3 buffer.

NOTE: When an uplink transmission is required, e.g., for contention resolution, the eNB should not provide a grant smaller than 56 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 RA Response window, or if none of all received Random Access Responses contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the UE shall:

- increment PREAMBLE_TRANSMISSION_COUNTER by 1;

- If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:

  - indicate a Random Access problem to upper layers.

- if in this Random Access procedure, the Random Access Preamble was selected by MAC:

  - based on the backoff parameter in the UE, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;

  - delay the subsequent Random Access transmission by the backoff time;

- proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.5 Contention Resolution

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

Once Msg3 is transmitted, the UE shall:

- start *mac-ContentionResolutionTimer* and restart *mac-ContentionResolutionTimer* at each HARQ retransmission;

- regardless of the possible occurrence of a measurement gap, monitor the PDCCH until *mac-ContentionResolutionTimer* expires or is stopped;

- 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 Msg3:

    - 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 for a new transmission; or

    - if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00038

- consider this Contention Resolution successful;
- stop *mac-ContentionResolutionTimer*;
- discard the Temporary C-RNTI;
- consider this Random Access procedure successfully completed.

- else if the CCCH SDU was included in Msg3 and the PDCCH transmission is addressed to its Temporary C-RNTI:
  - if the MAC PDU is successfully decoded:
    - stop *mac-ContentionResolutionTimer*;
    - 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 Msg3:
      - 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;
      - discard the Temporary C-RNTI;
      - consider this Random Access procedure successfully completed.
    - else
      - discard the Temporary C-RNTI;
      - consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.

- if *mac-ContentionResolutionTimer* expires:
  - discard the Temporary C-RNTI;
  - consider the Contention Resolution not successful.
- if the Contention Resolution is considered not successful the UE shall:
  - flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer;
  - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
  - If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:
    - indicate a Random Access problem to upper layers.
  - based on the backoff parameter in the UE, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;
  - delay the subsequent Random Access transmission by the backoff time;
  - proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.6 Completion of the Random Access procedure

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

- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00039

5.2 Maintenance of Uplink Time Alignment

The UE has a configurable timer *timeAlignmentTimer* which is used to control how long the UE is considered uplink time aligned [8].

The UE shall:

- when a Timing Advance Command MAC control element is received:
  - apply the Timing Advance Command;
  - start or restart *timeAlignmentTimer*.
- when a Timing Advance Command is received in a Random Access Response message:
  - if the Random Access Preamble was not selected by UE MAC:
    - apply the Timing Advance Command;
    - start or restart *timeAlignmentTimer*.
  - else, if the *timeAlignmentTimer* is not running:
    - apply the Timing Advance Command;
    - start *timeAlignmentTimer*;
    - when the contention resolution is considered not successful as described in subclause 5.1.5, stop *timeAlignmentTimer*.
  - else:
    - ignore the received Timing Advance Command.
- when *timeAlignmentTimer* expires:
  - flush all HARQ buffers;
  - notify RRC to release PUCCH/SRS;
  - clear any configured downlink assignments and uplink grants.

5.3 DL-SCH data transfer

5.3.1 DL Assignment reception

Downlink assignments transmitted on the PDCCH indicate if there is a transmission on the DL-SCH for a particular UE and provide the relevant HARQ information.

When the UE has a C-RNTI, Semi-Persistent Scheduling C-RNTI, or Temporary C-RNTI, the UE shall for each TTI during which it monitors PDCCH:

- if a downlink assignment for this TTI has been received on the PDCCH for the UE's C-RNTI, or Temporary C-RNTI:
  - if this is the first downlink assignment for this Temporary C-RNTI:
    - consider the NDI to have been toggled.
  - if the downlink assignment is for UE's C-RNTI and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the UE's Semi-Persistent Scheduling C-RNTI or a configured downlink assignment:
    - consider the NDI to have been toggled regardless of the value of the NDI.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00040

- indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.

- else, if a downlink assignment for this TTI has been received on the PDCCH for the UE's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:
    - consider the NDI not to have been toggled;
    - indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.
  - else, if the NDI in the received HARQ information is 0:
    - if PDCCH contents indicate SPS release:
      - clear the configured downlink assignment (if any);
      - if *timeAlignmentTimer* is running:
        - indicate a positive acknowledgement for the downlink SPS release to the physical layer.
    - else:
      - store the downlink assignment and the associated HARQ information as configured downlink assignment;
      - initialise (if not active) or re-initialise (if already active) the configured downlink assignment to start in this TTI and to recur according to rules in subclause 5.10.1;
      - set the HARQ Process ID to the HARQ Process ID associated with this TTI;
      - consider the NDI bit to have been toggled;
      - indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

- else, if a downlink assignment for this TTI has been configured and there is no measurement gap in this TTI and this TTI is not an MBSFN subframe:
  - instruct the physical layer to receive, in this TTI, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;
  - set the HARQ Process ID to the HARQ Process ID associated with this TTI;
  - consider the NDI bit to have been toggled;
  - indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

For configured downlink assignments, the HARQ Process ID associated with this TTI is derived from the following equation:

HARQ Process ID = [floor(CURRENT_TTI/(Downlink Semi-Persistent Scheduling Interval))] modulo Number of Configured SPS Processes,

where CURRENT_TTI=[(SFN * 10) + subframe number], Downlink Semi-Persistent Scheduling Interval is the periodicity of semi-persistent scheduling signalled via RRC and Number of Configured SPS Processes is the number of HARQ processes allocated for semi-persistent scheduling signalled via RRC.

When the UE needs to read BCCH, the UE may, based on the scheduling information from RRC:

- if a downlink assignment for this TTI has been received on the PDCCH for the SI-RNTI;
  - if the redundancy version is not defined in the PDCCH format:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00041

- the redundancy version of the received downlink assignment for this TTI is determined by RV_K = ceiling(3/2*k) modulo 4, where k depends on the type of system information message: for *SystemInformationBlockType1* message, k = (SFN/2) modulo 4, where SFN is the system frame number; for *SystemInformation* messages, $k=i$ modulo 4, i =0,1,..., n_s^w-1, where i denotes the subframe number within the SI window n_s^w;

- indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity for this TTI.

5.3.2 HARQ operation

5.3.2.1 HARQ Entity

There is one HARQ entity at the UE which maintains a number of parallel HARQ processes. Each HARQ process is associated with a HARQ process identifier. The HARQ entity directs HARQ information and associated TBs received on the DL-SCH to the corresponding HARQ processes (see subclause 5.3.2.2).

The number of DL HARQ processes is specified in [2], clause 7.

When the physical layer is configured for spatial multiplexing [2], one or two TBs are expected per subframe and they are associated with the same HARQ process. Otherwise, one TB is expected per subframe.

The UE shall:

- If a downlink assignment has been indicated for this TTI:
  - allocate the TB(s) received from the physical layer and the associated HARQ information to the HARQ process indicated by the associated HARQ information.
- If a downlink assignment has been indicated for the broadcast HARQ process:
  - 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 subframe where a transmission takes place for the HARQ process, one or two (in case of spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

- if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or
- if the HARQ process is equal to the broadcast process and if this is the first received transmission for the TB according to the system information schedule indicated by RRC; or
- if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):
  - consider this transmission to be a new transmission.
- else:
  - consider this transmission to be a retransmission.

The UE then shall:

- if this is a new transmission:
  - replace the data currently in the soft buffer for this TB with the received data.
- else if this is a retransmission:
  - if the data has not yet been successfully decoded:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00042

- combine the received data with the data currently in the soft buffer for this TB.
- if the TB size is different from the last valid TB size signalled for this TB:
- the UE may replace the data currently in the soft buffer for this TB with the received data.

- attempt to decode the data in the soft buffer for this TB;
- if the data in the soft buffer was successfully decoded for this TB:
- if the HARQ process is equal to the broadcast process:
- deliver the decoded MAC PDU to upper layers.
- else if this is the first successful decoding of the data in the soft buffer for this TB:
- deliver the decoded MAC PDU to the disassembly and demultiplexing entity.
- generate a positive acknowledgement (ACK) of the data in this TB.
- else:
- generate a negative acknowledgement (NACK) of the data in this TB.
- if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and the Contention Resolution is not yet successful (see subclause 5.1.5); or
- if the HARQ process is equal to the broadcast process; or
- if *timeAlignmentTimer* is stopped or expired:
- do not indicate the generated positive or negative acknowledgement to the physical layer.
- else:
- indicate the generated positive or negative acknowledgement for this TB to the physical layer.

The UE shall ignore NDI received in all downlink assignments on PDCCH for its Temporary C-RNTI when determining if NDI on PDCCH for its C-RNTI has been toggled compared to the value in the previous transmission.

5.3.3 Disassembly and demultiplexing

The UE shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.2.

5.4 UL-SCH data transfer

5.4.1 UL Grant reception

In order to transmit on the UL-SCH the UE must have a valid uplink grant (except for non-adaptive HARQ retransmissions) which it may receive dynamically on the PDCCH or in a Random Access Response or which may be configured semi-persistently. To perform requested transmissions, the MAC layer receives HARQ information from lower layers.

When *timeAlignmentTimer* is running and 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:
- if the uplink grant is for UE's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the UE's Semi-Persistent Scheduling C-RNTI or a configured uplink grant:
- consider the NDI to have been toggled regardless of the value of the NDI.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00043

- deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else, if an uplink grant for this TTI has been received on the PDCCH for the UE's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:
    - consider the NDI not to have been toggled;
    - deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.
  - else if the NDI in the received HARQ information is 0:
    - if PDCCH contents indicate SPS release:
      - clear the configured uplink grant (if any).
    - else:
      - store the uplink grant and the associated HARQ information as configured uplink grant;
      - initialise (if not active) or re-initialise (if already active) the configured uplink grant to start in this TTI and to recur according to rules in subclause 5.10.2;
      - consider the NDI bit to have been toggled;
      - deliver the configured 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:
  - consider the NDI bit to have been toggled;
  - deliver the configured uplink grant, 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 in a Random Access Response and a grant for its C-RNTI or Semi persistent scheduling C-RNTI requiring transmissions in the same UL subframe, the UE may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI or Semi persistent scheduling C-RNTI.

NOTE: When a configured uplink grant is indicated during a measurement gap and indicates an UL-SCH transmission during a measurement gap, the UE processes the grant but does not transmit on UL-SCH.

5.4.2 HARQ operation

5.4.2.1 HARQ entity

There is one HARQ entity at the UE, which maintains a number of parallel HARQ processes allowing transmissions to take place continuously while waiting for HARQ the feedback on the successful or unsuccessful reception of previous transmissions.

The number of parallel HARQ processes is specified in [2], clause 8.

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 received HARQ feedback (ACK/NACK information), MCS and resource, relayed by the physical layer, to the appropriate HARQ process.

When TTI bundling is configured, the parameter TTI_BUNDLE_SIZE provides the number of TTIs of a TTI bundle. TTI bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle HARQ retransmissions are non-adaptive and triggered without waiting for feedback from previous transmissions according to TTI_BUNDLE_SIZE. The HARQ feedback of a bundle is only received for the last TTI of the bundle (i.e the TTI corresponding to TTI_BUNDLE_SIZE), regardless of whether a

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00044

transmission in that TTI takes place or not (e.g. when a measurement gap occurs). A retransmission of a TTI bundle is also a TTI bundle.

For transmission of Msg3 during Random Access (see section 5.1.5) TTI bundling does not apply.

For each TTI, the HARQ entity shall:

- identify the HARQ process associated with this TTI;
- if an uplink grant has been indicated for this TTI:
  - if the received grant was not addressed to a Temporary C-RNTI on PDCCH and if the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this HARQ process; or
  - if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or
  - if the uplink grant was received in a Random Access Response:
    - if there is a MAC PDU in the Msg3 buffer and the uplink grant was received in a Random Access Response:
      - obtain the MAC PDU to transmit from the Msg3 buffer.
    - else:
      - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
    - deliver the MAC PDU and the uplink grant and the HARQ information to the identified HARQ process;
    - instruct the identified HARQ process to trigger a new transmission.
  - else:
    - deliver the uplink grant and the HARQ information (redundancy version) to the identified HARQ process;
    - instruct the identified 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 identified HARQ process to generate a non-adaptive retransmission.

When determining if NDI has been toggled compared to the value in the previous transmission UE shall ignore NDI received in all uplink grants on PDCCH for its Temporary C-RNTI.

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, and a state variable HARQ_FEEDBACK, which indicates the HARQ feedback 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 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is up-dated modulo 4.

New transmissions are performed on the resource and with the MCS indicated on PDCCH or Random Access Response. Adaptive retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH. 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 Msg3 HARQ transmissions by RRC: *maxHARQ-Tx* and *maxHARQ-Msg3Tx* respectively. For transmissions on all HARQ processes

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00045

and all logical channels except for transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Tx*. For transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Msg3Tx*.

When the HARQ feedback is received for this TB, the HARQ process shall:

- set HARQ_FEEDBACK to the received value.

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;
- store the uplink grant received from the HARQ entity;
- set HARQ_FEEDBACK to NACK;
- generate a transmission as described below.

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

- increment CURRENT_TX_NB by 1;
- if the HARQ entity requests an adaptive retransmission:
  - store the uplink grant received from the HARQ entity;
  - set CURRENT_IRV to the index corresponding to the redundancy version value provided in the HARQ information;
  - set HARQ_FEEDBACK to NACK;
  - generate a transmission as described below.
- else if the HARQ entity requests a non-adaptive retransmission:
  - if HARQ_FEEDBACK = NACK:
    - generate a transmission as described below.

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

NOTE: When no UL-SCH transmission can be made due to the occurrence of a measurement gap, no HARQ feedback can be received and a non-adaptive retransmission follows.

To generate a transmission, the HARQ process shall:

- if the MAC PDU was obtained from the Msg3 buffer; or
- if there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer in this TTI:
  - instruct the physical layer to generate a transmission according to the stored uplink grant with the redundancy version corresponding to the CURRENT_IRV value;
  - increment CURRENT_IRV by 1;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00046

- if there is a measurement gap at the time of the HARQ feedback reception for this transmission and if the MAC PDU was not obtained from the Msg3 buffer:
  - set HARQ_FEEDBACK to ACK at the time of the HARQ feedback reception for this transmission.

After performing above actions, the HARQ process then shall:

- if CURRENT_TX_NB = maximum number of transmissions – 1:
  - flush the HARQ buffer;

5.4.3 Multiplexing and assembly

5.4.3.1 Logical channel prioritization

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

RRC controls the scheduling of uplink data by signalling for each logical channel: *priority* where an increasing *priority* value indicates a lower priority level, *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR), *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

The UE shall maintain a variable Bj for each logical channel j. Bj shall be initialized to zero when the related logical channel is established, and incremented by the product PBR × TTI duration for each TTI, where PBR is Prioritized Bit Rate of logical channel j. However, the value of Bj can never exceed the bucket size and if the value of Bj is larger than the bucket size of logical channel j, it shall be set to the bucket size. The bucket size of a logical channel is equal to PBR × BSD, where PBR and BSD are configured by upper layers.

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 steps:
  - Step 1: All the logical channels with Bj > 0 are allocated resources in a decreasing priority order. 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);
  - Step 2: the UE shall decrement Bj by the total size of MAC SDUs served to logical channel j in Step 1

NOTE: The value of Bj can be negative.

  - Step 3: if any resources remain, all the logical channels are served in a strict decreasing priority order (regardless of the value of Bj) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.
- 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;
  - UE should maximise the transmission of data.

The UE shall not transmit data for a logical channel corresponding to a radio bearer that is suspended (the conditions for when a radio bearer is considered suspended are defined in [8]).

For the Logical Channel Prioritization procedure, the UE shall take into account the following relative priority in decreasing order:

- MAC control element for C-RNTI or data from UL-CCCH;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00047

- MAC control element for BSR, with exception of BSR included for padding;
- MAC control element for PHR;
- data from any Logical Channel, except data from UL-CCCH;
- MAC control element for BSR included for padding.

5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The UE shall multiplex MAC control elements and MAC SDUs in a MAC PDU according to subclauses 5.4.3.1 and 6.1.2.

5.4.4 Scheduling Request

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

When an SR is triggered, it shall be considered as pending until it is cancelled.

If an SR is triggered and there is no other SR pending, the UE shall set the SR_COUNTER to 0.

As long as one SR is pending, the UE shall for each TTI:

- if no UL-SCH resources are available for a transmission in this TTI:
  - if the UE has no valid PUCCH resource for SR configured in any TTI: initiate a Random Access procedure (see subclause 5.1) and cancel all pending SRs;
  - else if the UE has a valid PUCCH resource for SR configured for this TTI and if this TTI is not part of a measurement gap:
    - if SR_COUNTER < *dsr-TransMax*:
      - increment SR_COUNTER by 1;
      - instruct the physical layer to signal the SR on PUCCH;
    - else:
      - notify RRC to release PUCCH/SRS;
      - clear any configured downlink assignments and uplink grants;
      - initiate a Random Access procedure (see subclause 5.1) and cancel all pending SRs.
- else if UL-SCH resources are available for a new transmission in this TTI, cancel all pending SR(s).

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 available for transmission in the UL buffers of the UE. RRC controls BSR reporting by configuring the two timers *periodicBSR-Timer* and *retxBSR-Timer* and by, for each logical channel, optionally signalling *logicalChannelGroup* which allocates the logical channel to an LCG [8].

For the Buffer Status reporting procedure, the UE shall consider all radio bearers which are not suspended and may consider radio bearers which are suspended.

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

- UL data, for a logical channel which belongs to a LCG, becomes available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively) and either the data belongs to a logical channel with higher priority than the priorities of the logical channels which belong to any LCG and for which data is already available for transmission, or there is no data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00048

- UL resources are allocated and number of padding bits is equal to or larger than the size of the Buffer Status Report MAC control element plus its subheader, in which case the BSR is referred below to as "Padding BSR";
- *retxBSR-Timer* expires and the UE has data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";
- *periodicBSR-Timer* expires, in which case the BSR is referred below to as "Periodic BSR".

For Regular and Periodic BSR:

- if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Long BSR;
- else report Short BSR.

For Padding BSR:

- if the number of padding bits is equal to or larger than the size of the Short BSR plus its subheader but smaller than the size of the Long BSR plus its subheader:
  - if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Truncated BSR of the LCG with the highest priority logical channel with data available for transmission;
  - else report Short BSR.
- else if the number of padding bits is equal to or larger than the size of the Long BSR plus its subheader, report Long BSR.

If the Buffer Status reporting procedure determines that at least one BSR has been triggered since the last transmission of a BSR or if this is the first time that at least one BSR is triggered:

- 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;
  - start or restart *periodicBSR-Timer* except when the BSR is a Truncated BSR;
  - start or restart *retxBSR-Timer*.
- else if a Regular BSR has been triggered:
  - a Scheduling Request shall be triggered.

A MAC PDU shall contain at most one MAC BSR control element, even when multiple events trigger a BSR by the time a BSR can be transmitted in which case the Regular BSR and the Periodic BSR shall have precedence over the padding BSR.

The UE shall restart *retxBSR-Timer* upon indication of a grant for transmission of new data on UL-SCH.

All triggered BSRs shall be cancelled in case the UL grant can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the BSR MAC control element plus its subheader. All triggered BSRs shall be cancelled when a BSR is included in a MAC PDU for transmission.

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 nominal UE maximum transmit power and the estimated power for UL-SCH transmission. The reporting period, delay and mapping of Power Headroom are defined in subclause 9.1.8 of [9]. RRC controls Power Headroom reporting by configuring the two timers *periodicPHR-Timer* and *prohibitPHR-Timer*, and by signalling *dl-PathlossChange* which sets the change in measured downlink pathloss to trigger a PHR [8].

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

- *prohibitPHR-Timer* expires or has expired and the path loss has changed more than *dl-PathlossChange* dB since the transmission of a PHR when UE has UL resources for new transmission;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00049

- *periodicPHR-Timer* expires;
- upon configuration or reconfiguration of the power headroom reporting functionality by upper layers [8], which is not used to disable the function.

If the UE has UL resources allocated for new transmission for this TTI:

- if it is the first UL resource allocated for a new transmission since the last MAC reset, start *periodicPHR-Timer*;
- if the Power Headroom reporting procedure determines that at least one PHR has been triggered since the last transmission of a PHR or this is the first time that a PHR is triggered, and;
- if the allocated UL resources can accommodate a PHR MAC control element plus its subheader as a result of logical channel prioritization:
  - obtain the value of the power headroom from the physical layer;
  - instruct the Multiplexing and Assembly procedure to generate and transmit a PHR MAC control element based on the value reported by the physical layer;
  - start or restart *periodicPHR-Timer*;
  - start or restart *prohibitPHR-Timer*;
  - cancel all triggered PHR(s).

5.5 PCH reception

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

- 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 upper 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 upper layers.

5.7 Discontinuous Reception (DRX)

The UE may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the UE's C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and Semi-Persistent Scheduling C-RNTI (if configured). When in RRC_CONNECTED, if DRX is configured, the UE is allowed to monitor the PDCCH discontinuously using the DRX operation specified in this subclause; otherwise the UE monitors the PDCCH continuously. When using DRX operation, the UE shall also monitor PDCCH according to requirements found in other subclauses of this specification. RRC controls DRX operation by configuring the timers *onDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimer* (one per DL HARQ process except for the broadcast process), the *longDRX-Cycle*, the value of the *drxStartOffset* and optionally the *drxShortCycleTimer* and *shortDRX-Cycle*. A HARQ RTT timer per DL HARQ process (except for the broadcast process) is also defined (see subclause 7.7).

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00050

- *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
- a Scheduling Request sent on PUCCH is pending (as described in subclause 5.4.4); or
- an uplink grant for a pending HARQ retransmission can occur and there is data in the corresponding HARQ buffer; or
- a PDCCH indicating a new transmission addressed to the C-RNTI of the UE has not been received after successful reception of a Random Access Response for the preamble not selected by the UE (as described in subclause 5.1.4).

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

- If the Short DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*shortDRX-Cycle*) = (*drxStartOffset*) modulo (*shortDRX-Cycle*); or
- if the Long DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*longDRX-Cycle*) = *drxStartOffset*:
  - start *onDurationTimer*.
- 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-RetransmissionTimer* for the corresponding HARQ process.
- if a DRX Command MAC control element is received:
  - stop *onDurationTimer*;
  - stop *drx-InactivityTimer*.
- if *drx-InactivityTimer* expires or a DRX Command MAC control element is received in this subframe:
  - if the Short DRX cycle is configured:
    - start or restart *drxShortCycleTimer*;
    - use the Short DRX Cycle.
  - else:
    - use the Long DRX cycle.
- if *drxShortCycleTimer* expires in this subframe:
  - use the Long DRX cycle.
- during the Active Time, for a PDCCH-subframe, if the subframe is not required for uplink transmission for half-duplex FDD UE operation and if the subframe is not part of a configured measurement gap:
  - monitor the PDCCH;
  - if the PDCCH indicates a DL transmission or if a DL assignment has been configured for this subframe:
    - start the HARQ RTT Timer for the corresponding HARQ process;
    - stop the *drx-RetransmissionTimer* for the corresponding HARQ process.
  - if the PDCCH indicates a new transmission (DL or UL):
    - start or restart *drx-InactivityTimer*.
- when not in Active Time, CQI/PMI/RI on PUCCH 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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00051

NOTE: A UE may optionally choose to not send CQI/PMI/RI reports on PUCCH and/or SRS transmissions for up to 4 subframes following a PDCCH indicating a new transmission (UL or DL) received in the last subframe of active time. The choice not to send CQI/PMI/RI reports on PUCCH and/or SRS transmissions is not applicable for subframes where *onDurationTimer* is running.

5.8 MAC reconfiguration

When a reconfiguration of the MAC entity is requested by upper layers, the UE shall:

- for timers apply the new value when the timer is (re)started;
- when counters are initialized apply the new maximum parameter value;
- for other parameters, apply immediately the configurations received from upper layers.

5.9 MAC Reset

If a reset of the MAC entity is requested by upper layers, the UE shall:

- initialize Bj for each logical channel to zero;
- stop (if running) all timers;
- consider *timeAlignmentTimer* as expired and perform the corresponding actions in subclause 5.2;
- set the NDIs for all uplink HARQ processes to the value 0;
- stop, if any, ongoing RACH procedure;
- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush Msg3 buffer;
- cancel, if any, triggered Scheduling Request procedure;
- cancel, if any, triggered Buffer Status Reporting procedure;
- cancel, if any, triggered Power Headroom Reporting procedure;
- flush the soft buffers for all DL HARQ processes;
- for each DL HARQ process, consider the next received transmission for a TB as the very first transmission;
- release, if any, Temporary C-RNTI.

5.10 Semi-Persistent Scheduling

When Semi-Persistent Scheduling is enabled by RRC, the following information is provided [8]:

- Semi-Persistent Scheduling C-RNTI;
- Uplink Semi-Persistent Scheduling interval *semiPersistSchedIntervalUL* and number of empty transmissions before implicit release *implicitReleaseAfter*, if Semi-Persistent Scheduling is enabled for the uplink;
- Whether *twoIntervalsConfig* is enabled or disabled for uplink, only for TDD;
- Downlink Semi-Persistent Scheduling interval *semiPersistSchedIntervalDL* and number of configured HARQ processes for Semi-Persistent Scheduling *numberOfConfSPS-Processes*, if Semi-Persistent Scheduling is enabled for the downlink;

When Semi-Persistent Scheduling for uplink or downlink is disabled by RRC, the corresponding configured grant or configured assignment shall be discarded.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00052

5.10.1 Downlink

After a Semi-Persistent downlink assignment is configured, the UE shall consider that the assignment recurs in each subframe for which:

- (10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * *semiPersistSchedIntervalDL*] modulo 10240, for all N>0.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured downlink assignment were (re-)initialised.

5.10.2 Uplink

After a Semi-Persistent Scheduling uplink grant is configured, the UE shall:

- if *twoIntervalsConfig* is enabled by upper layer:
  - set the Subframe_Offset according to Table 7.4-1.
- else:
  - set Subframe_Offset to 0.
- consider that the grant recurs in each subframe for which:
  - (10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * *semiPersistSchedIntervalUL* + Subframe_Offset * (N modulo 2)] modulo 10240, for all N>0.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured uplink grant were (re-)initialised.

The UE shall clear the configured uplink grant immediately after *implicitReleaseAfter* [8] number of consecutive new MAC PDUs each containing zero MAC SDUs have been provided by the Multiplexing and Assembly entity, on the Semi-Persistent Scheduling resource.

NOTE: Retransmissions for Semi-Persistent Scheduling can continue after clearing the configured uplink grant.

5.11 Handling of unknown, unforeseen and erroneous protocol data

When a MAC entity receives a MAC PDU for the UE's C-RNTI or Semi-Persistent Scheduling C-RNTI, or by the configured downlink assignment, containing reserved or invalid values, the MAC entity shall:

- discard the received PDU.

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00053

The UE shall ignore the value of Reserved bits in downlink MAC PDUs.

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

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 subheaders; each subheader corresponds 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 subheaders for fixed sized MAC control elements consist solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

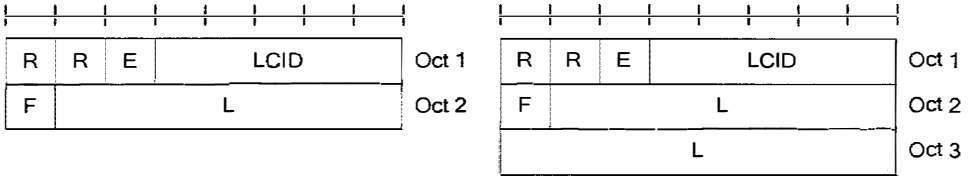


Figure 6.1.2-1: R/R/E/LCID/F/L MAC subheader

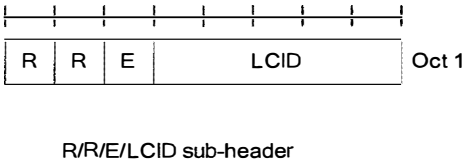


Figure 6.1.2-2: R/R/E/LCID MAC subheader

MAC PDU subheaders have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements are always placed before any MAC SDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the UE shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB per UE.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00054

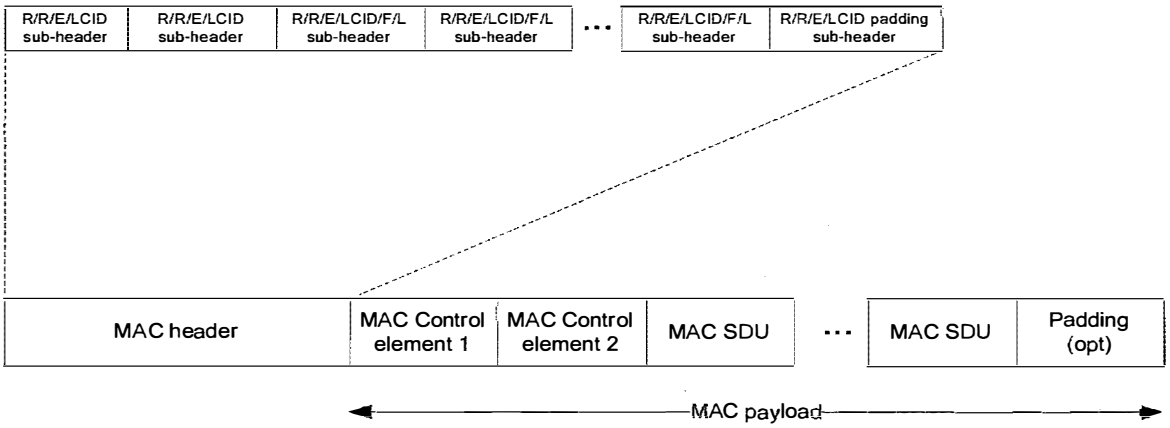


Figure 6.1.2-3: Example of MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding

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 and Truncated BSR format: one LCG ID field and one corresponding Buffer Size field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #0 through #3 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1-2.

The fields LCG ID and Buffer Size 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 6.1.3.1-1.

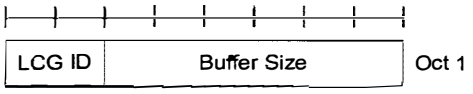


Figure 6.1.3.1-1: Short BSR and Truncated BSR MAC control element

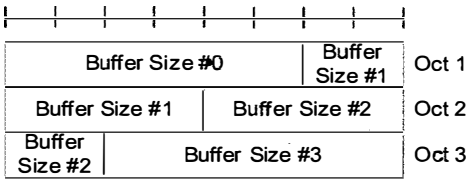


Figure 6.1.3.1-2: Long BSR MAC control element

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00055

Table 6.1.3.1-1: Buffer size levels for BSR

Index	Buffer Size (BS) value [bytes]	Index	Buffer Size (BS) value [bytes]
0	BS = 0	32	1132 < BS <= 1326
1	0 < BS <= 10	33	1326 < BS <= 1552
2	10 < BS <= 12	34	1552 < BS <= 1817
3	12 < BS <= 14	35	1817 < BS <= 2127
4	14 < BS <= 17	36	2127 < BS <= 2490
5	17 < BS <= 19	37	2490 < BS <= 2915
6	19 < BS <= 22	38	2915 < BS <= 3413
7	22 < BS <= 26	39	3413 < BS <= 3995
8	26 < BS <= 31	40	3995 < BS <= 4677
9	31 < BS <= 36	41	4677 < BS <= 5476
10	36 < BS <= 42	42	5476 < BS <= 6411
11	42 < BS <= 49	43	6411 < BS <= 7505
12	49 < BS <= 57	44	7505 < BS <= 8787
13	57 < BS <= 67	45	8787 < BS <= 10287
14	67 < BS <= 78	46	10287 < BS <= 12043
15	78 < BS <= 91	47	12043 < BS <= 14099
16	91 < BS <= 107	48	14099 < BS <= 16507
17	107 < BS <= 125	49	16507 < BS <= 19325
18	125 < BS <= 146	50	19325 < BS <= 22624
19	146 < BS <= 171	51	22624 < BS <= 26487
20	171 < BS <= 200	52	26487 < BS <= 31009
21	200 < BS <= 234	53	31009 < BS <= 36304
22	234 < BS <= 274	54	36304 < BS <= 42502
23	274 < BS <= 321	55	42502 < BS <= 49759
24	321 < BS <= 376	56	49759 < BS <= 58255
25	376 < BS <= 440	57	58255 < BS <= 68201
26	440 < BS <= 515	58	68201 < BS <= 79846
27	515 < BS <= 603	59	79846 < BS <= 93479
28	603 < BS <= 706	60	93479 < BS <= 109439
29	706 < BS <= 826	61	109439 < BS <= 128125
30	826 < BS <= 967	62	128125 < BS <= 150000
31	967 < BS <=1132	63	BS > 150000

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00056

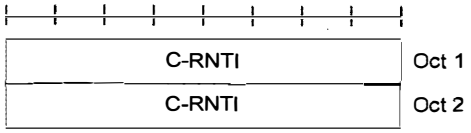


Figure 6.1.3.2-1: C-RNTI MAC control element

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.

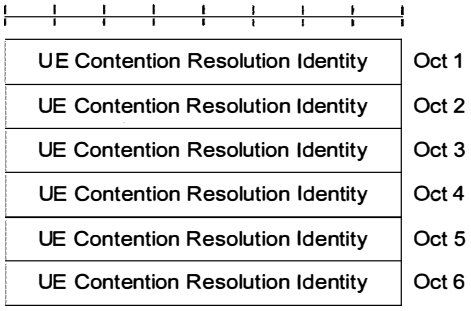


Figure 6.1.3.4-1: UE Contention Resolution Identity MAC control element

6.1.3.5 Timing Advance Command MAC Control Element

The Timing Advance Command 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 octet defined as follows (figure 6.1.3.5-1):

- R: reserved bit, set to "0";
- Timing Advance Command: This field indicates the index value T_A (0, 1, 2... 63) used to control the amount of timing adjustment that UE has to apply (see subclause 4.2.3 of [2]). The length of the field is 6 bits.

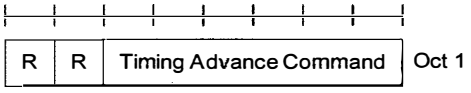


Figure 6.1.3.5-1: Timing Advance Command MAC control element

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 6.2.1-2. It has a fixed size and consists of a single octet defined as follows (figure 6.1.3.6-1):

- R: reserved bit, set to "0";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00057

- Power Headroom (PH): this field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.6-1 below (the corresponding measured values in dB can be found in subclause 9.1.8.4 of [9]).

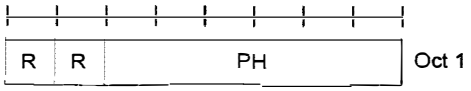


Figure 6.1.3.6-1: Power Headroom MAC control element

Table 6.1.3.6-1: Power Headroom levels for PHR

PH	Power Headroom Level
0	POWER_HEADROOM_0
1	POWER_HEADROOM_1
2	POWER_HEADROOM_2
3	POWER_HEADROOM_3
...	...
60	POWER_HEADROOM_60
61	POWER_HEADROOM_61
62	POWER_HEADROOM_62
63	POWER_HEADROOM_63

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.

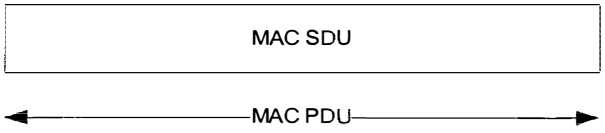


Figure 6.1.4-1: Example of MAC PDU (transparent MAC)

6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of a MAC header and zero or more MAC Random Access Responses (MAC RAR) and optionally padding 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 subheaders; each subheader corresponding to a MAC RAR except for the Backoff Indicator subheader. If included, the Backoff Indicator subheader is only included once and is the first subheader included within the MAC PDU 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 four fields R/Timing Advance Command/UL Grant/Temporary C-RNTI (as described in figure 6.1.5-3).

Padding may occur after the last MAC RAR. Presence and length of padding is implicit based on TB size, size of MAC header and number of RARs.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00058

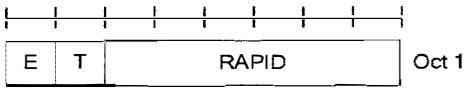


Figure 6.1.5-1: E/T/RAPID MAC subheader

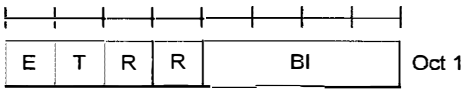


Figure 6.1.5-2: E/T/R/R/BI MAC subheader

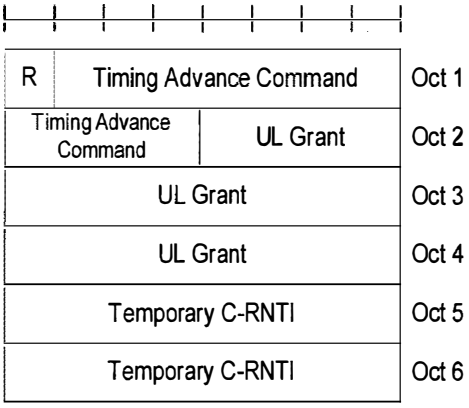


Figure 6.1.5-3: MAC RAR

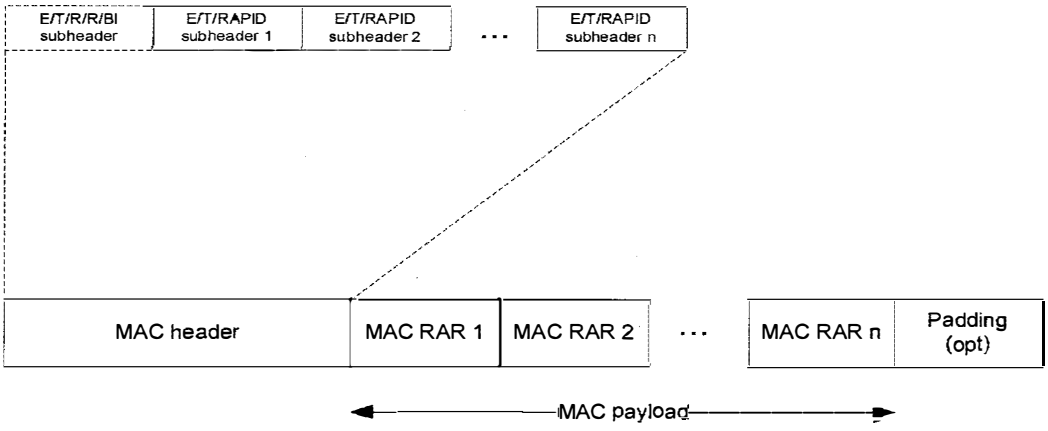


Figure 6.1.5-4: Example of MAC PDU consisting of a MAC header and MAC RARs

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. In addition to that, one or two additional LCID fields are included in 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. The LCID field size is 5 bits;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00059

- L: The Length field indicates the length of the corresponding MAC SDU in bytes. There is one L field per MAC PDU subheader except for the last subheader and subheaders 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 subheaders corresponding to fixed-sized MAC control elements. The size of the F field is 1 bit. If the size of the MAC SDU 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 bit, set to "0".

The MAC header and subheaders are octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-11011	Reserved
11100	UE Contention Resolution Identity
11101	Timing Advance Command
11110	DRX Command
11111	Padding

Table 6.2.1-2 Values of LCID for UL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-11001	Reserved
11010	Power Headroom Report
11011	C-RNTI
11100	Truncated BSR
11101	Short BSR
11110	Long BSR
11111	Padding

Table 6.2.1-3 Values of F field:

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

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 at least another set of E/T/RAPID fields follows. The E field is set to "0" to indicate that a MAC RAR or padding 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, set to "0";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00060

- 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 subheaders 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:

- R: Reserved bit, set to "0";
- Timing Advance Command: The Timing Advance Command field indicates the index value T_A (0, 1, 2... 1282) used to control the amount of timing adjustment that UE has to apply (see subclause 4.2.3 of [2]). The size of the Timing Advance Command field is 11 bits;
- UL Grant: The UpLink Grant field indicates the resources to be used on the uplink (see subclause 6.2 of [2]). The size of the UL Grant field is 20 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.

7 Variables and constants

7.1 RNTI values

RNTI values are presented in Table 7.1-1 and their usage and associated Transport Channels and Logical Channels are presented in Table 7.1-2.

Table 7.1-1: RNTI values.

Value (hexa-decimal)	RNTI
0000	N/A
0001-003C	RA-RNTI, C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI and TPC-PUSCH-RNTI (see note)
003D-FFF3	C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI and TPC-PUSCH-RNTI
FFF4-FFFD	Reserved for future use
FFFE	P-RNTI
FFFF	SI-RNTI

NOTE: The values corresponding to the RA-RNTI values of a cell's PRACH configuration are not used in the cell for any other RNTI (C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI or TPC-PUSCH-RNTI).

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00061

Table 7.1-2: RNTI usage.

RNTI	Usage	Transport Channel	Logical Channel
P-RNTI	Paging and System Information change notification	PCH	PCCH
SI-RNTI	Broadcast of System Information	DL-SCH	BCCH
RA-RNTI	Random Access Response	DL-SCH	N/A
Temporary C-RNTI	Contention Resolution (when no valid C-RNTI is available)	DL-SCH	CCCH
Temporary C-RNTI	Msg3 transmission	UL-SCH	CCCH, DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	DL-SCH, UL-SCH	DCCH, DTCH
C-RNTI	Triggering of PDCCH ordered random access	N/A	N/A
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (activation, reactivation and retransmission)	DL-SCH, UL-SCH	DCCH, DTCH
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (deactivation)	N/A	N/A
TPC-PUCCH-RNTI	Physical layer Uplink power control	N/A	N/A
TPC-PUSCH-RNTI	Physical layer Uplink power control	N/A	N/A

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
13	Reserved
14	Reserved
15	Reserved

The reserved values of the backoff parameter if received by the current release version UEs shall be taken as 960 ms.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00062

7.3 PRACH Mask Index values

Table 7.3-1: PRACH Mask Index values

PRACH Mask Index	Allowed PRACH (FDD)	Allowed PRACH (TDD)
0	All	All
1	PRACH Resource Index 0	PRACH Resource Index 0
2	PRACH Resource Index 1	PRACH Resource Index 1
3	PRACH Resource Index 2	PRACH Resource Index 2
4	PRACH Resource Index 3	PRACH Resource Index 3
5	PRACH Resource Index 4	PRACH Resource Index 4
6	PRACH Resource Index 5	PRACH Resource Index 5
7	PRACH Resource Index 6	Reserved
8	PRACH Resource Index 7	Reserved
9	PRACH Resource Index 8	Reserved
10	PRACH Resource Index 9	Reserved
11	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe
12	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe
13	Reserved	1st PRACH Resource Index in subframe
14	Reserved	2nd PRACH Resource Index in subframe
15	Reserved	3rd PRACH Resource Index in subframe

7.4 Subframe_Offset values

Subframe_Offset values are presented in Table 7.4-1.

Table 7.4-1: Subframe_Offset values

TDD UL/DL configuration	Position of initial Semi-Persistent grant	Subframe_Offset value (ms)
0	N/A	0
1	Subframes 2 and 7	1
	Subframes 3 and 8	-1
2	Subframe 2	5
	Subframe 7	-5
3	Subframes 2 and 3	1
	Subframe 4	-2
4	Subframe 2	1
	Subframe 3	-1
5	N/A	0
6	N/A	0

7.5 TTI_BUNDLE_SIZE value

The parameter TTI_BUNDLE_SIZE is 4.

7.6 DELTA_PREAMBLE values

The DELTA_PREAMBLE preamble format based power offset values are presented in Table 7.6-1.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00063

Table 7.6-1: DELTA_PREAMBLE values.

Preamble Format	DELTA_PREAMBLE value
0	0 dB
1	0 dB
2	-3 dB
3	-3 dB
4	8 dB

Where the Preamble Format is given by *prach-ConfigIndex* [7].

7.7 HARQ RTT Timer

For FDD the HARQ RTT Timer is set to 8 subframes. For TDD the HARQ RTT Timer is set to k + 4 subframes, where k is the interval between the downlink transmission and the transmission of associated HARQ feedback, as indicated in Table 10.1-1 of [2].

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00064

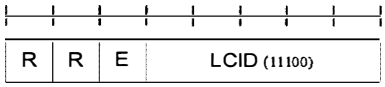
Annex A (normative): Handling of measurement gaps

In a subframe that is part of a measurement gap, the UE shall not perform the transmission of HARQ feedback and CQI/PMI/RI, and SRS shall not be reported.

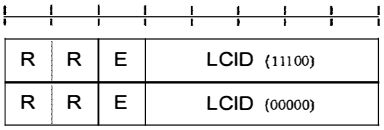
IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00065

Annex B (informative): Contention resolution for RACH access

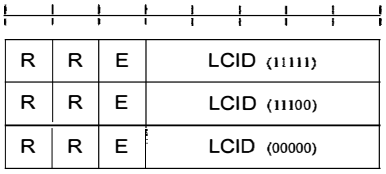
When checking whether contention resolution was successful a UE considers the MAC header structures shown below for the processing of a MAC PDU containing a UE Contention Resolution Identity MAC control element.



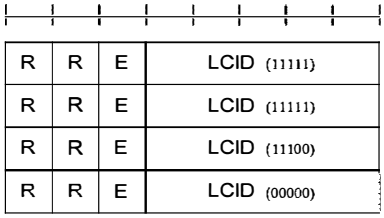
Case 1: MAC subheader for MAC control element



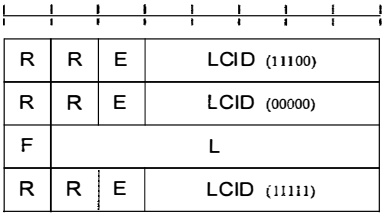
Case 2: MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



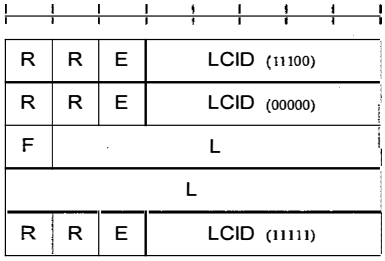
Case 3: MAC subheader for single-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 4: MAC subheaders for two-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 5: MAC subheader for MAC control element + MAC subheader (7-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding



Case 6: MAC subheader for MAC control element + MAC subheader (15-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00066

Annex C (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	RP-38	RP-070917			Clean version, presented at TSG RAN-38 for approval	1.3.0	2.0.0
2007-12	RP-38	-			Approved at TSG RAN-38 and placed under change control	2.0.0	8.0.0
2008-03	RP-39	RP-080162	0001	2	CR to 36.321 with E-UTRA MAC protocol specification update	8.0.0	8.1.0
2008-05	RP-40	RP-080410	0002	1	36.321 CR covering agreements of RAN2 #61bis and RAN2#62	8.1.0	8.2.0
2008-09	RP-41	RP-080690	0003	-	Clarification on data available for transmission for BSR triggering	8.2.0	8.3.0
	RP-41	RP-080690	0004	-	CR to 36.321 on failure indication after maximum number of HARQ transmissions	8.2.0	8.3.0
	RP-41	RP-080690	0005	4	Clarifications and Corrections of DL and UL Data Transfer (SCH, RACH and SR)	8.2.0	8.3.0
	RP-41	RP-080690	0006	-	CR to 36.321 on Buffer size levels for BSR	8.2.0	8.3.0
	RP-41	RP-080690	0007	-	Clarifications on DRX	8.2.0	8.3.0
	RP-41	RP-080690	0008	-	Clarification on UE behavior for DRX and configured measurement gaps	8.2.0	8.3.0
	RP-41	RP-080690	0009	3	Correction to MAC Padding BSR	8.2.0	8.3.0
	RP-41	RP-080690	0010	-	Correction to UE transmission power headroom report for LTE	8.2.0	8.3.0
	RP-41	RP-080690	0011	-	Corrections on BSR	8.2.0	8.3.0
	RP-41	RP-080690	0012	-	CR to 36.321 REL-8 on Format of UL grant in Message 2	8.2.0	8.3.0
	RP-41	RP-080690	0015	-	CR to 36.321 REL-8 on PUSCH PUCCH Power Control RNTIs	8.2.0	8.3.0
	RP-41	RP-080690	0016	-	CR to 36.321 REL-8 on RACH uniform random backoff	8.2.0	8.3.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00067

	RP-41	RP-080690	0017	1	E-UTRA MAC protocol specification update	8.2.0	8.3.0
	RP-41	RP-080690	0020	-	TP for number of HARQ processes and MIMO	8.2.0	8.3.0
	RP-41	RP-080690	0022	-	Update of MAC dedicated preamble expiry	8.2.0	8.3.0
	RP-41	RP-080690	0027	-	Handling of Semi-Persistent grants and assignments	8.2.0	8.3.0
	RP-41	RP-080690	0051	1	Corrections relating to RACH	8.2.0	8.3.0
	RP-41	RP-080690	0058	1	UL Channel Prioritisation	8.2.0	8.3.0
	RP-41	RP-080690	0071	2	Corrections relating to RACH partitioning	8.2.0	8.3.0
	RP-41	RP-080690	0091	-	Correction on Random Access Response reception behaviour	8.2.0	8.3.0
	RP-41	RP-080690	0103	-	Upper limit of logical channel id	8.2.0	8.3.0
	RP-41	RP-080690	0104	-	Clarifications and Corrections for HARQ operation at TAT expiry and RACH contention resolution	8.2.0	8.3.0
2008-12	RP-42	RP-081018	0105	-	CR0105 to 36.321 [Rel-8] on PHR Periodic Timer Start	8.3.0	8.4.0
	RP-42	RP-081018	0106	1	Proposed R1 of CR0106 to 36.321 [Rel-8] on PHR Reference	8.3.0	8.4.0
	RP-42	RP-081018	0107	1	CR 0107 to 36.321 Interactions between measurement gap and Msg3 transmission	8.3.0	8.4.0
	RP-42	RP-081018	0108	2	Proposed R1 of CR0108 to 36.321 [Rel-8] on PHR Reporting Values	8.3.0	8.4.0
	RP-42	RP-081018	0109	-	Correction relating to equal priorities	8.3.0	8.4.0
	RP-42	RP-081018	0110	-	CR 0110 to 36.321 on Correction to PHR	8.3.0	8.4.0
	RP-42	RP-081018	0112	1	CR0112r1 to 36.321 [Rel-8] Correction to BCCH Reception procedure	8.3.0	8.4.0
	RP-42	RP-081018	0113	-	Contention Resolution Timer	8.3.0	8.4.0
	RP-42	RP-081018	0114	-	PCH reception	8.3.0	8.4.0
	RP-42	RP-081018	0115	-	Correction to reception of assignments and grants	8.3.0	8.4.0
	RP-42	RP-081018	0116	-	Correction on Contention Resolution	8.3.0	8.4.0
	RP-42	RP-081018	0117	2	Proposed R1 of CR0117 to 36.321 [Rel-8] on on SR Clarifications and Repetitions	8.3.0	8.4.0
	RP-42	RP-081078	0118	2	Clarification on Padding value	8.3.0	8.4.0
	RP-42	RP-081018	0119	-	CR 0119 to 36.321 Correction and Clarification on TTI Bundling	8.3.0	8.4.0
	RP-42	RP-081018	0120	1	Clarification of DRX Active Time	8.3.0	8.4.0
	RP-42	RP-081018	0121	4	Text Proposal for Dedicated Preamble Assignment	8.3.0	8.4.0
	RP-42	RP-081018	0122	-	CR0122 to 36.321 [Rel-8] on Message 3 Definition	8.3.0	8.4.0
	RP-42	RP-081018	0123	1	Correction to prevent wrong contention resolution by adaptive retransmission command	8.3.0	8.4.0
	RP-42	RP-081018	0124	-	Bucket Size Parameter	8.3.0	8.4.0
	RP-42	RP-081018	0125	2	CR0125r2 to 36.321 [Rel-8] Correction to Multiple BSR	8.3.0	8.4.0
	RP-42	RP-081018	0127	-	CR0127 to 36.321 [Rel-8] RACH preambles labelling	8.3.0	8.4.0
	RP-42	RP-081018	0128	1	CR0128r1 to 36.321 [Rel-8] merging CR0126r0 and CR0128r0	8.3.0	8.4.0
	RP-42	RP-081018	0129	1	CR0129r1 to 36.321 [Rel-8] Correction to PDU Format	8.3.0	8.4.0
	RP-42	RP-081018	0130	-	CQI/ SRS/PMI/RI transmission during active time	8.3.0	8.4.0
	RP-42	RP-081018	0131	1	NDI and Msg4 Carrying Contention Resolution ID	8.3.0	8.4.0
	RP-42	RP-081018	0132	1	CR0132 to 36.321 [Rel-8] on MAC BSR trigger	8.3.0	8.4.0
	RP-42	RP-081018	0133	-	Clarification about Restarting the Periodic BSR Timer	8.3.0	8.4.0
	RP-42	RP-081018	0134	-	Correction to RA procedure initiated by eNB PDCCH order	8.3.0	8.4.0
	RP-42	RP-081018	0135	1	Correction on PHR triggering condition	8.3.0	8.4.0
	RP-42	RP-081018	0136	-	CR 0136 to 36.321 on Correction to UL HARQ Process for the transmission of Msg3	8.3.0	8.4.0
	RP-42	RP-081018	0137	2	SPS occasions	8.3.0	8.4.0
	RP-42	RP-081018	0138	-	Robustness of Buffer Status Reporting	8.3.0	8.4.0
	RP-42	RP-081018	0139	-	Proposed CR to 36.321 [Rel-8] on UL HARQ and Measurement Gaps	8.3.0	8.4.0
	RP-42	RP-081018	0142	1	TAT and RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0143	1	SRS and CQI Resources Release upon TAT Expiry	8.3.0	8.4.0
	RP-42	RP-081018	0157	1	Proposed CR to 36.321 Correction to RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0162	1	BSR format for reporting empty buffers	8.3.0	8.4.0
	RP-42	RP-081018	0165	-	TTI Bundling Configuration	8.3.0	8.4.0
	RP-42	RP-081018	0166	1	Corrections to semi-persistent scheduling	8.3.0	8.4.0
	RP-42	RP-081018	0167	2	Priotitization of MAC control elements	8.3.0	8.4.0
	RP-42	RP-081018	0168	-	Correction to starting of TA timer	8.3.0	8.4.0
	RP-42	RP-081018	0173	1	Proposed CR to 36.321 SPS implicit release on UL	8.3.0	8.4.0
	RP-42	RP-081018	0174	-	Proposed CR to 36.321 Measurement gaps and SPS	8.3.0	8.4.0
	RP-42	RP-081018	0175	-	Proposed CR to 36.321 Setting reserved bits to zero	8.3.0	8.4.0
	RP-42	RP-081018	0185	-	Proposed CR to 36.321 [Rel-8] MAC ResetReconfig Option 2	8.3.0	8.4.0
	RP-42	RP-081018	0188	2	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0189	-	Corrections to Random Access Procedure	8.3.0	8.4.0
	RP-42	RP-081018	0198	-	Number of HARQ processes for MIMO	8.3.0	8.4.0
	RP-42	RP-081018	0201	-	Corrections to power control and random access	8.3.0	8.4.0
	RP-42	RP-081018	0206	-	Correction on the definition of the PDCCH-subframe	8.3.0	8.4.0
	RP-42	RP-081018	0211	1	Correction to the coexist of SPS-RNTI and SI-RNTI or RA-RNTI	8.3.0	8.4.0
	RP-42	RP-081018	0220	-	Explicit release of SPS	8.3.0	8.4.0
	RP-42	RP-081018	0225	2	Linking HARQ process ID with the SPS resource	8.3.0	8.4.0
	RP-42	RP-081018	0231	-	Bucket Parameter Update	8.3.0	8.4.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00068

	RP-42	RP-081018	0232	1	Clarification on "PDCCH indicates a new transmission" for DRX	8.3.0	8.4.0
	RP-42	RP-081018	0233	1	Editorial corrections to MAC	8.3.0	8.4.0
	RP-42	RP-081018	0236	-	RB suspension and BSR contents	8.3.0	8.4.0
	RP-42	RP-081018	0239	-	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0240	2	Preamble group selection	8.3.0	8.4.0
	RP-42	RP-081018	0241	-	Use of dedicated preambles after HO complete	8.3.0	8.4.0
	RP-42	RP-081018	0242	-	Introduction of HARQ RTT Timer	8.3.0	8.4.0
	RP-42	RP-081018	0243	-	Correction to DRX configuration	8.3.0	8.4.0
2009-03	RP-43	RP-090128	0245	-	CR to 36.321 on BSR clarification	8.4.0	8.5.0
	RP-43	RP-090128	0246	2	Freeing of reserved RNTIs	8.4.0	8.5.0
	RP-43	RP-090128	0247	-	Correction to MAC reset	8.4.0	8.5.0
	RP-43	RP-090128	0248	-	Correction to Initialization of Prioritization	8.4.0	8.5.0
	RP-43	RP-090128	0249	-	Local NACKing Optionality MAC CR	8.4.0	8.5.0
	RP-43	RP-090128	0250	1	Position of the Backoff Indicator subheader	8.4.0	8.5.0
	RP-43	RP-090128	0251	-	Missing reserved bit setting	8.4.0	8.5.0
	RP-43	RP-090128	0252	-	Expired TAT and PUSCH transmission	8.4.0	8.5.0
	RP-43	RP-090128	0253	-	Expired TAT and HARQ feedback	8.4.0	8.5.0
	RP-43	RP-090128	0254	1	Counter proposal to R2-090969 on Management for HARQ buffer with TAT	8.4.0	8.5.0
	RP-43	RP-090128	0255	-	HARQ Feedback and Contention Resolution	8.4.0	8.5.0
	RP-43	RP-090128	0256	-	Corrections to redundancy version control for system information	8.4.0	8.5.0
	RP-43	RP-090128	0257	-	Mapping of the RNTIs to different transport channels	8.4.0	8.5.0
	RP-43	RP-090128	0258	-	DRX and UL Retransmissions	8.4.0	8.5.0
	RP-43	RP-090128	0259	-	Definition of DRX Short Cycle Timer	8.4.0	8.5.0
	RP-43	RP-090128	0260	-	Small corrections to RACH	8.4.0	8.5.0
	RP-43	RP-090128	0261	-	Processing of contention resolution message	8.4.0	8.5.0
	RP-43	RP-090128	0262	-	Corrections to power control and random access	8.4.0	8.5.0
	RP-43	RP-090128	0263	-	Missing condition for unsuccessful reception of Msg2	8.4.0	8.5.0
	RP-43	RP-090128	0264	1	Corrections relating to Random Access required inputs	8.4.0	8.5.0
	RP-43	RP-090128	0265	-	Bucket Parameter Update	8.4.0	8.5.0
	RP-43	RP-090128	0266	2	Correction to Handling of triggered PHR	8.4.0	8.5.0
	RP-43	RP-090128	0267	-	SPS resource release on D-SR failure	8.4.0	8.5.0
	RP-43	RP-090128	0269	2	NDI handling when measurement gap and SPS occassion collide	8.4.0	8.5.0
	RP-43	RP-090128	0270	-	Correction relating to PDCCH order	8.4.0	8.5.0
	RP-43	RP-090128	0271	-	Error Handling	8.4.0	8.5.0
	RP-43	RP-090128	0272	-	Various clarifications/corrections to TS36.321	8.4.0	8.5.0
	RP-43	RP-090128	0273	1	Disassembly, Demultiplexing and Multiplexing functions	8.4.0	8.5.0
	RP-43	RP-090128	0274	1	Miscellaneous corrections to MAC	8.4.0	8.5.0
	RP-43	RP-090128	0275	2	CR on Interactions between Msg3 transmission and TTI bundling	8.4.0	8.5.0
	RP-43	RP-090128	0276	-	TTI Bundling	8.4.0	8.5.0
	RP-43	RP-090128	0278	1	Correction to BSR trigger at serving cell change	8.4.0	8.5.0
	RP-43	RP-090128	0279	1	Correction to Release of SPS	8.4.0	8.5.0
	RP-43	RP-090128	0280	2	Usage of RRC Parameters	8.4.0	8.5.0
	RP-43	RP-090128	0281	-	Clarification of MAC Timer status	8.4.0	8.5.0
	RP-43	RP-090128	0282	1	Correction on MAC PDU subheader description	8.4.0	8.5.0
	RP-43	RP-090128	0283	1	UE behaviour at CURRENT_TX_NB reaches maximum value	8.4.0	8.5.0
	RP-43	RP-090128	0285	-	Reporting During DRX	8.4.0	8.5.0
	RP-43	RP-090128	0289	-	NDI handling after random access procedure	8.4.0	8.5.0
	RP-43	RP-090128	0290	1	Dedicated preamble handling after random access failure	8.4.0	8.5.0
	RP-43	RP-090128	0292	-	NDI and grant in Message 2	8.4.0	8.5.0
	RP-43	RP-090128	0293	1	Correction relating to BCCH HARQ	8.4.0	8.5.0
	RP-43	RP-090128	0300	1	Corrections to Msg3 definition and usage	8.4.0	8.5.0
	RP-43	RP-090128	0303	-	PRACH selection must use prach-ConfigurationIndex	8.4.0	8.5.0
	RP-43	RP-090128	0305	-	Clarification on RETX_BSR_TIMER	8.4.0	8.5.0
	RP-43	RP-090128	0307	3	MAC Structure in UE Side	8.4.0	8.5.0
	RP-43	RP-090128	0308	-	Clarification on Random Access Procedure	8.4.0	8.5.0
	RP-43	RP-090128	0314	-	Clarification on the CR timer	8.4.0	8.5.0
	RP-43	RP-090128	0316	-	Correction on BSR	8.4.0	8.5.0
	RP-43	RP-090128	0318	1	Clarification on MAC reconfiguration of timers and counters	8.4.0	8.5.0
	RP-43	RP-090128	0320	-	HARQ feedback, CQI/PMI/RI and SRS transmissions and measurement gaps	8.4.0	8.5.0
	RP-43	RP-090128	0324	-	MAC PDU subheader corresponding to padding	8.4.0	8.5.0
	RP-43	RP-090128	0333	-	CR On Backoff table	8.4.0	8.5.0
	RP-43	RP-090128	0334	3	TTI Bundling Operation	8.4.0	8.5.0
	RP-43	RP-090128	0341	1	Enforcing new transmission after flushing HARQ process	8.4.0	8.5.0
2009-06	RP-44	RP-090513	0342	-	Correction on HARQ feedback transmission	8.5.0	8.6.0
	RP-44	RP-090513	0343	1	Clarification on the DL assignment/UL grant reception in SPS	8.5.0	8.6.0
	RP-44	RP-090513	0344	1	PHR timer handling after handover	8.5.0	8.6.0
	RP-44	RP-090513	0346	2	MAC PDU for Msg2	8.5.0	8.6.0
	RP-44	RP-090513	0347	2	MAC Error handling	8.5.0	8.6.0
	RP-44	RP-090513	0348	-	Correction on SR cancellation	8.5.0	8.6.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00069

	RP-44	RP-090513	0349	1	Correction to RETX_BSR_TIMER	8.5.0	8.6.0
	RP-44	RP-090513	0350	1	CR to 36.321 on UL SPS Implicit Release	8.5.0	8.6.0
	RP-44	RP-090513	0351	2	Various correction to MAC	8.5.0	8.6.0
	RP-44	RP-090513	0369	-	Correction to Uplink grant by temporary C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0370	-	Clarification on simultaneous reception of RA-RNTI and C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0374	-	Correction on timeAlignmentTimer validity in MAC	8.5.0	8.6.0
	RP-44	RP-090513	0376	1	CR for MAC padding	8.5.0	8.6.0
	RP-44	RP-090513	0377	-	Correction to duplicate reception of TA command (2nd method)	8.5.0	8.6.0
2009-09	RP-45	RP-090906	0379	-	Correction to NDI semantics	8.6.0	8.7.0
	RP-45	RP-090906	0380	1	Minor corrections to 36.321	8.6.0	8.7.0
	RP-45	RP-090906	0381	2	UE behaviour when MBSFN subframe and a configured downlink assignment collide	8.6.0	8.7.0
	RP-45	RP-090906	0399	-	Correction to HARQ process ID for DL SPS retransmissions	8.6.0	8.7.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00070

Title: Reconfiguration in CA

Document for: Discussion, Decision

1. Introduction

After discussion in Miyazaki, following is agreed as TP to 36.912.

5.3.2.2 Connection Control

As in LTE Rel-8, the UE only has one RRC connection with the network. One cell - the "special cell" - provides the security input and the NAS mobility information (one ECGI, one PCI and one ARFCN). There is only one "special cell" per UE in connected mode.

After RRC connection establishment to the "special cell", the reconfiguration, addition and removal of CCs can be performed by *RRCConnectionReconfiguration* including *mobilityControlInfo* (i.e. "intra-cell handover"). *RRCConnectionReconfiguration* without *mobilityControlInfo* can also be used for the addition of CCs, and for the removal of CCs with the exception of the CC corresponding to the "special cell".

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

In addition, following can be found in the minutes of Miyazaki meeting.

What other CC reconfigurations may be possible without performing a handover is FFS

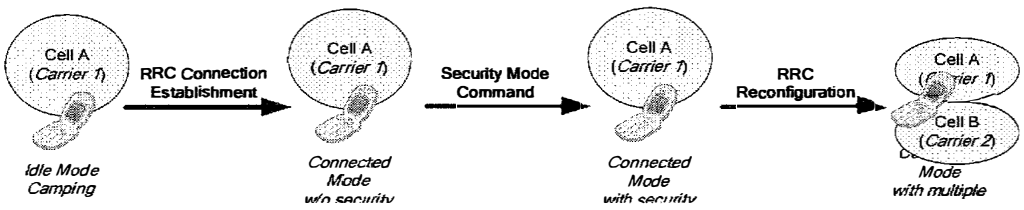
2. Discussion

According to the RRC procedure of LTE, there seem two cases when (re-)keying is performed:

1. In LTE, when a UE receives Security Mode Command message, the UE calculate KeNB using the PCI of the cell from which Security Mode Command message is received.

   Even in LTE-A, it is likely that first activation of additional carrier is performed only after security context is established between eNB and UE. Before establishment of security context, user plane data transmission is not likely to occur. Having multiple CCs without possible data transmission seems not logical.

   Thus, at the time when Security Mode Command is received, there will be only one DL carrier. Thus, without ambiguity, UE can use the PCI of this DL carrier as security input.

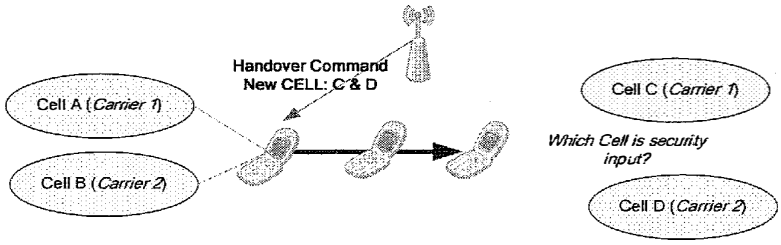


Conclusion 1: Activation of additional carrier is done after SMC is finished.

2. In LTE, when a UE receives *RRC Connection Re-configuration with mobility information* message, the UE calculate KeNB using the PCI of the cell to which the UE should be switched to.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00071

If only one carrier is activated when serving eNB is changed, there will be no difference between LTE-A and LTE. I.e., the only DL carrier included in the handover message will serve as input to KeNB calculation.

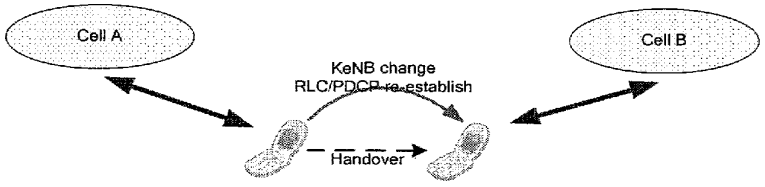


However, though it has not been discussed yet, it is likely that more than one carrier can be configured at the time of handover. In this case, it is not clear which cell should be served as input for security setting. Simply, the Handover Command message sent by eNB can explicitly indicate which DL carrier should be used as input.

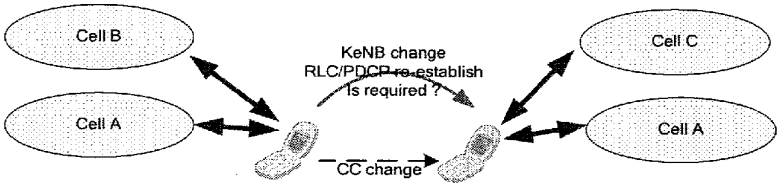
The above approach where eNB can indicate 'the specific cell' can be generally used even for intra-eNB reconfiguration. I.e., whenever there is an ambiguity regarding which carrier should be used as input for NAS system information or as input for KeNB generation, eNB can indicate the specific carrier via the RRC message. Based on the indicated carrier, a UE know which carrier is used for KeNB generation. Furthermore, eNB can re-key without change of CCs by just indicating one of active CCs as new special cell.

Conclusion 2: eNB can indicate which cell is the "special cell" that provides security input and NAS SIB when it transmits RRC messages.

In Rel-8, every handover leads to PDCP/RLC re-establishment and re-keying, regardless of whether the handover is performed within a same eNB or not. Thus, UE in LTE network experiences interruption of data transfer whenever there is a handover.



In Rel-10 with LTE-A, a UE can be configured with multiple DL/UL carriers. This means that a UE has to prepare for not only Rel-8 cell change procedures but also DL/UL carrier change procedures. If each (re-)configuration of additional carrier is considered as handover, the UE will experience much more data interruption. Unless some smart mechanism is introduced, user perception will be worse in LTE-A than in LTE.



First of all, we need to decide which procedure will be used for the (re-) configuration of activated component carriers. In LTE, there are two RRC messages that eNB can use to adjust radio parameter for the given UE. First one is *RRC Connection Reconfiguration with mobility information* message and the other one is *RRC Connection Reconfiguration without mobility information* message.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00072

Following is extracted from TS36.331:

5.3.5.3 Reception of an *RRCConnectionReconfiguration* not including the *mobilityControlInfo* by the UE

If the *RRCConnectionReconfiguration* message does not include the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

...

1> else:

2> if the *RRCConnectionReconfiguration* message includes the *radioResourceConfigDedicated*:

3> perform the radio resource configuration procedure as specified in 5.3.10;

5.3.5.4 Reception of an *RRCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover)

...

1> reset MAC;

1> re-establish PDCP for all RBs that are established;

1> re-establish RLC for all RBs that are established;

...

1> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *mobilityControlInfo*;

...

1> else:

2> update the K_{eNB} key based on the current K_{eNB} or the NH, using the *nextHopChainingCount* value indicated in the *securityConfigHO*, as specified in TS 33.401 [32];

As can be seen in the above text, *RRC Connection Reconfiguration with mobility information* message always requires a UE to re-establish RLC/PDCP and change of KeNB. In this case, data interruption is unavoidable. On the other hand, *RRC Connection Reconfiguration without mobility information* message does not introduce this behavior.

Activation or deactivation of component carrier may be used to dynamically meet QoS requirement of established bearers rather than to respond to cell quality change caused by UE's actual mobility. If the actual move of a UE triggers eNB's action, the eNB may choose to change serving cell on the same frequency rather than to (de-)activate another component carrier. In this case, re-establishment is natural consequence. However, if a UE demands for higher data rate without change of location, the eNB may just increase the number of used component carrier. In this case, re-establishment is over-reaction.

Overall, there seem two cases. First case is to reconfigure activated CC without re-establishment or security change and the second case is to reconfigure activated CC with re-establishment or security change. Support of these two scenarios can be easily done. I.e., it seems enough to introduce a new Information Elements related to component carrier configuration into *RRC Connection Reconfiguration* message. Based on whether the new IE is included with *mobility information* or not, the UE can easily identify whether it needs to re-establish security context when it reconfigures activated components carrier.

Conclusion 3: When *RRC Connection Reconfiguration* message which (re-)configures component carriers is received, PDCP/RLC re-establishment and re-keying of security context depends on whether the message includes *mobility information* or not.

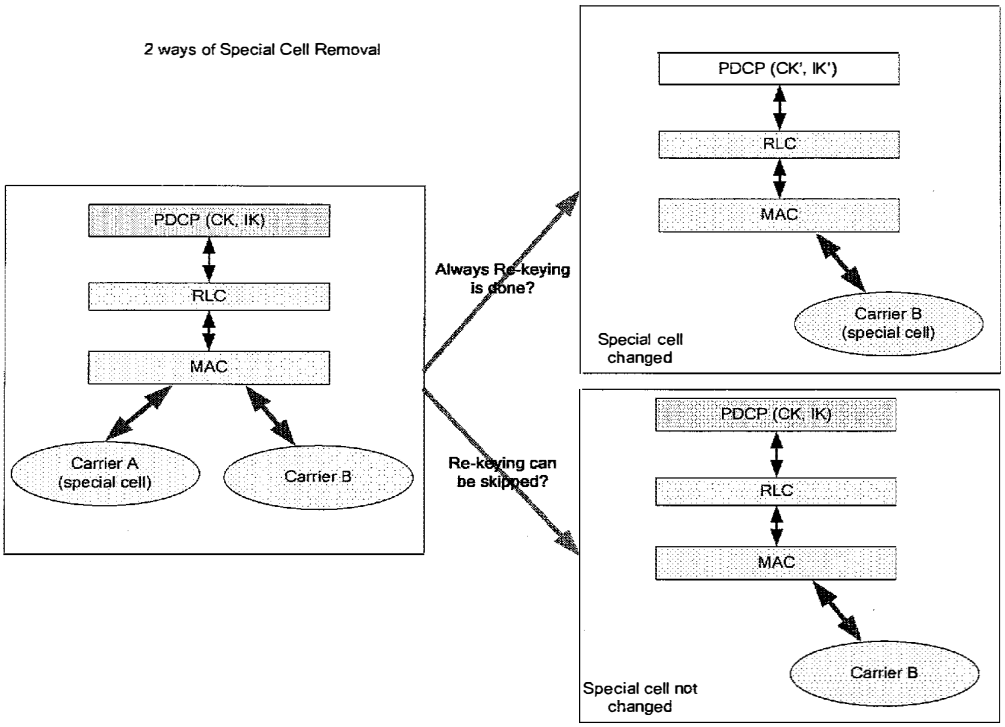
IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00073

In general, the question is when change of 'special cell' can be declared or when 'special cell' provides security input to PDCP. According to the above conclusions, eNB can control when a rekeying is performed. I.e., by deciding whether to include 'mobility information' or not, eNB can decided whether to trigger re-keying or not. At this moment when re-keying is performed, it become important which cell should be considered as 'special cell' which provides security input. If eNB decides not to re-synchronize security keys, it seems not so important which cell is special cell.

Then, we can link change of 'serving cell' to the rekeying procedure. I.e., whenever re-keying is performed, 'special cell change' is declared. Then, even if 'special cell' before reconfiguration is same as the 'special cell' after reconfiguration, we have to consider it as 'special cell change'. However, this seems not a problem because we consider 'intra-cell handover'' as a 'handover'.

Conclusion 4: 'Special cell' is considered as being changed when security re-keying occurs.

Currently, it is not yet decided whether removal of "special cell" can be done without handover procedure. For the reconfiguration procedure within same eNB, to request re-calculation of security parameter for each removal of special cell seems to be too restrictive. If it is possible to remove 'special cell' either by intra-handover procedure or by reconfiguration without handover, to allow both option is to give more flexibility to eNB. I.e., if eNB sees a need to security re-synchronization while performing special cell removal, it can use 'intra-handover' procedure. And, if eNB does not want to change security setting while performing special cell removal, it can use 'reconfiguration without handover' procedure.



Though 'special cell' provides security input to PDCP, it does not necessarily mean that security parameter used in PDCP always should be from the one of the activated carrier. As a matter of fact, PDCP layer which is in charge of security protection does not know to which carrier/cell it is connected. Thus, practically, there is no problem even if used security parameter is not associated with any active carriers/cells. In this sense, removal of serving cell should be allowed without involving a handover procedure. By not performing rekeying at each removal of special cell, data interruption can be minimized.

Conclusion 5: 'Special cell' can be removed from activated CCs with RRC reconfiguration procedure without handover.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00074

3. Proposal

It is proposed to agree on the following:

Proposal 1: Activation of additional carrier is done after SMC is finished.

Proposal 2: eNB can indicate which cell is the "special cell" which provides security input and NAS system information via RRC signaling.

Proposal 3: When *RRC Connection Reconfiguration* message which (re-)configures component carriers is received, PDCP/RLC re-establishment and re-keying of security context depends on whether the message includes *mobility information* or not.

Proposal 4: 'Special cell' is considered as being changed when security re-keying occurs.

Proposal 5: 'Special cell' can be removed from activated CCs with RRC reconfiguration procedure without handover.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00075

Title: SR procedure and DRX procedure.

Document for: Discussion, Decision

1. Introduction

SR procedure is used to request radio resource for UL transmission and DRX procedure is used to increase battery efficiency. According to section 5.7 of TS36.321, SR procedure affects DRX as follows:

> When a DRX cycle is configured, the Active Time includes the time while:
>
> - *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
> - a Scheduling Request sent on PUCCH is pending (as described in subclause 5.4.4); or

2. Discussion

According to section 5.4.4, pending SR is cancelled when a relevant BSR has been transmitted. Regarding SR procedure, elements that constitute active time are shown in the following figure 1.

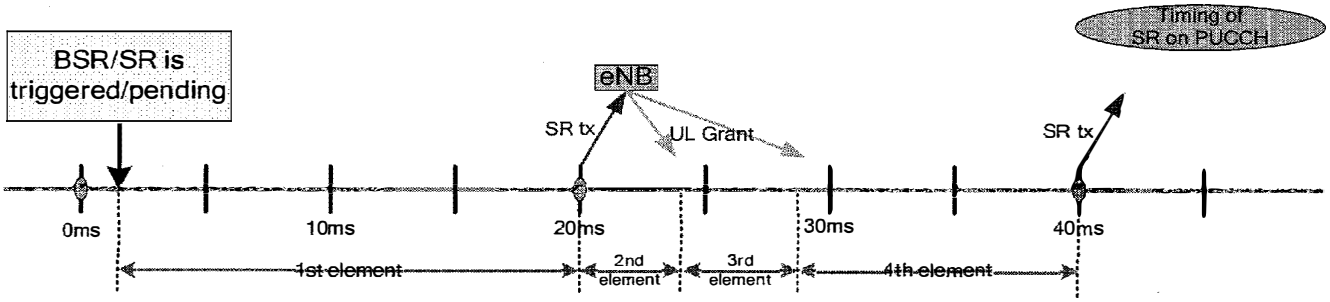


Fig 1 Elements of DRX Active time

UE is in active time as long as SR is pending. The component of active time in figure 1 is as following:

- Element 1: This is the period from when a SR is triggered to when SR on PUCCH is firstly available. I.e., this element is related to how often SR on PUCCH resource is available.
- Element 2: This is the period from when transmission over SR on PUCCH is made to when earliest UL Grant can be received. I.e., this element is related to UL/DL RTT plus eNB's minimum processing time.
- Element 3: This is the period when eNB may transmit UL Grant to the UE, with the condition that the eNB had successfully decoded UE's transmission of SR over PUCCH. This is related to how much scheduling flexibility eNB wants to have in response to SR request of a UE.
- Element 4: this is the period from when the UE has to wait until next available SR on PUCCH after previous transmission of SR over PUCCH has failed. This is the case when previous transmission of SR over PUCCH didn't reach eNB.

Regarding whether a UE is required to monitor PDCCH while SR is pending, following analysis can be made for each elements:

- Element 1: eNB does not know whether SR has been triggered at the UE side. Thus, eNB will not give any UL Grant to the UE. In this sense, PDCCH monitoring by UE is meaningless during this period.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00076

- Element 2: Even if the transmission of SR over PUCCH is successful, the UE will not receive any UL grant due to propagation delay and eNB processing. Thus, there is no need for the UE to monitor PDCCH during this period.
- Element 3: Even if eNB successfully detects SR transmission over PUCCH by a UE, the eNB may not immediately allocate UL grant for the UE. A UE must monitor PDCCH during this period due to the scheduling flexibility of eNB. However, as this period gets longer, UE battery performance will be more impacted.
- Element 4: When SR is pending, UE monitors PDCCH to receive UL grant. The assumption behind this is that eNB successfully receives transmission of SR over PUCCH. If SR transmission over PUCCH has not reached eNB, there is no reason for the UE to listen PDCCH. Thus, UE does not need to monitor during this period.

According to the above analysis, it is meaningful for the UE to monitor DL channels only during element 3. Under current specification, it is evident that UE monitors DL channels unnecessarily longer.

3. Proposal

In this contribution, we analyzed the relation of SR and DRX. To prevent unnecessary UE monitoring during SR procedure, it is proposed to relax the definition of DRX Active time so that UE is required to monitor PDCCH only during when possible UL Grant can be received.

If agreement is reached, LG is happy to provide CR for the next meeting.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00077

Title : SI Providing for CA

Document for : Discussion and Decision

1 SI providing for non-extension carrier

[All background information can be found in annex or 3GPP TS 36.300, 3GPP TS36.321, 3GPP TS TS36.331, TR36.912]

SI providing at CC addition (i.e. at CC configuration)

As identified so far, we have two options: when a CC (Component Carrier) is added,

1. Option 1: the UE receives the system information by common signalling, i.e. broadcast.

   (+) less signalling overhead

2. Option 2: the UE receives the system information by dedicated signalling.

   (+) no delay to use the CC as no extra time to read SI is required

In option1, the eNB may need to conservatively take the delay until the use of the CC as it is difficult to expect when SI reading is finished by the UE. We think it is not desirable to introduce such delay at CC addition.

In option 2, we think that the signalling overhead would not be an issue in LTE-A system to provide data with higher rate, considering the LTE Rel-8 system already supports to provide SI by the dedicated signalling at handover.

Proposal 1: It is proposed to support dedicated signalling to provide system information at CC addition

SI providing at SI change

As identified so far, we have two options: to know the SI change of each DL CC

1. Option 1: the UE periodically checks paging or SIB1 on every DL CC.

   (+) simple

2. Option 2: the UE can periodically check paging or SIB1 on only a certain DL CC, e.g. CC specific *systemInfoModification* in paging message or CC specific *systemInfoValueTag* in SIB1.

   (+) UE power saving

As this issue is about an UE power saving aspect, we think it is quite related to DRX and CC activation/de-activation for CA being discussed.

In non-DRX case, as the UE may be required to monitor paging or SIB1 on each DL CC where it is receiving data, there would not be an issue in terms of the UE power saving.

In DRX case, we currently have two signalling solutions for CC activation/de-activation: RRC signalling and PDCCH signalling [1-4].

If RRC signalling is used, due to the nature of RRC signalling, we think that there would be several DL CCs the UE is monitoring in DRX. In this case, the UE in option 1 would wake up more often to monitor paging or SIB1 than in option 2. So, we think that option 2 is useful.

If PDCCH signalling is used, as the eNB can dynamically manage CCs of the UE, we think that there would be one (or small number of) DL CC the UE is monitoring in DRX. In this case, there would not be an issue for option 2. However, we may need to consider how the UE will manage SI for de-activated CCs. If the UE needs to maintain up-to-date SI even for de-activated CC, i.e. monitors paging/SIB1 on the de-activated CCs, we think option 2 is useful as the UE in option1 needs to wake up for monitoring paging/SIB1 on the de-activated CCs. Otherwise if the UE receives the updates SI by dedicated signalling when the CC is re-activated, we think option 1 is enough.

Alternatively,

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00078

1. the eNB can request the UE to read system information by sending the UE an indication in the PDCCH, MAC, or RRC signalling. The indication also includes which DL CC the UE reads system information on.
2. The UE, after receiving the indication, starts reading the system information on the indicated DL CC.
3. The UE, after completing the system information reading, indicates the completion of the system information reading to the eNB.

For example ,

1. The eNB configures the several DL CCs to the UE for CA functionality (assume DL CC 1 and DL CC2).
2. And the eNB activates those two DL CCs.
3. Afterwards, the eNB de-activates the DL CC 2.
4. The SI of DL CC 2 is changed.
5. Afterwards, the eNB re-activated the DL CC2.
6. Also, the eNB sends the indication to the UE to request the UE to read the system information on the DL CC2.
7. The UE, after completing the system information reading, indicates the completion of the system information reading of DL CC2 to the eNB.

Subject: SI, MAC RLF and DRX 정리 for CA

의견 있으시면 알려주세요.

SI for CA

- For non-extension carrier
  - For SI acquisition at CC addition
    - By dedicated signaling

[Young] 제 생각에는, CC addition 될 때 단말이 SI를 직접 읽으면 될 것 같아요. eNB는 단말이 SI를 읽는데 걸리는 시간을 감안해서 스케줄링하면 될 것 같구요.

  - For SI acquisition at SI change

[SungDuck] 이 부분은 Activation/Deactivation 과도 관련이 있다고 보는데, (addition 이 activation 과 다른 것인지도 모르겠지만.) 만약 Activation 이 pdcch 로 dynamic 하게 된다면, activation 되면 단말은 우선 SI acquisition 을 해야 하는지? 아니면, 단말은 activation/deaction 의 여부에 상관없이 각 carrier 에 대해서 SI 를 관리하고 up-to-date follow up 을 해야 하는지? 이 질문은 각각의 option 에 적용될 것으로 생각됨.

    - Option 1 (baseline): Like LTE R8, the UE checks the paging msg. or value tag on the each CC and then acquires the updated SI on each CC.

[SungDuck] 한 CC 에서 SIB 가 바뀐다고, 다른 CC 도 sIB 가 바뀌는 것은 아님. 가장 효율적일 수 있음.

[Young] 제 생각에는, SIB1 의 value tag 의 경우에, 현재 CC 의 value tag 와 이웃 CC 들의 common value tag 만을 전송할 수도 있을 것 같습니다.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00079

Aggregated CC가 많지 않다면, 꼭 CC별 value tag가 필요할까요? 단말이 activated/configured carrier의 SI만 추적한다면 더욱 그렇구요.

물론, paging도 이웃 CC들간 common SI modification indication을 고려해 볼 수 있겠습니다.

덧붙이면, 현재 CC의 paging에서 다른 이웃 CC의 SI 변경을 알려줄 때, common SI의 변경은 제외하는 것이 바람직할 것 같네요.

아래 Paging ASN.1 구조와 같이 하면, 단말은 현재 위치한 CC의 SI 변경만 추적하면 common SI 변경도 알수 있을 겁니다. (특정 CC의 SIB1 value tag도 common SI 변경 포함)

제 의견을 정리하면 아래와 같습니다.

```
Paging ::=                  SEQUENCE {
    pagingRecordList                PagingRecordList                    OPTIONAL,  -- Need ON
    systemInfoModification              ENUMERATED {true}                   OPTIONAL,  -- Need ON  =>
R10 단말은 이 부분을 현재 CC의 SI modification으로 인식(현재 CC의 SI가 common SI도 포함)
    etws-Indication                 ENUMERATED {true}                   OPTIONAL,  -- Need ON
    nonCriticalExtension            Paging-v10x0-IEs                    OPTIONAL   -- Need OP  =>
이하 R10 단말용으로 각각의 이웃 CC별 SI modification 정보만 포함 (CC별 Common SI 변경 제외)
}
Paging-v10x0-IEs ::=        SEQUENCE {
    V10x0NcnCricticalExtensions     SEQUENCE {
      CCspecific-systemInfoModification             BIT STRING (SIZE(1..maxCC-1))      =>
bitmap으로 각 CC별 SI modification 알림. 각 CC와 bitmap bit 매칭은 SIB1 or SIB2에서 알림(CC별 common SI 변경
제외)
          or
      CCcommon-systemInfoModification               ENUMERATED {true}                  -> 1 bit로
모든 이웃 CC의 SI modification 정보 알림 (CC별 common SI 변경 제외)

    },
```

- \+ simple
- \- required to acquire SI on all CCs even if the common SI (as opposed to CC specific SI) is only changed (**point 1**)
- \- required to monitor/decode paging msg. and value tag on all CCs (**point 2**)

◆Option 2 (optimization to **point 1**): the paging msg. and/or SIB1 contain "no CC specific SI change info". Then, the UE who acquired the updated common SI on a certain carrier can avoid to acquire the common SI on other CCs in case CC specific SI is not changed.

[SungDuck] option2/3 질문: "CC Specific SI" 의 정의는? 새로운 SIB 메시지 인지? 현재 LTE에는 CC Specific SI라는 것이 없음. 새로운 SIB가 정의 된다면, Rel-8 LTE UE의 backward compatible 문제는? (Other issue.. 에 이미 언급되어있네요..)

[Young] 의도를 잘 이해했는지 모르겠지만, Option 1에서 ASN.1 구조내에서 제기한 문제가 해결될 것 같습니다. 아니면, common SI modification indication이나 common SI value tag를 만들고, 현재 CC에 있는 SI modification indication이나 value tag는 common SI의 변경을 알려주지 않는 방식이 있겠지만…)

◆Option 3 (optimization to **point 2**): the paging msg. and/or SIB1 contains all CC changes info. Then, the UE is only required to monitor/decode the paging msg. and/or SIB1 on a certain carrier

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00080

[Young] 의도를 잘 이해했는지 모르겠지만, 특별히 paging message와 SIB1에 추가 사항없이도 가능할 것 같습니다. 즉, Rel-8 단말은 SI modification in paging과 SIB1 value tag를 현재 CC에 대한 SI 변경으로 이해하고, Rel-10 단말은 모든 CC가 변경된 것으로 이해하면 될 듯 합니다.

```
Paging ::=                  SEQUENCE {
    pagingRecordList                PagingRecordList                OPTIONAL,   -- Need ON
    systemInfoModification              ENUMERATED {true}               OPTIONAL,   -- Need ON  =>
R10 단말은 이 부분을 모든 CC의 SI modification으로 인식
    etws-Indication                     ENUMERATED {true}               OPTIONAL,   -- Need ON
    nonCriticalExtension            Paging-v10x0-IEs                OPTIONAL    -- Need OP
```

◆Option 4 (optimization to **point 1 and point 2)**: option 2+option3

- For extension carrier if needed
  - For SI acquisition at CC addition
    - ◆By dedicated signaling
  - For SI acquisition at SI change
    - ◆By dedicated signaling

[SungDuck] 개인적인 view를 말하자면, extension carrier는 그냥 carrier. EX는 connected mode 단말에게 단지 좀더 high data rate를 제공하기 위한 carrier일뿐이지, Cell은 아니라고 봄.

그런데 Cell은 SI를 뿌리지만, Cell이 아닌 놈이 SI를 뿌린다는 것은 이상하다고 봄. 즉, Ex는 SI 자체가 존재 하지 않는다고 봄.

[Young] Extension carrier에 SIB2가 포함되는지 여부가 중요하지 않을까 싶은데요.

Extension Carrier가 RACH 같은 common resource를 사용하거나, MBSFN subframe이 있다면 SIB2가 필요할 수도 있고, 그러면 SIB1도 필요하겠지요….

common resource와 MBSFN subframe이 없다면, DL/UL BW는 dedicated signalling으로 뿌려져도 무방할 듯 하구요.

그런데, Extension Carrier에서도 SFN때문에 MIB 은 있어야겠네요.

MAC RLF for CA

- Assumptions
  - multiple RACH carriers
  - RACH dedicated preamble (re-)transmissions are only available on the concerned CC
  - RACH non-dedicated preamble (re-)transmissions are available on all available RACH carriers

[SungDuck] 이전에도 언급되었듯, carrier를 jump하게 되면, TX power setting문제가 발생할 수 있음.

[Young] adjacent UL carriers에서는 문제가 없지 않을까요?

- Proposal 1: if RACH preamble hits max, consider all uplinks broken

[Young] 제 의견으로는 아래와 같이 생각해 볼 수 있을 것 같습니다.

1. 단말이 multiple RACH carrier 환경에서도, 현재 preamble transmission counting을 특정 UL CC에서만 했다면 (preamble transmission counter가 CC specific),,

➔ *현재 우리 RLF 가정에 따르면, RLF가 아니고, carrier failure입니다.*

➔ *이 경우 단말 동작은*

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00081

1. *어떤 식으로든 문제점을 eNB에게 알린다. (가령 UL CC addition을 위한 RA가 실패할 경우, 이웃 CC의 UL SCH를 통해 failure 보고)*
2. *다른 UL CC는 무사하므로 그냥 가만 있는다. (그래도, 문제가 있으니 어떤 식으로든 알리는 것이 맞겠죠...)*
3. *다른 UL CC는 무사하므로 다른 UL CC에서 RA를 재 시도한다.*

➔ *3번의 경우를 자세히 생각해보면, 특정 CC로만 access하려는 것(가령 UL CC addition)이 목적이라면 적용될 수 없을 수도 있습니다.*

그렇지 않을 경우는 (가령 SR전송), CC specific counter와 전체 CC에 대한 counter를 정의할 수 있을 것 같습니다.

그리고, CC specific counter가 max가 되면, 다른 UL CC에서 RA를 재 시도하고, 전체 CC의 counter가 max일 경우에만 RLF를 선언하는 겁니다.

2. 단말이 multiple RACH carrier 환경에서, 현재 preamble transmission counting을 여러 UL CC들에서 시도했다면 (preamble transmission counter가 CC common),

➔ *이건 RLF이고, 그럼 the connection re-establishment procedure가 triggering되겠죠.*

- Proposal 2: if RACH dedicated preamble hits max, FFS if another RACH carrier. if any, can be considered alive.

[Young] dedicated preamble이 특정 UL CC에 할당되었다고 가정한다면, 위의 CC specific counter와 전체 CC에 대한 counter를 고려해 볼 수 있겠습니다.

가령, dedicated preamble로 특정 CC에서 CC specific counter가 max가 되면, 다른 UL CC에서 non-dedicated preamble를 가지고 RA를 재 시도하는 거죠 (전체 CC에 대한 counter의 max까지.)

Activation/De-activation with DRX

- Combination
  - RRC + common DRX (선호?)
  - RRC + CC specific DRX
  - PDCCH + common DRX (선호?)
  - PDCCH + CC specific DRX (x)

Other issue?:

- does the UE need to monitor e..g paging/SI on the de-activated carriers?
  - If no, how does the UE get the SI, if changed, on deactivated ➔ activated carriers?

[Young] 제 생각에는, 단말은 deactivated carrier를 monitoring할 필요가 없을 것 같습니다. 그냥, Activation될 때 단말이 SI를 직접 읽으면 될 것 같아요.

eNB는 단말이 SI를 읽는데 걸리는 시간을 감안해서 스케줄링하면 될 것 같구요.

As a result of discussion, we see the solutions for SI providing at SI change have dependency with CC activation/de-activation. Thus, we would propose to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00082

Proposal 2: It is proposed to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

2 SI providing for extension carrier

We feel that RAN2 has a difficulty to expect the existence of the extension carrier in CA without inputs from RAN1/4. Also if it exists, it is also unclear in RAN2 whether or not the extension carrier will provide the system information. Basically, one of requirement of a "cell" is to broadcast a system information. Thus, if an extension carrier broadcast a system information, it is not just a 'carrier' but it is a 'cell'.

In this situation, we don't think that CA work with extension carrier is worthwhile. Therefore, we would propose to defer the extension carrier aspects until the details of the extension carrier are somewhat clear.

Proposal 3: It is proposed to defer the extension carrier aspects for SI until the details of the extension carrier are somewhat clear

3 Conclusions

For SI providing for non-extension carrier,

Proposal 1: It is proposed to support dedicated signalling to provide system information at CC addition

Proposal 2: It is proposed to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

For SI providing for extension carrier,

Proposal 3: It is proposed to defer the extension carrier aspects for SI until the details of the extension carrier are somewhat clear

Annex A: Prior Art: system information

5.2 System information

5.2.1 Introduction

5.2.1.1 General

System information is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs). The MIB includes a limited number of most essential and most frequently transmitted parameters that are needed to acquire other information from the cell, and is transmitted on BCH. SIBs other than *SystemInformationBlockType1* are carried in *SystemInformation* (SI) messages and mapping of SIBs to SI messages is flexibly configurable by *schedulingInfoList* included in *SystemInformationBlockType1*, with restrictions that: each SIB is contained only in a single SI message, only SIBs having the same scheduling requirement (periodicity) can be mapped to the same SI message, and *SystemInformationBlockType2* is always mapped to the SI message that corresponds to the first entry in the list of SI messages in *schedulingInfoList*. There may be multiple SI messages transmitted with the same periodicity. *SystemInformationBlockType1* and all SI messages are transmitted on DL-SCH.

5.2.1.2 Scheduling

The MIB uses a fixed schedule with a periodicity of 40 ms and repetitions made within 40 ms. The first transmission of the MIB is scheduled in subframe #0 of radio frames for which the SFN mod 4 = 0, and repetitions are scheduled in subframe #0 of all other radio frames.

The *SystemInformationBlockType1* uses a fixed schedule with a periodicity of 80 ms and repetitions made within 80 ms. The first transmission of *SystemInformationBlockType1* is scheduled in subframe #5 of radio frames for which the SFN mod 8 = 0, and repetitions are scheduled in subframe #5 of all other radio frames for which SFN mod 2 = 0.

The SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00083

not overlap. That is, within one SI-window only the corresponding SI is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN subframes, uplink subframes in TDD, and subframe #5 of radio frames for which SFN mod 2 = 0. The UE acquires the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, used transport format) from decoding SI-RNTI on PDCCH (see TS 36.321 [6]).

A single SI-RNTI is used to address *SystemInformationBlockType1* as well as all SI messages.

SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

5.2.1.3 System information validity and notification of changes

Change of system information (other than for ETWS and CMAS) only occurs at specific radio frames, i.e. the concept of a modification period is used. System information may be transmitted a number of times with the same content within a modification period, as defined by its scheduling. The modification period boundaries are defined by SFN values for which SFN mod m= 0, where m is the number of radio frames comprising the modification period. The modification period is configured by system information.

When the network changes (some of the) system information, it first notifies the UEs about this change, i.e. this may be done throughout a modification period. In the next modification period, the network transmits the updated system information. These general principles are illustrated in figure 5.2.1.3-1, in which different colours indicate different system information. Upon receiving a change notification, the UE acquires the new system information immediately from the start of the next modification period. The UE applies the previously acquired system information until the UE acquires the new system information.

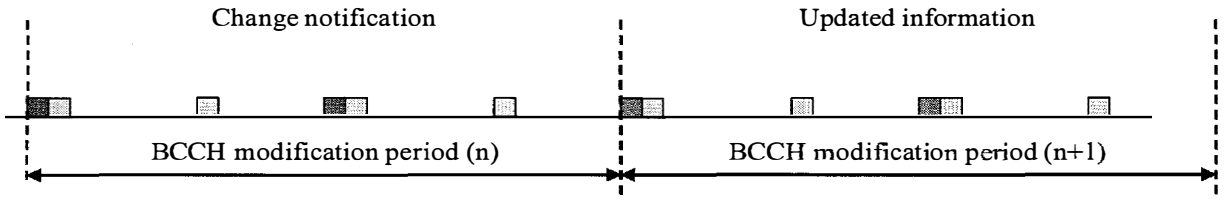


Figure 5.2.1.3-1: Change of system Information

The *Paging* message is used to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change. If the UE receives a *Paging* message including the *systemInfoModification*, it knows that the system information will change at the next modification period boundary. Although the UE may be informed about changes in system information, no further details are provided e.g. regarding which system information will change.

SystemInformationBlockType1 includes a value tag, *systemInfoValueTag*, that indicates if a change has occurred in the SI messages. UEs may use *systemInfoValueTag*, e.g. upon return from out of coverage, to verify if the previously stored SI messages are still valid. Additionally, the UE considers stored system information to be invalid after 3 hours from the moment it was successfully confirmed as valid, unless specified otherwise.

E-UTRAN may not update *systemInfoValueTag* upon change of some system information e.g. ETWS information, CMAS information, regularly changing parameters like CDMA2000 system time (see 6.3). Similarly, E-UTRAN may not include the *systemInfoModification* within the *Paging* message upon change of some system information.

The UE verifies that stored system information remains valid by either checking *systemInfoValueTag* in *SystemInformationBlockType1* after the modification period boundary, or attempting to find the *systemInfoModification* indication at least *modificationPeriodCoeff* times during the modification period in case no paging is received, in every modification period. If no paging message is received by the UE during a modification period, the UE may assume that no change of system information will occur at the next modification period boundary. If UE in RRC_CONNECTED, during a modification period, receives one paging message, it may deduce from the presence/ absence of *systemInfoModification* whether a change of system information other than ETWS information will occur in the next modification period or not.

ETWS and/or CMAS capable UEs in RRC_CONNECTED shall attempt to read paging at least once every *defaultPagingCycle* to check whether ETWS and/or CMAS notification is present or not.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00084

5.2.2 System information acquisition

5.2.2.1 General

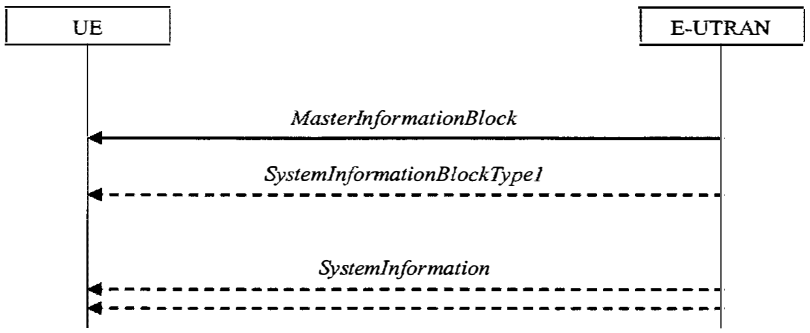


Figure 5.2.2.1-1: System information acquisition, normal

The UE applies the system information acquisition procedure to acquire the AS- and NAS- system information that is broadcasted by the E-UTRAN. The procedure applies to UEs in RRC_IDLE and UEs in RRC_CONNECTED.

5.2.2.2 Initiation

The UE shall apply the system information acquisition procedure upon selecting (e.g. upon power on) and upon re-selecting a cell, after handover completion, after entering E-UTRA from another RAT, upon return from out of coverage, upon receiving a notification that the system information has changed, upon receiving an indication about the presence of an ETWS notification, upon receiving an indication about the presence of a CMAS notification, upon receiving a request from CDMA2000 upper layers and upon exceeding the maximum validity duration. Unless explicitly stated otherwise in the procedural specification, the system information acquisition procedure overwrites any stored system information, i.e. delta configuration is not applicable for system information and the UE discontinues using a field if it is absent in system information unless explicitly specified otherwise.

5.2.2.3 System information required by the UE

The UE shall:

1> ensure having a valid version, as defined below, of (at least) the following system information, also referred to as the 'required' system information:

2> if in RRC_IDLE:

3> the *MasterInformationBlock* and *SystemInformationBlockType1* as well as *SystemInformationBlockType2* through *SystemInformationBlockType8*, depending on support of the concerned RATs;

2> if in RRC_CONNECTED:

3> the *MasterInformationBlock*, *SystemInformationBlockType1* and *SystemInformationBlockType2* as well as *SystemInformationBlockType8*, depending on support of CDMA2000;

1> delete any stored system information after 3 hours from the moment it was confirmed to be valid as defined in 5.2.1.3, unless specified otherwise;

1> consider any stored system information except *SystemInformationBlockType10* and *SystemInformationBlockType11* to be invalid if *systemInfoValueTag* included in the *SystemInformationBlockType1* is different from the one of the stored system information;

5.2.2.4 System information acquisition by the UE

The UE shall:

1> apply the specified BCCH configuration defined in 9.1.1.1;

1> if the procedure is triggered by a system information change notification:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00085

2> start acquiring the required system information, as defined in 5.2.2.3, from the beginning of the modification period following the one in which the change notification was received;

NOTE 1: The UE continues using the previously received system information until the new system information has been acquired.

1> if the UE is in RRC_IDLE and enters a cell for which the UE does not have stored a valid version of the system information required in RRC_IDLE, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_IDLE, as defined in 5.2.2.3;

1> following successful handover completion to a cell for which the UE does not have stored a valid version of the system information required in RRC_CONNECTED, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_CONNECTED, as defined in 5.2.2.3;

2> upon acquiring the concerned system information:

3> discard the corresponding radio resource configuration information included in the *radioResourceConfigCommon* previously received in a dedicated message, if any;

1> following a request from CDMA2000 upper layers:

2> acquire *SystemInformationBlockType8*, as defined in 5.2.3;

1> neither initiate the RRC connection establishment procedure nor initiate transmission of the *RRCConnectionReestablishmentRequest* message until the UE has a valid version of the *MasterInformationBlock* and *SystemInformationBlockType1* messages as well as *SystemInformationBlockType2* ;

1> if the UE is ETWS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

2> when the UE acquires *SystemInformationBlockType1* following ETWS indication, upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

4> start acquiring *SystemInformationBlockType10* immediately;

3> if *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

4> start acquiring *SystemInformationBlockType11* immediately;

NOTE 2: UEs shall start acquiring *SystemInformationBlockType10* and *SystemInformationBlockType11* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

1> if the UE is CMAS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, stored values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType12* associated with the discarded *warningMessageSegment* ;

2> when the UE acquires *SystemInformationBlockType1* following CMAS indication, upon entering a cell during RRC_IDLE, following successful handover and upon connection re-establishment:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00086

4> aquire *SystemInformationBlockType12*;

NOTE 3: UEs shall start acquiring *SystemInformationBlockType12* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

The UE may apply the received SIBs immediately, i.e. the UE does not need to delay using a SIB until all SI messages have been received. The UE may delay applying the received SIBs until completing lower layer procedures associated with a received or a UE originated RRC message, e.g. an ongoing random access procedure.

NOTE 4: While attempting to acquire a particular SIB, if the UE detects from *schedulingInfoList* that it is no longer present, the UE should stop trying to acquire the particular SIB.

5.3.2 Paging

5.3.2.1 General



Figure 5.3.2.1-1: Paging

The purpose of this procedure is:

- to transmit paging information to a UE in RRC_IDLE and/ or;
- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change and/ or;
- to inform about an ETWS primary notification and/ or ETWS secondary notification and/ or;
- to inform about a CMAS notification.

The paging information is provided to upper layers, which in response may initiate RRC connection establishment, e.g. to receive an incoming call.

5.3.2.2 Initiation

E-UTRAN initiates the paging procedure by transmitting the *Paging* message at the UE's paging occasion as specified in TS 36.304 [4]. E-UTRAN may address multiple UEs within a *Paging* message by including one *PagingRecord* for each UE. E-UTRAN may also indicate a change of system information, and/ or provide an ETWS notification or a CMAS notification in the *Paging* message.

5.3.2.3 Reception of the *Paging* message by the UE

Upon receiving the *Paging* message, the UE shall:

1> if in RRC_IDLE, for each of the *PagingRecord*, if any, included in the *Paging* message:

2> if the *ue-Identity* included in the *PagingRecord* matches one of the UE identities allocated by upper layers:

3> forward the *ue-Identity* and the *cn-Domain* to the upper layers;

1> if the *systemInfoModification* is included:

2> re-acquire the required system information using the system information acquisition procedure as specified in 5.2.2.

1> if the *etws-Indication* is included and the UE is ETWS capable:

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00087

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

3> acquire *SystemInformationBlockType10*;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

3> acquire *SystemInformationBlockType11*;

1> if the *cmas-Indication* is included and the UE is CMAS capable:

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary as specified in 5.2.1.5;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

3> acquire *SystemInformationBlockType12*;

– *Paging*

The *Paging* message is used for the notification of one or more UEs.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: PCCH

Direction: E-UTRAN to UE

Paging message

```
-- ASN1START

Paging ::=                  SEQUENCE {
    pagingRecordList                PagingRecordList                OPTIONAL,   -- Need ON
    systemInfoModification          ENUMERATED {true}               OPTIONAL,   -- Need ON
    etws-Indication                 ENUMERATED {true}               OPTIONAL,   -- Need ON
    nonCriticalExtension            Paging-v9x0-IEs                 OPTIONAL    -- Need OP
}

PagingRecordList ::=            SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord

PagingRecord ::=                SEQUENCE {
    ue-Identity                     PagingUE-Identity,
    cn-Domain                       ENUMERATED  {ps, cs},
    ...
}

PagingUE-Identity ::=           CHOICE {
    s-TMSI                          S-TMSI,
    imsi                            IMSI,
    ...
}

IMSI ::=                        SEQUENCE (SIZE (6..21)) OF IMSI-Digit

IMSI-Digit::=                   INTEGER (0..9)

Paging-v9x0-IEs ::=         SEQUENCE {
    v9x0NonCricticalExtensions      SEQUENCE {
        cmas-Indication                 ENUMERATED {true}               OPTIONAL    -- Need ON
    },
    nonCriticalExtension            SEQUENCE {}                         OPTIONAL    -- Need OP
}

-- ASN1STOP
```


IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00088

Paging field descriptions
cn-Domain Indicates the origin of paging.
ue-Identity Provides the NAS identity of the UE that is being paged.
systemInfoModification If present: indication of a BCCH modification other than SIB10, SIB11 and SIB12.
etws-Indication If present: indication of an ETWS primary notification and/ or ETWS secondary notification.
cmas-Indication If present: indication of a CMAS notification.
imsi The International Mobile Subscriber Identity, a globally unique permanent subscriber identity, see TS 23.003 [27]. The first element contains the first IMSI digit, the second element contains the second IMSI digit and so on.

– *SystemInformationBlockType1*

SystemInformationBlockType1 contains information relevant when evaluating if a UE is allowed to access a cell and defines the scheduling of other system information.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: BCCH

Direction: E-UTRAN to UE

***SystemInformationBlockType1* message**

```
-- ASN1START

SystemInformationBlockType1 ::=     SEQUENCE {
    cellAccessRelatedInfo               SEQUENCE {
        plmn-IdentityList                   PLMN-IdentityList,
        trackingAreaCode                    TrackingAreaCode,
        cellIdentity                        CellIdentity,
        cellBarred                          ENUMERATED {barred, notBarred},
        intraFreqReselection                ENUMERATED {allowed, notAllowed},
        csg-Indication                      BOOLEAN,
        csg-Identity                        BIT STRING (SIZE (27))  OPTIONAL    -- Need OR
    },
    cellSelectionInfo                   SEQUENCE {
        q-RxLevMin                          Q-RxLevMin,
        q-RxLevMinOffset                    INTEGER (1..8)          OPTIONAL    -- Need OP
    },
    p-Max                               P-Max                       OPTIONAL,           -- Need OP
    freqBandIndicator                   INTEGER (1..64),
    schedulingInfoList                  SchedulingInfoList,
    tdd-Config                          TDD-Config                  OPTIONAL,   -- Cond TDD
    si-WindowLength                     ENUMERATED {
                                            ms1, ms2, ms5, ms10, ms15, ms20,
                                            ms40},
    systemInfoValueTag                  INTEGER (0..31),
    nonCriticalExtension                SystemInformationBlockType1-v9x0-IEs
    OPTIONAL    -- Need OP
}

PLMN-IdentityList ::=                   SEQUENCE (SIZE (1..6)) OF PLMN-IdentityInfo

PLMN-IdentityInfo ::=                   SEQUENCE {
    plmn-Identity                           PLMN-Identity,
    cellReservedForOperatorUse              ENUMERATED {reserved, notReserved}
}

SchedulingInfoList ::= SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo

SchedulingInfo ::=  SEQUENCE {
    si-Periodicity                      ENUMERATED {
                                            rf8, rf16, rf32, rf64, rf128, rf256, rf512},
    sib-MappingInfo                     SIB-MappingInfo
}
```


IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00089

```
SIB-MappingInfo ::= SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type

SIB-Type ::=                        ENUMERATED {
                                        sibType3, sibType4, sibType5, sibType6,
                                        sibType7, sibType8, sibType9, sibType10,
                                        sibType11, sibType12, spare6, spare5,
                                        spare4, spare3, spare2, spare1, ...}

SystemInformationBlockType1-v9x0-IEs::= SEQUENCE {
    v9x0NonCricticalExtensions          SEQUENCE {
        imsEmergencySupportIndicator    ENUMERATED {supported}              OPTIONAL    -- Need OP
    },
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}

-- ASN1STOP
```

***SystemInformationBlockType1* field descriptions**
plmn-IdentityList List of PLMN identities. The first listed *PLMN-Identity* is the primary PLMN.
cellReservedForOperatorUse As defined in TS 36.304 [4].
trackingAreaCode A *trackingAreaCode* that is common for all the PLMNs listed.
cellBarred 'barred' means the cell is barred, as defined in TS 36.304 [4].
intraFreqReselection Used to control cell reselection to intra-frequency cells when the highest ranked cell is barred, or treated as barred by the UE, as specified in TS 36.304 [4].
csg-Indication If set to TRUE the UE is only allowed to access the cell if the CSG identity matches an entry in the allowed CSG list that the UE has stored.
q-RxLevMinOffset Parameter $Q_{rxlevminoffset}$ in 36.304 [4]. Actual value $Q_{rxlevminoffset}$ = IE value * 2 [dB]. If absent, apply the (default) value of 0 [dB] for $Q_{rxlevminoffset}$. Affects the minimum required Rx level in the cell.
p-Max Value applicable for the cell.
freqBandIndicator Defined in TS 36.101 [42, table 5.5-1].
si-Periodicity Periodicity of the SI-message in radio frames, such that rf8 denotes 8 radio frames, rf16 denotes 16 radio frames, and so on.
sib-MappingInfo List of the SIBs mapped to this *SystemInformation* message.There is no mapping information of SIB2; it is always present in the first *SystemInformation* message listed in the *schedulingInfoList* list.
si-WindowLength Common SI scheduling window for all SIs. Unit in milliseconds, where ms1 denotes 1 millisecond, ms2 denotes 2 milliseconds and so on.
systemInfoValueTag Common for all SIBs other than MIB, SIB1, SIB10 and SIB11.
csg-Identity Identity of the Closed Subscriber Group within the primary PLMN the cell belongs to. The IE is present in a CSG cell.
imsEmergencySupportIndicator Indicates whether the cell supports IMS emergency bearer services for UEs in limited service mode. If absent, IMS emergency call is not supported by the network in the cell for UEs in limited service mode.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00090

Conditional presence	Explanation
TDD	This field is mandatory present for TDD; it is not present for FDD and the UE shall delete any existing value for this field.

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].

1xRTT	CDMA2000 1x Radio Transmission Technology
AM	Acknowledged Mode
ASN.1	Abstract Syntax Notation.1
ARQ	Automatic Repeat Request
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
CCCH	Common Control Channel
CCO	Cell Change Order
CMAS	Commercial Mobile Alert Service
CP	Control Plane
C-RNTI	Cell RNTI
CSG	Closed Subscriber Group
DCCH	Dedicated Control Channel
DRB	(user) Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DL	Downlink
DL-SCH	Downlink Shared Channel
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
ENB	Evolved Node B
EPC	Enhanced Packet Core
EPS	Enhanced Packet System
FDD	Frequency Division Duplex
FFS	For Further Study
GERAN	GSM/EDGE Radio Access Network
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat Request
HRPD	CDMA2000 High Rate Packet Data
IE	Information element
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
kB	Kilobyte (1000 bytes)
L1	Layer 1
L2	Layer 2
L3	Layer 3
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MIB	Master Information Block
N/A	Not Applicable
NACC	Network Assisted Cell Change
NAS	Non Access Stratum
PCCH	Paging Control Channel
PDU	Protocol Data Unit
PDCP	Packet Data Convergence Protocol
PLMN	Public Land Mobile Network
QoS	Quality of Service
RACH	Random Access CHannel
RAT	Radio Access Technology

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00091

RB	Radio Bearer
RLC	Radio Link Control
RNTI	Radio Network Temporary Identifier
RRC	Radio Resource Control
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSSI	Received Signal Strength Indicator
SAE	System Architecture Evolution
SAP	Service Access Point
SFN	System Frame Number
SI	System Information
SIB	System Information Block
SI-RNTI	System Information RNTI
SPS	Semi-Persistent Scheduling
SRB	Signalling Radio Bearer
S-TMSI	SAE Temporary Mobile Station Identifier
TA	Tracking Area
TDD	Time Division Duplex
TM	Transparent Mode
TPC-RNTI	Transmit Power Control RNTI
UE	User Equipment
UICC	Universal Integrated Circuit Card
UL	Uplink
UM	Unacknowledged Mode
UL-SCH	Uplink Shared Channel
UP	User Plane
UTRAN	Universal Terrestrial Radio Access Network

Annex B: Prior Art: Carrier Aggregation

LTE-Advanced extends LTE Rel.-8 with support for C*arrier Aggregation*, where two or more *component carriers* (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz and for spectrum aggregation.

It shall be possible to configure all component carriers which are LTE Rel-8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are same. Not all component carriers may necessarily be LTE Rel-8 compatible.

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.

Carrier aggregation is supported for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks in the frequency domain using the LTE Rel-8 numerology

It is possible to configure a UE to aggregate a different number of component carriers originating from the same eNB and of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same.

Component carriers originating from the same eNB need not to provide the same coverage.

5.2 User Plane

5.2.1 Structure

Compared to the Layer 2 structure of LTE Rel-8, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per CC. The Layer 2 structure for the downlink is depicted on Figured 5.2.1-1 below.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00092

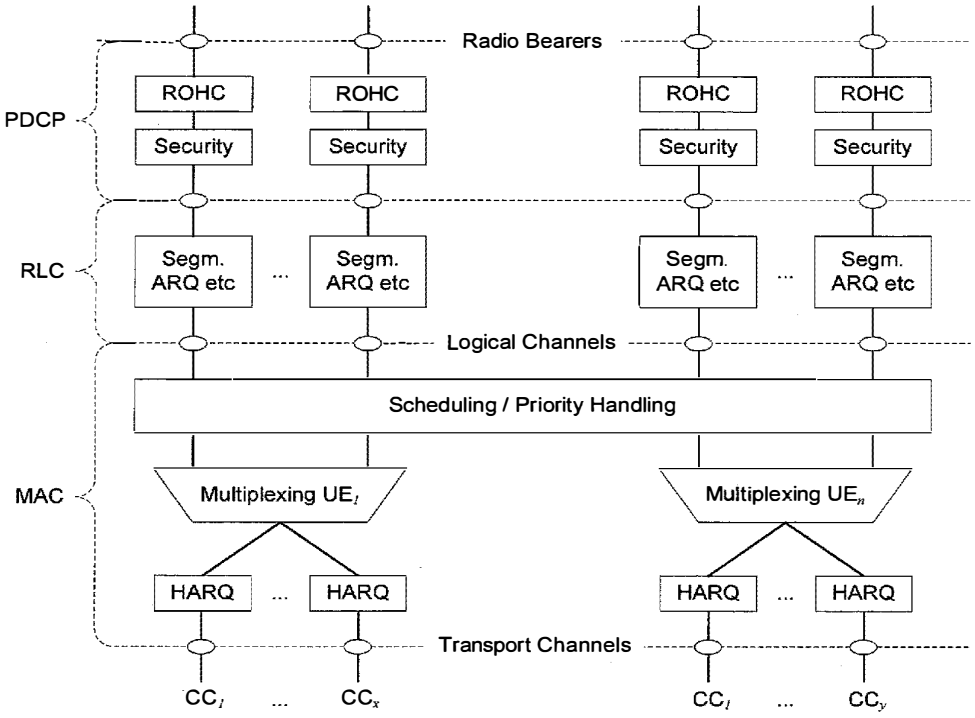


Figure 5.2.1-1: Layer 2 Structure for the DL

The Layer 2 structure for the uplink is depicted on Figured 5.2.1-2 below.

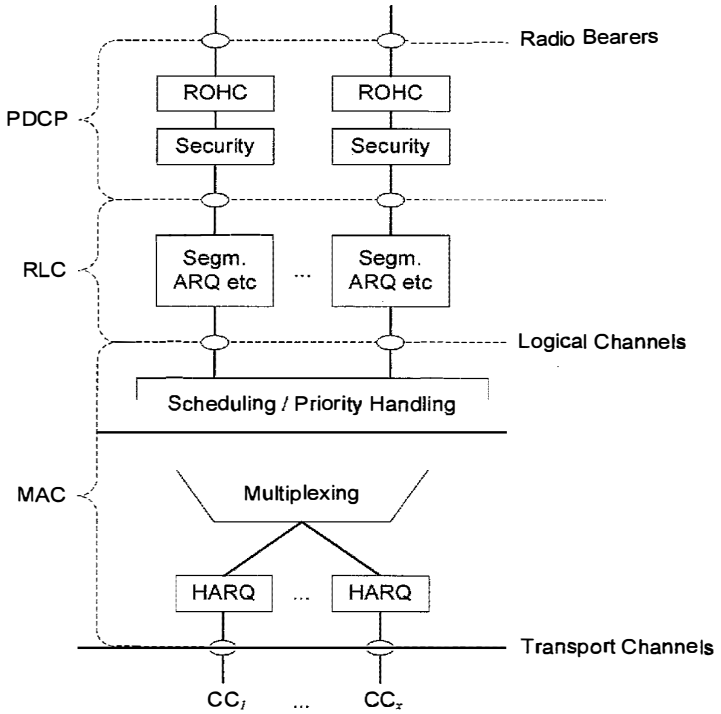


Figure 5.2.1-2: Layer 2 Structure for the UL

5.2.2 MAC

From a UE perspective, the Layer 2 aspects of HARQ are kept Rel-8 compliant unless modifications provide significant gains. There is one transport block (in absence of spatial multiplexing, up to two transport blocks in case of spatial

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00093

multiplexing) and one independent hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only where all possible HARQ retransmissions also take place. A UE may be scheduled over multiple component carriers simultaneously but at most one random access procedure shall be ongoing at any time.

5.2.3 RLC

Apart from a potential issue with the RLC SN size, the RLC protocol of LTE Rel-8 also applies to carrier aggregation.

5.2.4 PDCP

The PDCP protocol of LTE Rel-8 also applies to carrier aggregation.

5.3 Control Plane

5.3.1 Structure

The C-Plane architecture of LTE Rel-8 also applies to carrier aggregation.

5.3.2 RRC procedures

After RRC connection establishment, the configuration and/or activation of additional component carriers is performed by dedicated signaling. At intra-LTE handover, multiple CCs can be included in the "handover command" for usage in the target cell.

5.3.3 Idle mode procedures

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

4

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00094

Title: The best cell selection method for reading and reporting system information

1. Abstract

A UE can read system information of the target CSG or Hybrid and then report it to the network prior to perform handover. In this case, the UE has to choose only one (best cell) target CSG or Hybrid cells to read and report system information. Since there is no detailed procedure for selecting the best CSG or Hybrid cell for reading and reporting system information, the UE may choose one among detected CSG or Hybrid cells with best effort manner or comparison manner based on radio quality. However, the current best cell selection does not consider the Probability of CSG/Hybrid cell handover success. Therefore, we present the best cell selection method for reading and reporting system information considering handover success.

2. Background

2.1 Inbound Mobility

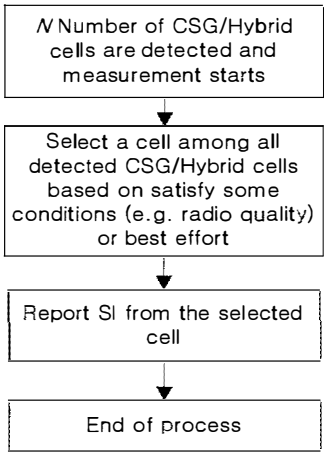
If a UE detects CSG or Hybrid cells which satisfies inbound mobility conditions (e.g. fingerprint match), the UE may read target system information during DRX. If it is possible, the UE includes system information in the measurement report message. If reading system information during DRX is not possible, the UE sends the measurement report message without system information, but includes a "likely or non-likely" bit which is based on the target's membership history. For example, if the target cell is the previously visited cell, the UE should have the result of preliminary access check. If the result was failure of Handover since the target was non-member cell, the target would be marked as "non-likely." After reception of the measurement report message without system information, the network may order the UE to read system information. As soon as the UE receives the system information reading command, starts to read system information, and then sends second measurement report message with acquired system information to the network.

2.2 Current cell selection for reading and reporting target system information

Currently, a UE can detect more than one CSG or Hybrid cell which satisfies inbound mobility conditions, but the UE can report only one target CSG or Hybrid cell's system information to the network. Therefore, the best target CSG or Hybrid cell to read and report system information is decided by a random procedure (best effort) or radio quality based procedure.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00095

The details of the above procedure are described as follows.



3 Problem of current art

3.1 Problem of current method

The whole purpose of reading target system information for inbound mobility prior to receiving network reading system information command (i.e. reading target system information during DRX), is reducing inbound mobility delay. If the UE can acquire system information during DRX, the UE does not have to use a gap to read system information of the target cell. However, this advantage is meaningful only if the handover is successful. Even if the UE acquires system information of the target cell, the target may not be the member cell. Therefore, the UE cannot perform handover successfully. The current best cell selection from detected CSG or Hybrid cells for reading and sending system information overlooks handover success aspect, so the new best cell selection method which increases the handover success rate is needed.

4. Invention

4.1 Invention General

In the proposed scheme, the UE detects CSG or Hybrid target cells and then it has to choose the best cell based on "likely/non-likely" information. "likely/non-likely" information is based on UE's history information, so if the UE choose only "likely" cell to read system information and then report it to the network, the handover success rate should be high comparing to reading system information of "non-likely" cell. If there is no likely cell among detected cells, the best cell may be selected from the non-likely target cells.

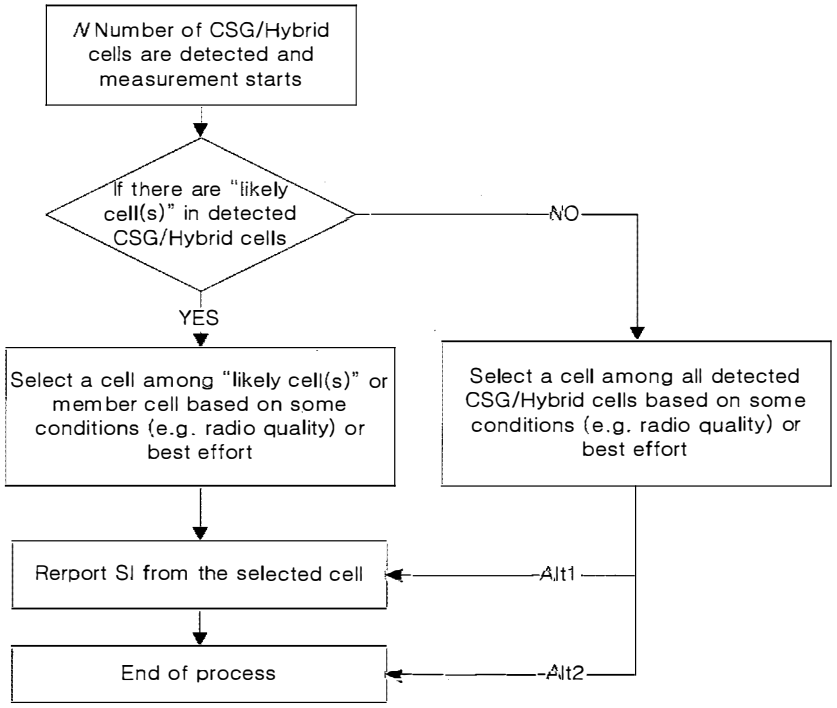
The second way is using membership information acquired from system information. "likely/non-likely" information may not entirely be trusted, so the UE read system information of target

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00096

CSG/Hybrid with the best effort manner. If there are more than one cells has system information, choose one that is the member cell.

4.2 Invention Details

The detail of proposed scheme is described as below flow chart:



To facilitate the description of invention, terminology definition is first suggested:

- CSG cell
  - It is defined in [1].
- Hybrid cell
  - It is defined in [2].
- Member CSG/Hybrid cell
  - Member CSG/Hybrid cell is that the target cell's CSG-id is in UE's allowed CSG list
- Non Member CSG/Hybrid cell
  - Non Member CSG/Hybrid cell is that the target cell's CSG-id is not in UE's allowed CSG list
- Likely bit
  - Likely bit is set for the target CSG or Hybrid cells which the UE already visited the target cells and the UE was a member of the target cells.
- Non-Likely bit
  - Non-Likely bit is set for the target CSG or Hybrid cells which the UE already visited the target cells and the UE was a non member of the target cells.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00097

The details of proposed scheme are described as follows:

UE aspect-likely/non-likely

- If a UE detects a CSG or Hybrid target cells which satisfy handover conditions (e.g. matching fingerprint).
  - If the target cell(s) is(are) "likely" cells
    - If there is more than one "likely" cells
      - Select the best radio quality cell as the best cell among likely cells; or
      - Select one arbitrarily as the best cell among likely cells (best effort).
    - Else (If there is only one "likely cell")
      - Select the likely cell as the best cell.
  - Else (If there is no "likely" cell among detected CSG/Hybrid cells)
    - Select the best radio quality cell as the best cell among non-likely cells; or
    - Select one arbitrarily as the best cell among non-likely cells (best effort); or
    - Do not include system information of the target CSG/Hybrid cells (end of process).
  - Read system information of the best target cell and send the information in the measurement report message; or
  - Send the information of the best target cell in the measurement report message (we may assume that the reading system information is already done when the UE starts to measure the target cell).
-

UE aspect-member/non-member

- If a UE detects a CSG or Hybrid target cells which satisfy handover conditions (e.g. matching fingerprint).
  - If the target cell(s) is(are) member which system information are already acquired.
    - If there is more than one member cells
      - Select the best radio quality cell as the best cell among member cells; or
      - Select one arbitrarily as the best cell among member cells (best effort).
    - Else (If there is only one member cell)
      - Select the member cell as the best cell.
  - Else (If there is no member cell among detected CSG/Hybrid cells)
    - Select the best radio quality cell as the best cell among non-member cells; or
    - Select one arbitrarily as the best cell among non-member cells (best effort); or
    - Do not include system information of the target CSG/Hybrid cells (end of process).
  - Send the information of the best target cell in the measurement report message.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00098

Title: Handling of unsuccessful SI reading

1. Introduction

For inbound mobility to be triggered, NW should get the required information for HO preparation. For this purpose, NW can let UE to initiate SI acquisition. Currently it is FFS what if UE fails to read SI acquisition.

2. Discussion

2.1 Current status and remaining issue

Regarding SI acquisition on request by NW, we agreed the following during RAN2 #67bis:

- we will specify a timer to limit the maximum duration for SI acquisition (LTE + UMTS)

It is FFS what UE should do if the timer expires, i.e., UE has failed to acquire SI. This document aims at resolving the FFS by suggesting possible candidates for UE behaviors.

2.2 UE actions at the failure of SI acquisition

For the case of UE that has failed to read system information from the concerned cell, we can consider the following UE behaviors:

- **Alt.1: UE sends MR including null SI to NW**
  - From the lack of SI in the reported MR, NW detects that UE failed SI acquisition.
  - If SI reading failure is infrequent, this approach is acceptable
  - Typically it is expected that NW would not issue HO command in response to the MR including null SI, since eNB has not obtained information for triggering HO. As a result, HO would not be triggered.
- **Alt.2: UE does not send measurement.**
  - Radio resource can be saved. The saving is however meaningful only if SI reading failure is not infrequent.
  - From the absence of reporting, NW should be able to detect that UE failed SI acquisition
  - Typically it is expected that NW would not issue HO command in response to the MR including null SI, since eNB has not obtained information for triggering HO. As a result, HO would not be triggered. (Same as Alt.1)
- **Alt.3: UE sends MR including stored SI, if available, to NW.**
  - The stored SI means the SI that was obtained and stored from the previous visit of the concerned cell.
  - If the stored SI not available for the concerned cell, UE sends MR including null SI to NW as it does in Alt1.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00099

- From the UE side, UE may not ensure that the stored system information is 100% valid. From the NW perspective, NW should be able to know whether the included SI is a version of either actually read SI or stored SI at previous visit. To assist NW to be aware of this, it is sufficient for UE to include 'likely/non-likely' indication in the MR instead of 'member/non-member' indication.
- Depending on 'likely/non-likely' indication in the MR, NW could decide whether it issues HO command or not. (Different from Alt.1 and Alt.2)
- For some target CSG cell, the required time to read

Among the three options, alt.3 seems to have advantages over others from the following reasons:

- Mostly HO would be successful in case the target cell is what UE has previously visited.
- UE is highly likely to have valid system information of the target cell which UE already visited before.
- No performance degradation in HO expected compared to Alt1 and Alt2.
- Since NW can receive required SI for suitable HO preparation, HO could be triggered even in case UE has failed to read SI due to e.g., insufficient time to read SI.

Proposal 1 If UE fails to read SI within given time duration, UE sends MR including stored SI, if available, to NW.

Proposal 2 When UE sends MR including stored SI to NW, it includes 'likely/non-likely' indication instead of 'member/non-member' indication

3. Conclusion

We summary our proposals regarding UE behaviors at the failure of SI reading:

Proposal 1 If UE fails to read SI within given time duration, UE sends MR including stored SI, if available, to NW.

Proposal 2 When UE sends MR including stored SI to NW, it includes 'likely/non-likely' indication instead of 'member/non-member' indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00100

Title: On applying inboundHO-support indication

1. Introduction

It was previously agreed that NW can control inbound HO support. This is currently implemented by introducing an indicator 'inboundHO-support'[1] which can be included in e.g., RRCConnectionReconfiguration. In this document we try to clarify what the scope of the indication should be.

2. Discussion

2.1 Different results of inboundHO-support set to 'non-support'

If UE was configured that *inboundHO-support* is set to 'non-support'

- **Case 1**: Inter-frequency case with no previously configured measConfig at UE:
  - No proximity indication sent ➔ No measurement performed on the concerned freq ➔ No non-SI MR sent ➔ No inter-f HO occurs
- **Case 2**: Inter-frequency case with previously configured measConfig at UE:
  - No proximity indication sent ➔ Measurement performed on the concerned freq ➔ Non-SI MR sent if triggered ➔ ... ➔ Inter-frequency HO can occur
- **Case 3**: Intra-frequency case:
  - No proximity indication sent (N/A) ➔ Measurement performed on the serving freq ➔ Non-SI MR sent if triggered ➔ ... ➔ Intra-frequency HO can occur

It is observed that with the common configuration of inboundHO-support set to 'non-support', inbound HO can or cannot occur depending on whether the HO is deemed for inter-frequency or intra-frequency or whether the UE has measConfig for the concerned frequency. We are not sure if it would be good to have different UE behaviors for each case. This issue can be viewed at different angle by asking the following question:

Question: What is the scope of the inboundHO-support indication?

2.2 Scope of inboundHO-support

Regarding this scope of the indicator, there seems to be three possible approaches:

- **Alt1.** InboundHO-support indication is applied only for case 1
  - No change required in UE functionality.
  - The indication is only used to suppress proximity indication.
  - Need to clarify its scope of the indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00101

- **Alt2.** InboundHO-support indication shall be applied for inter-frequency cases, i.e., case 1 and case 2
  - Non-SI MR should not be triggered if the inboundHO-support is configured as 'non-support'.
  - No inter-frequency HO occurs if the indication is set to 'non-support'
  - Need to clarify its scope of the indication

- **Alt3.** InboundHO-support indication shall be applied for every case, i.e., both for intra/inter-frequency cases, including case1, 2 and 3.
  - Non-SI MR should not be triggered if the inboundHO-support is configured as 'non-support'
  - No intra-frequency HO occurs if the indication is set to 'non-support'
  - No inter-frequency HO occurs if the indication is set to 'non-support'

If NW only wants to suppress proximity indication from UE while it allows inbound HO which does involve transmission of proximity indication, then Alt1 should be adopted.

On the other hand, alternative 3 seems to be the most in line with the name 'inboundHO-support' itself. Unless NW wants to control the inboundHO-support for each case independently, alternative 3 could be adopted.

3. Conclusion

In this document, we ask what the scope of inboundHO-support is. Regarding this question, following alternatives are suggested:

Case definition:

- Case 1: Inter-frequency case with no previously configured measConfig at UE:
- Case 2: Inter-frequency case with previously configured measConfig at UE:
- Case 3: Intra-frequency case:

Alternatives:

- **Alt1.** InboundHO-support indication is applied only for case 1
- **Alt2.** InboundHO-support indication shall be applied for inter-frequency cases, i.e., case 1 and case 2
- **Alt3.** InboundHO-support indication shall be applied for every case, i.e., both for intra/inter-frequency cases, including case1, 2 and 3.

Note that 'applied' would mean that any signaling from UE to facilitate inbound HO can be suppressed by the indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00102

Proposal 1: RAN2 is kindly requested to discuss what the scope of inboundHO-support is.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00103

Title: Radio Link Failure considering carrier aggregation

1. Introduction

This document aims at establishing further requirements and clarification for detection criterion of radio link failure with consideration of carrier aggregation.

2. Discussion

2.1 Current agreement

During RAN2 #67bis, following agreements were made:

Radio downlink failure

A. Problem detection on one CC does not necessarily imply re-establishment triggering
B. Re-establishment is triggered if all PDCCH CCs fail
C. FFS if re-establishment is even triggered under more restrictive conditions (e.g. in case of problems on an even smaller subset of CC's).

Radio uplink failure

D. Re-establishment is triggered when we lose all UL communication
E. RLC layer re-establishment triggering remains the same as Rel-8.

2.2 Remaining issues for downlink failure detection

Question 1: What if not all PDCCH CCs are concerned for PDCCH monitoring?

Regarding the agreement B, we note that it is possible that UE monitors PDCCH of part of CCs having PDCCH. For example, UE is configured with three CCs and all three CCs have PDCCH. If UE is configured to monitor PDCCH of only a single CC, then the failure of the CC should trigger re-establishment. This observation requires small clarification of the agreement B as follows:

Proposal 1: Re-establishment is triggered if all CCs including PDCCH which UE is monitoring fail

Next question is related to the 'more restrictive conditions' which is captured in agreement C.

Question 2: Should UE declare RLF if a security CC (having provided EARFCN for security) fails?

There would be a 'security CC' which provides EARFCN used for security derivation. Based on the EARFCN, security in PDCP is established, and the PDCP is shared by several CCs. From the attribute of the source of security parameter, we may think that the special CC should be given a special status than other CCs, e.g., by arguing that the failure of security CC should always trigger re-establishment.

From the PDCP perspective, however, once security is established, every CC that is connected to the

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00104

PDCP is considered to be possible transmission path, each having the same importance. If failure of security CC is just a loss of one transmission path, and thus this would not always abrupt whole downlink transmissions, then it is clear that the failure of security CC is not *necessary* condition to declare RLF. So we propose that:

Proposal 2: Re-establishment is not triggered if a security CC which UE is monitoring fails while there is at least one alive CC including PDCCH which UE is monitoring

Question 3: Is any other restrictive condition required to declare RLF?

If proposal 2 is agreeable, then it would be natural to accept that unless there is no alive PDCCH CC which UE is monitoring, the failure of any CC should not lead to RLF declaration. So we propose that:

Proposal 3: Re-establishment is not triggered if a non-security-CC fails while there is at least one alive CC including PDCCH which UE is monitoring

It should be noted that, if proposal 1, 2 and 3 are all agreed, then the failure of all CCs including PDCCG which UE is monitoring becomes a necessary and sufficient condition to declare radio *downlink* failure, and thus to trigger re-establishment. So we propose that:

Proposal 4: Remove FFS for 'other restrictive conditions' for RLF declaration from previous agreements

Question 4: Is per DL CC failure detection supported?

When it comes to supportability of per DL CC failure detection, it should be first decided whether in/out-of sync from L1 is per CC indication or joint indication spanning several CCs. Regarding this question, it is noted that since we have a well defined mechanism for failure detection of a single CC exists in REL-8, we should be able to reuse this mechanism as much as possible.

The most straightforward extension of existing mechanism into CA could be to inherit the existing mechanism for failure detection of *each* CC. Then LTE-A UE would naturally have per-CC DL failure detection mechanism, where in-sync/out-of-sync is independently indicated per each CC. The in/out-of-sync is determined based on hypothetical PDCCH decoding error rate, and common reference signal strength is used to calculate the PDCCH error rate. Since every carrier has the common reference signals, REL-8 mechanism to detect a failure of (DL) CC can be applied for CC failure detection for any carrier type without any modification. That is, LTE-A UE declares the failure of concerned DL CC failure upon the expiry of e.g., T310 which needs to be defined per CC. So we propose:

Proposal 5: per DL CC failure detection is supported, and the criteria of DL CC failure is the same

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00105

as REL-8 mechanism

2.3 Remaining issues for uplink failure detection

Uplink failure can be detected upon the failure of RLC transmission failure or RACH transmission failure. Regarding the RLC transmission failure, since we have a common RLC, it was sufficient and thus agreed in the previous meeting to reuse RLC layer indication as re-establishment trigger.

Regarding the RACH transmission failure, it is still too early to decide anything since there is no agreed behaviors for RACH transmission, and several documents are being proposed to settle this. [1]. In spite of this, if there is only one RACH CC available to UE, it is obvious the MAC indication due to the consecutive RACH transmission failures should trigger re-establishment, since UE has no other option to recover from the failure. So, in case of only one RACH CC available, LTE-A UE should act the same as REL-8 regarding how to detect RACH problem and when concerned MAC indicates the failure to RRC.

Proposal 6: In case there is only one RACH CC available, re-establishment is triggered if RACH problem is detected, as is done in REL-8

Proposal 7: It is FFS for the case of more than one RACH CCs available.

3. Conclusion

Regarding radio link failure considering carrier aggregation, followings are proposed:

Radio downlink failure

Proposal 1: Re-establishment is triggered if all CCs including PDCCH which UE is monitoring fail (Clarification of previous agreement by adding highlighted phrases)

Proposal 2: Re-establishment is not triggered if a security CC which UE is monitoring fails while there is at least one alive CC including PDCCH which UE is monitoring

Proposal 3: Re-establishment is not triggered if a non-security-CC fails while there is at least one alive CC including PDCCH which UE is monitoring

Proposal 4: Remove FFS for other restrictive conditions for RLF declaration from previous agreements

Proposal 5: per DL CC failure detection is supported, and the criteria of DL CC failure is the same as REL-8 mechanism

Radio uplink failure

Proposal 6: In case there is only one RACH CC available, re-establishment is triggered if RACH problem is detected, as is done in REL-8

Proposal 7: It is FFS for the case of more than one RACH CCs available.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00106

Title: CSG cell detection

1. Introduction

Currently detection CSG cell is mostly up to UE implementation. Depending on NW deployment and UE implementation, UE may not have sufficiently fine resolution of finger print for CSG cell detection. In this document, it is suggested that the poor resolution would result in waste of UE battery by leading to useless measurement and even necessary SI reading and reporting. To remedy this, we propose that PCI matching of target CSG cell be mandatory implemented in CSG cell detection.

2. Discussion

2.1 Background of CSG cell detection

Currently UE is relying on autonomous search to detect its possibly allowed CSG cells. The autonomous search consists of finger print test where UE's position (in general sense) is estimated based on some geo-reference data, e.g., measurement result of macro cells, GPS, etc. Since which finger print mechanism is totally up to UE implementation, unified and consistent resolution of each finger print mechanism cannot be expected among UEs and even among NW deployment scenario.

For example, if UE counts on macro cell measurement for finger print implementation, the resolution of finger print is quite affected by NW environment, e.g., how densely the macro cells are deployed. When UE is operating under non-crowded area, e.g., rural place, UE may experience and measure quite small number of macro cells. In the worst scenario from finger print perspective, the case that only a single cell can be seen by the UE cannot be excluded. The less neighbor macro cells are seen, the less the finger print resolution would be.

In the current inbound mobility procedure, the detection of CSG cell by finger print test is informed to NW, in the name of proximity indication, by UE when necessary. Since the triggering of the signaling is totally up to UE implementation, NW cannot expect general behaviors regarding the proximity indication, and some bad UE implementation cause a flood of proximity indication, wasting network resource. So it was agreed that NW should be able to protect possibly a flood of such signaling from the poor UE which may not have any malicious will though.

The problem of poor finger print resolution is not the issue of NW side only. If the resolution of finger print is not sufficiently fine, UE can waste its battery to perform measurement and report SI even when those further measurement and reporting are highly likely to be unnecessary.

2.2 Problem of rough finger print from UE perspective

According to the understanding generally understood in RAN2, if finger print of macro cell(s) is matched, UE performs measurement based on measurement configuration. (Measurement

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00107

configuration can be involved in between.) If the resolution of the finger print is rough, the results from UE perspective would be that:

- More frequently UE sends proximity indication to NW, resulting in wasting radio resource
- More frequently UE performs measurement of CSG cells, resulting in wasting UE current drain.

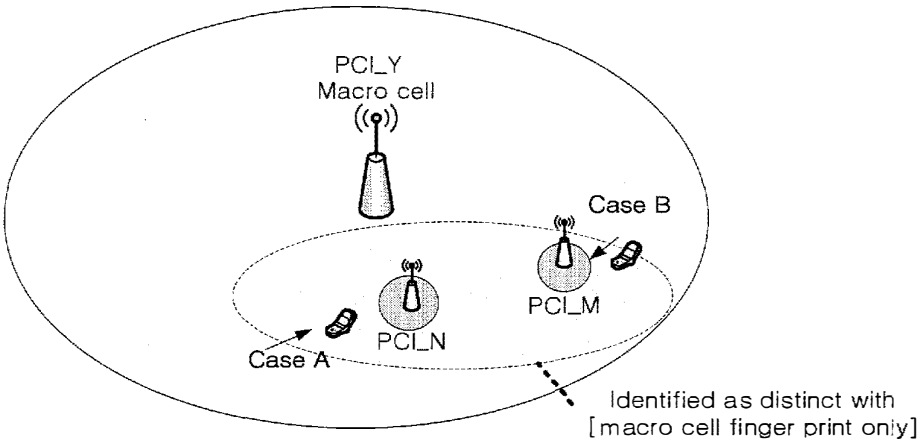


Figure 1 CSG cell detection based on macro cell finger print

For example, UE in figure 1 has a rough finger print resolution where two CSG cells are identified to be located in the same finger print. When UE is approaching to location A, finger print becomes matched, and measurement report is triggered afterward. In this case, CSG cell with PCI_N would trigger measurement report. When UE is approaching to location B, finger print becomes matched, and measurement report is triggered. In this case, CSG cell with PCI_M would trigger measurement report. If CSG cell with PCI_N is an allowed CSG cell and CSG cell with PCI_M is not allowed CSG cell,

- **Assumption**
  - UE ever visited the CSG cell with PCI_N and recorded the macro finger print when it visited there. That is, the finger print is bound to CSG cell with PCI_N which must ever be allowed for the UE.
  - CSG cell with PCI_N is an allowed CSG cell
  - CSG cell with PCI_M is non-allowed CSG cell. We can assume that this cell is ever visited by the UE and identified as non-allowed. No finger print was recorded. So this cell is equivalent to the cell which is unknown to the UE.

- **Case A: If UE is approaching to CSG cell**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print.
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_N, and then measurement report is triggered on the CSG cell with PCI_N

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00108

- NW lets UE to read system information required for HO preparation
- UE obtains the required system information for the CSG cell with PCI_N and reports it to NW
- NW issues HO command.

- **Case B: If UE is approaching to CSG cell with PCI_M**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print. Note that the matched finger print is not actually bound to the CSG cell with PCI_M, but to the CSG cell with PCI_N
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_M, and then measurement report is triggered on the CSG cell with PCI_M
  - NW may let UE to read system information required for HO preparation
  - UE obtains the required system information for the CSG cell with PCI_M and reports it to NW. UE indicates 'non-member' in the report.
  - NW does not issue HO command.

As shown in the sequence of UE behaviors for the case B, both UE measurement/measurement report and SI acquisition turn out to be in vain, since HO is not triggered at the end. Since the finger print area is serving as virtually the area forcing the UE to perform active measurement for CSG cells. This waste mainly comes from the fact that:

A. Single finger print is covering several CSG cells. Equivalently, the finger print is not sufficiently fine to distinguish CSG cell with PCI_N from the CSG cell with PCI_M
B. Not all CSG cells under the same finger print are allowed for the UE.

2.3 Enhancement of finger print resolution

To enhance the possibility of enhancement of finger print resolution, we review two facts that cause the waste.

Since the fact B suggested above is kind of NW environment to the UE and is something *given* to UE, UE cannot change this. Nothing else for the UE to break B seems to exist.

Regarding the fact A, we could think of PCI matching step to be a complementary remedy to the existing macro cell finger print matching. Even though this PCI matching is quite simple, it is sufficiently enhance finger print resolution, by which UE avoids useless measurement and unnecessary SI reading. More specifically, followings can be considered to enhance finger print resolution:

- UE tests finger print matching based on macro cell measurement and stored finger print

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00109

- If the finger print matching passes, UE would further attempt to read the PCI of the target cell
- If the PCI is read, the UE makes a test of PCI matching, where UE compares the PCI read from the target cell with the PCI of the cell which is bound to the matching finger print

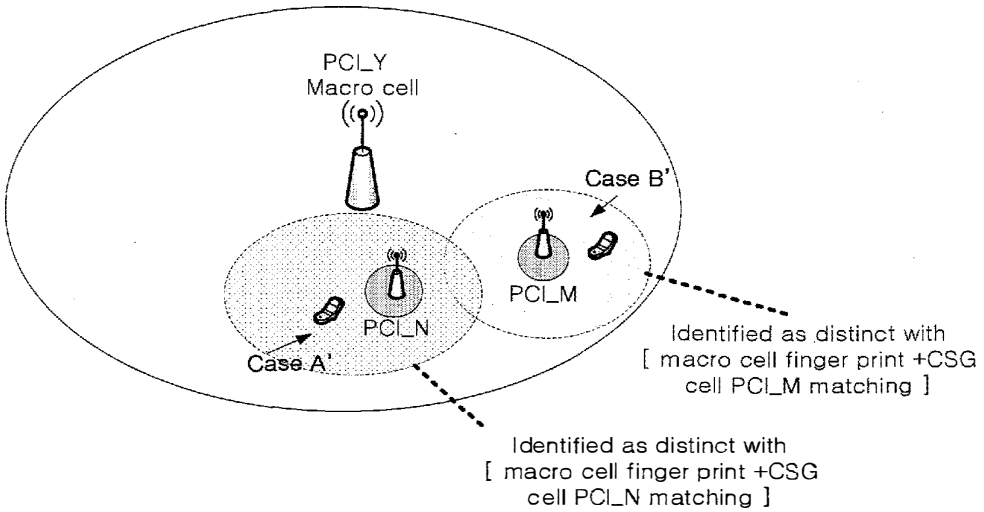


Figure 2 CSG cell detection based on macro cell finger print + CSG cell PCI matching

We describe expected UE behaviors for inbound handover assuming PCI matching is also implemented in addition to macro cell finger print matching mechanism for CSG cell detection.

- **Assumption (same as above in figure 1)**
  - UE recorded the macro finger print when it visited CSG cell with PCI_N. That is, the finger print is bound to CSG cell with PCI_N which is allowed for the UE.
  - CSG cell with PCI_N is an allowed CSG cell
  - CSG cell with PCI_M is non-allowed CSG cell.

- **Case A': If UE is approaching to CSG cell with PCI_N**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print.
  - *UE makes PCI matching test, where UE attempt to read PCI of the target cell, e.g., by cell search procedure, and checks if the PCI read from the target cell is matching with stored PCI information associated to the finger print*
  - *UE sees PCI matching, and thus it considers that wrong CSG cell is detected. The CSG cell is then discarded. No further step for inbound mobility proceeded.*

  (following behaviors are the same as above)
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_N, and then measurement report is triggered on the CSG cell with PCI_N

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00110

- NW lets UE to read system information required for HO preparation
- UE obtains the required system information for the CSG cell with PCI_N and reports it to NW
- NW issues HO command.

- **Case B': If UE is approaching to CSG cell with PCI_M**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print. Note that the matched finger print is not actually bound to the CSG cell with PCI_M, but to the CSG cell with PCI_N
  - *UE makes PCI matching test, where UE attempt to read PCI of the target cell, e.g., by cell search procedure, and checks if the PCI read from the target cell is matching with stored PCI information associated to the finger print*
  - *UE sees PCI not matching, and thus it considers that wrong CSG cell is detected. The CSG cell is then discarded. No further step for inbound mobility proceeded.*

(following behaviors are not performed)

- ~~UE may send proximity indication~~
- ~~UE performs measurement~~
- ~~Measurement event is met for CSG cell with PCI_M, and then measurement report is triggered on CSG cell with PCI_N~~
- ~~NW may let UE to read system information required for HO preparation~~
- ~~UE obtains the required system information for the CSG cell with PCI_N and reports it to NW. UE indicates 'non-member' in the report.~~
- ~~NW does not issue HO command.~~

Figure 2 is illustrating the effect of the implemented PCI matching, where it is observed that finger print resolution is highly increased.

With the simple PCI matching implemented into CSG cell detection, we see that UE can filter out the case where the UE is approaching non-allowed CSG cell, equivalently unknown CSG cell. UE then performs measurement only when it detects allowed CSG cell in the vicinity of where macro finger print has matched. Then UE can avoid unnecessary measurement of non-allowed CSG cell. The UE also avoids useless SI reading and reporting.

We note that PCI reading is mostly equivalent to cell search, and therefore it must be very quick and efficient. This enables the PCI matching to be used for detecting CSG cells on intra/inter-frequency. So we propose:

Proposal 1: PCI matching is mandatory implemented in CSG cell detection.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00111

3. Conclusion

To avoid unnecessary measurement and useless SI reading, we propose that

Proposal 1: PCI matching is mandatory implemented in CSG cell detection.

By means of this proposal, UE would perform measurement only when it detects allowed CSG cell (whether it is allowed or not is determined based on stored information) in the vicinity of where macro finger print has matched.

Reference

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00112

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SI PROVIDING FOR CA
First Named Inventor/Applicant Name:	Seung June YI
Filer:	Andrew S. Park/Soyoun MOON
Attorney Docket Number:	UT09-1365

Filed as Large Entity

Provisional Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Provisional application filing	1005	1	220	220
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00113

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**220**

Electronic Acknowledgement Receipt

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Application Number:	61257427
International Application Number:	
Confirmation Number:	1771
Title of Invention:	SI PROVIDING FOR CA
First Named Inventor/Applicant Name:	Seung June YI
Customer Number:	67487
Filer:	Andrew S. Park/Soyoun MOON
Filer Authorized By:	Andrew S. Park
Attorney Docket Number:	UT09-1365
Receipt Date:	02-NOV-2009
Filing Date:	
Time Stamp:	21:16:08
Application Type:	Provisional

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	UT09-1365_ADS.pdf	837106 55ddec9f8a0a30df73b4054251c3247627c39c7d	no	6
Warnings:					
Information:					
2	Specification - Not in English	UT091365_SPEC.pdf	8595721 ebd716740d7cc1604c460b3f133e3b33dfc6b1ef	no	106
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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COMPLETE IF KNOWN	
Application Number	61/257,427
Filing Date	
First Named Inventor	Seung June YI
Attorney Docket Number	UT09-1365
Title (Required)	SI PROVIDING FOR CA

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/Andrew S. PARK/	11-03-2009
Signature	Date
Andrew S. PARK	82-2-2193-0001
Printed or Typed Name	Telephone Number
SI PROVIDING FOR CA	47841
Title	Registration Number, if applicable

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	6378672
Application Number:	61257427
International Application Number:	
Confirmation Number:	1771
Title of Invention:	SI PROVIDING FOR CA
First Named Inventor/Applicant Name:	Seung June YI
Customer Number:	67487
Filer:	Andrew S. Park/Soyoun MOON
Filer Authorized By:	Andrew S. Park
Attorney Docket Number:	UT09-1365
Receipt Date:	03-NOV-2009
Filing Date:	
Time Stamp:	03:57:25
Application Type:	Provisional

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Authorization to access Appl. by Trilateral Office	UT09-1365_sb0039.pdf	222814 11f8ca65e3cd30b1004c99d083570807540ed763	no	2

Warnings:	
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: PD.TO.AUTH
Document Description: Authorization to access Appl. by Trilateral Office

PTO/SB/39 (01-09)
Approved for use through 02/28/2009. OMB 0651-0031
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AUTHORIZATION TO PERMIT ACCESS TO APPLICATION BY PARTICIPATING OFFICES

Send completed form to: Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

COMPLETE IF KNOWN	
Application Number	61/257,427
Filing Date	
First Named Inventor	Seung June YI
Attorney Docket Number	UT09-1365
Title (Required)	SI PROVIDING FOR CA

The undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h).

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the application-as-filed with respect to: 1) the above-identified application, 2) any foreign application to which the above-identified application claims priority under 35 USC 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified US application, and 3) any U.S. application from which benefit is sought in the above-identified application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

This written authorization should be submitted prior to the filing of a subsequent foreign application, in which priority is claimed to the above-identified patent application, with any intellectual property office (e.g., the EPO, JPO, or KIPO). However, if applicant does not wish the EPO, JPO, KIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified application is filed to have access to the application, this written authorization should not be filed.

No fee will be charged under 37 CFR 1.19(b)(1) for providing a participating intellectual property office with an electronic copy of the above-identified application.

This form must be signed by an authorized party in accordance with 37 CFR 1.14(c).

/Andrew S. PARK/	11-03-2009
Signature	Date
Andrew S. PARK	82-2-2193-0001
Printed or Typed Name	Telephone Number
SI PROVIDING FOR CA	47841
Title	Registration Number, if applicable

This collection of information is required by 37 CFR 1.14(h). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process an application). Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
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Electronic Acknowledgement Receipt

EFS ID:	6378672
Application Number:	61257427
International Application Number:	
Confirmation Number:	1771
Title of Invention:	SI PROVIDING FOR CA
First Named Inventor/Applicant Name:	Seung June YI
Customer Number:	67487
Filer:	Andrew S. Park/Soyoun MOON
Filer Authorized By:	Andrew S. Park
Attorney Docket Number:	UT09-1365
Receipt Date:	03-NOV-2009
Filing Date:	
Time Stamp:	03:57:25
Application Type:	Provisional

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Authorization to access Appl. by Trilateral Office	UT09-1365_sb0039.pdf	222814 11f8ca65e3cd30b1004c99d083570807540ed763	no	2

Warnings:	
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National Stage of an International Application under 35 U.S.C. 371

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New International Application Filed with the USPTO as a Receiving Office

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
61/257,427	11/02/2009	Seung June YI	UT09-1365

CONFIRMATION NO. 1771

IMPROPER PROVISIONAL LETTER

67487
KBK & Associates
GANGNAM P.O. 1655
SEOUL, 135-616
KOREA, REPUBLIC OF

OC00000038787947

Date Mailed: 11/18/2009

Letter re Non-English Language Application Papers in a Provisional Application

The above-identified provisional application was filed in a language other than English. An English-language translation of a non-English provisional application and a statement that the translation is accurate must be filed in the provisional application. See 37 CFR 1.78(a)(5)(iv). Applicants are strongly encouraged to file the English-language translation of the provisional application and the statement that the translation is accurate in the provisional application before a nonprovisional application claiming the benefit of the provisional application is filed, or, alternatively, when making a claim for the benefit of the provisional application in a nonprovisional application. If, however, an English translation and a statement that the translation is accurate have not been filed in the above-identified provisional application when a nonprovisional application is filed claiming the benefit of the filing date of the provisional application, the Office should mail a Notice requiring an English translation and the statement to be filed in the provisional application and a confirmation to be filed in the nonprovisional application.

In the event that the Office schedules a nonprovisional application that claims the benefit of a provisional application filed in a language other than English for publication without issuing a Notice requiring the applicant to file an English translation of the non-English provisional application, the applicant should file the English translation of the non-English provisional application and a statement that the translation is accurate as soon as possible in the provisional application.

/kxaysana/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING or 371(c) DATE	GRPART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
61/257,427	11/02/2009		220	UT09-1365		

CONFIRMATION NO. 1771

67487
KBK & Associates
GANGNAM P.O. 1655
SEOUL, 135-616
KOREA, REPUBLIC OF

FILING RECEIPT

OC00000038787943

Date Mailed: 11/18/2009

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Seung June YI, Seoul, KOREA, REPUBLIC OF;
Young Dae LEE, Seongnam, KOREA, REPUBLIC OF;
Sung Duck CHUN, Anyang, KOREA, REPUBLIC OF;
Sung Jun PARK, Ansan, KOREA, REPUBLIC OF;
Sung Hoon JUNG, Anyang, KOREA, REPUBLIC OF;
Sung Min LEE, Seoul, KOREA, REPUBLIC OF;
Sun Hee KIM, Seoul, KOREA, REPUBLIC OF;
Kyung Jun LEE, Seoul, KOREA, REPUBLIC OF;

Power of Attorney:
Andrew Park--47841

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 11/16/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/257,427**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00126

Title

SI PROVIDING FOR CA

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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Ex.1008.00127

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NOT GRANTED

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IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00128

Docket No.: UT09-1365
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Seung June YI, et al.

Application No.: 61/257,427 | Confirmation No.: 1771

Filed: November 2, 2009 | Art Unit:

For: SI PROVIDING FOR CA | Examiner:

REPLY TO LETTER RE NON-ENGLISH LANGUAGE APPLICATION PAPERS IN A PROVISIONAL APPLICATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner:

In response to the Letter re Non-English Language Application Papers in a Provisional Application forwarded with the Official Filing Receipt dated November 18, 2009, for the above-identified Provisional application, and in accordance with 37 C.F.R. 1.78(a)(5), enclosed are:

1. An English Translation of the Specification; and
2. A statement of Verification dated October 15, 2010.

Respectfully submitted,

Dated: October 18, 2010
Customer No. 67487

By: /Andrew S. Park/
Andrew S. PARK
Registration No.: 47,841
KBK & Associates

CERTIFICATE OF VERIFICATION

I, Suk Goo AHN of third floor, Mungap Building, 619-19, Yeoksam-dong, Gangnam-gu, Seoul, Korea state that the attached document is a true and complete translation to the best of my knowledge of the Korean-English language and that the writings contained in the following pages are correct English translation of the specification and claims of the US Patent Application No. 61/257,427.

Dated this 15th day of October, 2010

Signature of translator: Suk Goo AHN

Name: Suk Goo AHN

PROVISIONAL APPLICATION FOR UNITED STATES PATENT IN THE NAMES OF

Seung June YI, Young Dae LEE, Sung Duck CHUN, Sung Jun PARK, Sung Hoon JUNG, Sung Min LEE, Sun Hee KIM and Kyung Jun LEE

for

SI PROVIDING FOR CA

prepared by:

KBK & Associates

Customer Number: 67487

Attorney Docket Number: UT09-1365

Total Number of Pages : 106 (including cover)

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00131

Title: **Measurement procedure on DC-HSUPA**
Agenda item: **x.x.x**
Document for: **Discussion and decision**

1 Introduction

"[1]" has been approved as a baseline in RAN2 #6 bis meeting. Whether a primary carrier and a secondary carrier share a single measurement ID or each carrier uses a single measurement ID when the network configures an intra-frequency measurement for two frequencies used by one UE has not yet been determined in this baseline. How the UE notifies the network of measurement results of the secondary carrier when the network configures the primary and secondary carriers through a cell update confirmation message while it is in a CELL_PCH state has not yet been discussed in the baseline.

Thus, how the network uses a measurement ID for a UE which uses a dual cell operation, how the UE operates when receiving SIB11 or SIB12 while it is in a CELL_PCH state, and how the UE transmits measurement results of the secondary carrier to the network while it is in a CELL_PCH state will be defined and discussed in this paper.

2 Discussion

2.1 The number of Measurement Identity

Normally, one intra-frequency measurement identity corresponds to one intra-frequency event. So, in order to allow two intra-frequency events, two intra-frequency measurement identities are needed. It means that two MEASUREMENT CONTROL messages should be sent in DC-HSUPA (because one measurement identity corresponds to a MEASUREMENT CONTROL message).

Sending two MEASUREMENT CONTROL messages in DC-HSUPA has a good aspect that it provides measurement configuration flexibility to network. However, considering that the number of measurement identity is limited, it would be preferable to use only one measurement identity for both carriers. Since the geography of primary E-DCH serving cell is same as that of secondary E-DCH serving cell, it is expected that the measurement objects or measurement quantity per carrier would be almost same, so it might be enough to have same measurement identity for both carriers.

Proposal 1: It is asked to discuss how many measurement identities should be used for intra-frequency measurement of dual carriers.

From our point of view, only one measurement identity is sufficient.

2.2 Intra-frequency measurement system information

Frequency information in an intra-frequency cell information list IE of a measurement report transmitted by a UE is added according to "[1]" that has been approved as an RRC baseline CR. The purpose of addition of such frequency information is to determine which carrier (primary carrier/secondary carrier) is used during measurement configuration between the network and the UE. Similarly, frequency information is also added to the intra-frequency measurement reporting criteria in the measurement control message.

However, whether SIB11 or SIB12, which indicates measurement control information to be used in one cell, includes frequency information has not been defined.

Since SIB11 is a value that is received by all UEs, not only a UE that performs dual cell operation in the corresponding cell but also a UE that performs a single cell operation receive the same SIB11 value. However, the UE that performs a single cell operation does not require frequency information, unlike the UE

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00132

that performs a dual cell operation. Accordingly, there is a need to discuss about whether or not the network incorporates frequency information into SIB11 for intra-frequency measurement.

The result of comparison between a problem when frequency information is not included in SIB11 and a problem when frequency information is included in SIB11 shows that it is better to include frequency information in SIB11.

Proposal 2: SIB11 should contain the IE "frequency info".

2.3 Measured Results on RACH for intra-frequency measurement

According to "[1]" approved as the RRC baseline CR, the network may configure two frequencies for a UE that supports a dual cell not only through an RB control message but also through cell update confirmation. However, to accomplish this, a UE, which supports a dual cell and which is in a Cell_PCH state, should transmit measurement results of two frequencies, similar to a UE that is in a Cell_DCH state.

Proposal 3: The UE in CELL_PCH state should report measurement results on two frequencies to network.

When a UE which is in a Cell_PCH state transmits measurement results, measurement results on an RACH IE should be included in a measurement report to be transmitted. However, according to the current standard, frequency information is not included in measured results on an RACH IE. Accordingly, frequency information should be included in measured results on an RACH IE to discriminate between measurement results for two frequencies.

Proposal 4: Frequency information should be included in measured results on RACH IE.

Measured results on an RACH IE should carry a message that is as small as possible. This message may be transmitted through a CCCH message and the size of the transmitted message should be as small as possible since the size is restricted. Conventional intra-frequency measurement results information provides an indication of measurement results of cells corresponding to the "Maximum number of reported cells on RACH". Determination of the maximum number of cells which should be measured for the secondary carrier is a remaining issue.

1. The "Maximum number of reported cells on RACH" is measured and reported, similar to the primary carrier.

2. The network provides a threshold, initially for the secondary carrier.

1) Thereafter, cells allocated to the secondary frequency are measured. If the measured value exceeds a threshold received from the network, frequency and measurement results for the cells, whose measured value has exceeded the threshold, are reported (or indicated). Such measurement results are reported through Ec/No or the like.

3 Conclusion

We would like to suggest following proposals with appendix in the section 4:

Proposal 1: It is asked to discuss how many measurement identities should be used for intra-frequency measurement of dual carriers.

Proposal 2: SIB11 should contain the IE "frequency info".

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00133

Proposal 3: The UE in CELL_PCH state should report measurement results on two frequencies to network.

Proposal 4: Frequency information should be included in Measured Results on RACH IE.

4 Appendix

8.1.1.6.11 System Information Block type 11

If the cell is not operating in MBSFN mode according to subclause 8.1.1.6.3 the UE should store all relevant IEs included in this system information block. If the cell is not operating in MBSFN mode according to subclause 8.1.1.6.3 the UE shall:

1> if in idle mode:

2> clear the variable MEASUREMENT_IDENTITY.

1> if IE "FACH measurement occasion info" is included:

2> act as specified in subclause 8.6.7.

1> else:

2> may perform inter-frequency/inter-RAT measurements or inter-frequency/inter-RAT cell re-selection evaluation, if the UE capabilities permit such measurements while simultaneously receiving the S-CCPCH of the serving cell.

1> clear the variable CELL_INFO_LIST;

1> act upon the received IE "Intra-frequency cell info list"/"Inter-frequency cell info list"/"Inter-RAT cell info list" as described in subclause 8.6.7.3;

1> if the IE "Inter-frequency RACH reporting information" is included in the system information block:

2> read the IE and use that information for the inter-frequency measurements as specified in subclause 8.5.23.

1> if in idle mode; or

1> if in connected mode and if System Information Block type 12 is not broadcast in the cell:

2> if no intra-frequency measurement stored in the variable MEASUREMENT_IDENTITY was set up or modified through a MEASUREMENT CONTROL message:

3> if included, store the IE "Intra-frequency reporting quantity" and the IE "Intra-frequency measurement reporting criteria" or "Periodical reporting criteria" in order to activate reporting when state CELL_DCH is entered in the variable MEASUREMENT_IDENTITY. The IE "Cells for measurement" is absent for this measurement. The IE "Measurement Validity" is absent for this measurement after a state transition to CELL_DCH;

1> if in connected mode and if System Information Block type 12 is not broadcast in the cell:

2> read the IE "Traffic volume measurement system information";

2> if no traffic volume measurement with the measurement identity indicated in the IE "Traffic volume measurement system information" was set up or modified through a MEASUREMENT CONTROL message:

3> update the variable MEASUREMENT_IDENTITY with the measurement information received in that IE.

1> if the IE "Cell selection and reselection info" is not included for a new neighbouring cell in the IE "intra-frequency cell info list", the IE "inter-frequency cell info list" or the IE "inter-RAT cell info list" in System Information Block type 11:

2> use the default values specified for the IE "Cell selection and reselection info" for that cell except for the IE "HCS neighbouring cell information".

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00134

1> if the IE "Use of HCS" is set to "used", indicating that HCS is used, do the following:

2> if IE "HCS neighbouring cell information" is not included for the first new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 11:

3> use the default values specified for the IE "HCS neighbouring cell information" for that cell.

2> if IE "HCS neighbouring cell information" is not included for any other new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 11:

3> for that cell use the same parameter values as used for the preceding cell in the same cell info list in System Information Block type 11.

1> if the value of the IE "Cell selection and reselection quality measure" is different from the value of the IE "Cell selection and reselection quality measure" obtained from System Information Block type 3 or System Information Block type 4:

2> use the value of the IE from this System Information Block and ignore the value obtained from System Information Block type 3 or System Information Block type 4.

1> if in connected mode, and System Information Block type 12 is indicated as used in the cell:

2> read and act on information sent in System Information Block type 12 as indicated in subclause 8.1.1.6.12.

1> if IE "MBSFN frequency list" is included:

2> act as specified in subclause 8.6.9.9ac.

For 1.28 Mcps TDD if the cell is operating in MBSFN only mode according to subclause 8.1.1.6.3 the UE shall:

1> store the frequencies and their corresponding "cell parameter ID" indicated in the IE "MBSFN LCR TDD frequency list" included in the IE "MBSFN frequency list".

If the cell is operating in MBSFN mode according to subclause 8.1.1.6.3 the UE may:

1> for FDD and 3.84/7.68 Mcps TDD consider the cells indicated in the IE "Intra-frequency cell info list" in the IE "Intra-frequency measurement system information" as candidates for the selection of the MBSFN cluster;

1> for 1.28 Mcps TDD consider there exist MBSFN clusters deployed with the frequencies and their corresponding "cell parameter ID" stored.

For 1.28 Mcps TDD if the cell is not operating in MBSFN only mode but associated with one or more MBSFN clusters the UE shall:

1> store the frequencies and their corresponding "cell parameter ID" indicated in the IE "MBSFN LCR TDD frequency list" included in the IE "MBSFN frequency list";

1> consider there exist MBSFN clusters deployed with the frequencies and their corresponding “cell parameter ID” stored;

1> search an MBSFN cluster in MBSFN only mode with its frequency and corresponding "cell parameter ID" for monitoring the MBMS services delivered in dedicated MBSFN frequency layer.

NOTE: The IE "Intra-frequency cell info list" may not include information about all neighbouring MBSFN clusters

For FDD, the UE shall:

1> When the IE “frequency info” is included in the IE “Intra-frequency measurement system information” from System Information Block type 11,

2> if UE does not support multi cell E-DCH operation,

3>ignore the received IE and the UE behaviour is undefined.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00135

2> else

3> measure the frequency adjacent to frequency of the current cell among the frequencies in the IE "Frequency Info"

8.1.1.6.12 System Information Block type 12

If in connected mode, the UE should store all relevant IEs included in this system information block. The UE shall:

1> after reception of System Information Block type 11; and

1> after reception of System Information Block type 11bis, if broadcast in the cell:

2> update the variable MEASUREMENT_IDENTITY with the measurement information in the received IEs unless specified otherwise.

1> if IE "FACH measurement occasion info" is included:

2> act as specified in subclause 8.6.7.

1> else:

2> may perform inter-frequency/inter-RAT measurements or inter-frequency/inter-RAT cell re-selection evaluation, if the UE capabilities permit such measurements while simultaneously receiving the S-CCPCH of the serving cell.

1> act upon the received IE "Intra-frequency cell info list"/"Inter-frequency cell info list"/"Inter-RAT cell info list" as described in subclause 8.6.7.3;

1> if any of the IEs "Intra-frequency measurement quantity", "Intra-frequency reporting quantity for RACH reporting", "Maximum number of reported cells on RACH" or "Reporting information for state CELL_DCH" are not included in the system information block:

2> read the corresponding IE(s) in system information block type 11 and use that information for the intra-frequency measurement.

1> if the IE "Inter-frequency RACH reporting information" is included in this system information block or in System Information Block type 11:

2> if the IE is not included in the system information block, read the corresponding IE(s) in System Information Block type 11;

2> use the received information for the inter-frequency measurements as specified in subclause 8.5.23.

1> if included in this system information block or in System Information Block type 11:

2> if no intra-frequency measurement in the variable MEASUREMENT_IDENTITY was set up or modified through a MEASUREMENT CONTROL message:

3> store the IE "Intra-frequency reporting quantity" and the IE "Intra-frequency measurement reporting criteria" or "Periodical reporting criteria" in order to activate reporting when state CELL_DCH is entered in the variable MEASUREMENT_IDENTITY. The IE "Cells for measurement" is absent for this measurement. The IE "Measurement Validity" is absent for this measurement after a state transition to CELL_DCH;

1> if the IE "Traffic volume measurement system information" is not included in this system information block:

2> read the corresponding IE in System Information Block type 11.

1> if the IE "Traffic volume measurement system information" was received either in this system information block or in System Information Block type 11:

2> if no traffic volume measurement with the measurement identity indicated in the IE "Traffic volume measurement system information" was set up or modified through a MEASUREMENT CONTROL message:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00136

3> update the variable MEASUREMENT_IDENTITY with the measurement information received in that IE.

1> if in CELL_FACH state:

2> start or continue the traffic volume measurements stored in the variable MEASUREMENT_IDENTITY that are valid in CELL_FACH state.

1> if the IE "Cell selection and reselection info" is not included for a new neighbouring cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

2> use the default values specified for the IE "Cell selection and reselection info" for that cell except for the IE "HCS neighbouring cell information".

1> if the IE "Use of HCS" is set to "used", indicating that HCS is used, do the following:

2> if IE "HCS neighbouring cell information" is not included for the first new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

3> use the default values specified for the IE "HCS neighbouring cell information" for that cell.

2> if IE "HCS neighbouring cell information" is not included for any other new cell in the IE "Intra-frequency cell info list", the IE "Inter-frequency cell info list" or the IE "Inter-RAT cell info list" in System Information Block type 12:

3> for that cell use the same parameter values as used for the preceding cell in the same cell info list in System Information Block type 12.

1> if the value of the IE "Cell selection and reselection quality measure" is different from the value of the IE "Cell selection and reselection quality measure" obtained from System Information Block type 3 or System Information Block type 4:

2> use the value of the IE from this System Information Block and ignore the value obtained from System Information Block type 3 or System Information Block type 4.

If in idle mode, the UE shall not use the values of the IEs in this system information block.

For FDD, the UE shall:

1> When the IE “frequency info” is included in the IE “Intra-frequency measurement system information” from System Information Block type 12,

2> if UE does not support multi cell E-DCH operation,

3>ignore the received IE and the UE behaviour is undefined.

2> else

3> measure the frequency adjacent to frequency of the current cell among the frequencies in the IE “Frequency Info”

8.5.23 Measured results on RACH

When transmitting an uplink RRC message and System Information Block type 11, System Information Block type 11bis and System Information Block type 12, if transmitted, have been received, the UE shall:

1> if the uplink RRC message is an RRC CONNECTION REQUEST message:

2> if the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" are included in System Information Block type 11:

3> include a measurement report in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" in System Information Block type 11.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00137

2> if the IE "Inter-frequency RACH reporting information" is included in System Information Block type 11:

3> if, at the time the message is to be sent, valid measurements are available; and

3> there is one or more cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold":

4> include a measurement report in the IE "Measured results on RACH";

4> include the cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold";

4> set the IE "Inter-frequency cell indication- SIB11" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 11;

4> set the IE "Inter-frequency cell indication- SIB12" to any value.

1> for any other uplink RRC message which optionally includes the IE "Measured results on RACH":

2> if the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" are included in System Information Block type 12 (or "System Information Block Type 11", if these IEs are not included in the broadcast "System Information Block Type 12" or "System Information Block Type 12" is not being broadcast).

3> include a measurement report in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting" and the IE "Maximum number of reported cells on RACH" in System Information Block type 12 (or "System Information Block Type 11" if these IEs are not included in the broadcast "System Information Block Type 12" or "System Information Block Type 12" is not being broadcast).3> if the UE supports multi cell E-DCH operation:

4> if one frequency among the IE "Frequency info" of the "New intra-frequency cells" in the IE "Intra-frequency measurement system information" is adjacent frequency of the current cell;

5> include a measurement report corresponding to adjacent frequency of the current cell in the IE "Measured results on RACH", as specified in the IE "Intra-frequency reporting quantity for RACH reporting".

2> if the IE "Inter-frequency RACH reporting information" is included in "System Information Block type 12" (or "System Information Block Type 11" if this IE is not included in the "System Information Block Type 12" or if "System Information Block Type 12" is not being broadcast):

3> if, at the time the message is to be sent, valid measurements are available; and

3> there is one or more cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold":

4> include a measurement report in the IE "Measured results on RACH";

4> include the cells for which the quantity, indicated by the IE "Reporting quantity" in the IE "Inter-frequency RACH reporting information", exceeds the threshold specified by the IE "Inter-frequency RACH reporting threshold";

4> set the IE "Inter-frequency cell indication- SIB11" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 11;

4> if "System Information Block Type 12" is being broadcast:

5> set the IE "Inter-frequency cell indication- SIB12" to the following value: Value_Tag MOD 2, with Value_Tag corresponding to the value tag of System Information Block Type 12.

4> else:

5> set the IE "Inter-frequency cell indication- SIB12" to any value.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00138

1> include in the IE "Measured results on RACH" all requested reporting quantities for cells for which measurements are reported.

NOTE: The UE only includes measurement results for neighbour cells for which valid measurements are available at the time the message is sent. At cell access following selection or reselection to a cell, the UE may not have had sufficient time to obtain valid measurement results for neighbour cells.

1> for messages transmitted on CCCH, take care that the maximum allowed message size is not exceeded when forming the IE "Measured results on RACH", i.e. limit the number of included neighbour cells or if required omit the IE "Measured results on RACH" altogether. When limiting the number of included neighbouring cells, the number of inter-frequency cells should be limited first i.e. inter-frequency cells should be omitted before limiting the number of intra- frequency cells.

When transmitting an uplink RRC message and the System Information Block type 11, System Information Block type 11bis and System Information Block type 12, if transmitted, have not been received, the UE shall:

1> for any uplink RRC message which optionally includes the IE "Measured results on RACH", include a measurement report in the IE "Measured results on RACH" according to the following rules:

2> if the IE "Intra-frequency reporting quantity" was not present in System Information Block type 3:

3> include a measurement report for the serving cell using CPICH RSCP as a measurement quantity;

3> include measurement reports for cells on the used frequency for which measured results are available, using CPICH RSCP as measurement quantity for each cell;

3> omit the IE "Measurement results for monitored cells on non-used frequencies".

2> if the IE "Intra-frequency reporting quantity" was present in System Information Block type 3:

3> include a measurement report for the serving cell using as a measurement quantity given in IE "Intra-frequency reporting quantity";

3> include measurement reports for cells on the used frequency for which measured results are available, using as a measurement quantity given in IE "Intra-frequency reporting quantity" for each cell;

3> omit the IE "Measurement results for monitored cells on non-used frequencies".

2> for TDD, include measurement reports using the measurement quantities specified in the IE "Reporting quantity list".

If the IE "Measured results on RACH" is present in the message, the UTRAN should extract the contents to be used for radio resource control.

10.3.7.45 Measured results on RACH

For measurements on used frequency, this IE contains the measured results on RACH of the quantity indicated by Reporting quantity in the IE "Intra-frequency reporting quantity for RACH Reporting" in system information broadcast on BCH. The list, measurement results for monitored cells (not including the current cell) shall be in the order of the value of the measurement quantity as indicated by Reporting Quantity in the IE "Intra-frequency reporting quantity for RACH Reporting" (the first cell shall be the best cell).

For measurements on non-used frequencies, this IE includes the best cell on each non- used frequency, in order of decreasing quality and up to a maximum number as specified by the IE "Maximum number of inter-frequency RACH reporting cells".

The "best" FDD cell has the largest value when the measurement quantity is "Ec/No" or "RSCP". On the other hand, the "best" cell has the smallest value when the measurement quantity is "Pathloss". The "best" TDD cell has the largest value when measurement quantity is "Primary CCPCH RSCP".

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00139

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version
Measurement result for current cell	MP				
>CHOICE *mode*	MP				
>>FDD					
>>>CHOICE *measurement quantity*	MP			One spare value is needed.	
>>>>CPICH Ec/N0			Integer(0..49)	In dB. According to CPICH_Ec/No in [19]. Fourteen spare values are needed.	
>>>>CPICH RSCP			Integer(0..91)	In dBm. According to CPICH_RSCP_LEV in [19]. Thirty-six spare values are needed.	
>>>>Pathloss			Integer(46..158)	In dB. Fifteen spare values are needed.	
>>TDD					
>>>CHOICE *TDD option*	MP				REL-4
>>>>3.84 Mcps TDD					REL-4
>>>>>Timeslot List	OP	1 to 14			
>>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	
>>>7.68 Mcps TDD					REL-7
>>>>Timeslot List	OP	1 to 14			REL-7
>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	REL-7
>>>>1.28 Mcps TDD					REL-4
>>>>>Timeslot List	OP	1 to 6			REL-4
>>>>>>Timeslot ISCP	MP		Timeslot ISCP info 10.3.7.65	The UE shall report the Timeslot ISCP in the same order as indicated in the cell info	REL-4
>>>Primary CCPCH RSCP	OP		Primary CCPCH RSCP info 10.3.7.54		
Measurement results for monitored cells on used frequency	OP	1 to 12			
>SFN-SFN observed time difference	OP		SFN-SFN observed time difference 10.3.7.63		
>CHOICE *mode*	MP				
>>FDD					
>>>Primary CPICH info	MP		Primary CPICH info		

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00140

Information Element/group name	Need	Multi	Type and reference	Semantics description	Version
			10.3.6.60		
>>>Frequency info	OP		Enumerated (TRUE)	Absence of this IE means it is the primary UL frequency.	REL-9
>>>CHOICE *measurement quantity*	OP			One spare value is needed.	
>>>>CPICH Ec/N0			Integer(0..49)	In dB. According to CPICH_Ec/No in [19]. Fourteen spare values are needed.	
>>>>CPICH RSCP			Integer(0..91)	In dBm. According to CPICH_RSCP_LEV in [19]. Thirty-six spare values are needed.	
>>>>Pathloss			Integer(46..158)	In dB. Fifteen spare values are needed.	
>>TDD					
>>>Cell parameters Id	MP		Cell parameters Id 10.3.6.9		
>>>Primary CCPCH RSCP	MP		Primary CCPCH RSCP info 10.3.7.54		
Measurement results for monitored cells on non-used frequencies	OP				REL-6
>Inter-frequency cell indication-SIB11	MP		Integer (0..1)		REL-6
>Inter-frequency cell indication-SIB12	MP		Integer (0..1)		REL-6
>Inter-frequency cell list	MP	1 to <maxFreq>			REL-6
>>Inter-frequency cell id	MP		Integer(0 .. <maxCellMeas>-1)		REL-6

NOTE: Monitored cells consist of neighbouring cells.

14.1.2 Intra-frequency reporting events for FDD

Within the measurement reporting criteria field in the Measurement Control message the UTRAN notifies the UE which events should trigger a measurement report. The listed events are the toolbox from which the UTRAN can choose the reporting events that are needed for the implemented handover evaluation function, or other radio network functions.

All the specified events are measured with respect to any of the measurement quantities given in subclause 14.1.1. The measurement quantities are measured on the monitored primary common pilot channels (CPICH) of the cell defined in the measurement object.

Special mechanisms for the events are illustrated in subclause 14.1.4 and 14.1.5.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00141

NOTE: The events below are numbered 1A, 1B, 1C,... since all intra-frequency reporting events would be labelled 1X, inter-frequency reporting events would be labelled 2X, and so on for the other measurement types.

When one intra-frequency measurement identity corresponds to multiple intra-frequency events with identical event identities, the UE behaviour is not specified, excpet that SECONDARY_E_DCH_TRANSMISSION is set to TRUE.

NOTE: A intra-frequency measurement identity corresponds to two intra-frequency event when DC-HSUPA is configured.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00142

Title: **De-activation/Re-activation of Secondary Carrier**

Agenda item: **x.x.x**

Document for: **Discussion and decision**

1 Introduction

In Dual Cell E-DCH operation, unlike the primary carrier, the secondary carrier is dynamically activated/de-activated by Node B. The UE behaviour when the secondary carrier deactivated is re-activated has not been discussed.

Therefore, this paper discusses what the UE does when secondary carrier is de-activated and re-activated.

2 Discussion

2.1 Flush of HARQ process buffer on secondary carrier

When the secondary carrier is de-activated, the data to be transmitted on the carrier might be remained in the HARQ process buffer on the UE. Assuming that Node B receives data on the secondary carrier from the UE then transmits the HARQ ACK to the UE and de-activates the secondary carrier. If ACK-to-NACK error occurs at the UE side, the UE will not flush HARQ process buffer on the secondary carrier. Moments later if the secondary carrier is re-activated by Node B, the UE might try to re-transmit the data in the HARQ process buffer since the buffer is not empty. In order to prevent this problem, the UE should flush HARQ process buffer on the secondary carrier when the carrier is de-activated (or re-activated).

Proposal 1: The UE shall flush HARQ process buffer corresponding to the secondary carrier when secondary carrier is de-activated (or re-activated).

2.2 Initial variables on secondary carrier

When the secondary carrier is de-activated, the UE does not initialize the variable and timers related to Serving Grant Update function. Therefore, when the secondary carrier is re-activated, the UE might use the value calculated at deactivation. It leads that after the secondary carrier is re-activated the UE may start to transmit data even if the UE has not received the Serving Grant from Node B.

Hence, the UE needs to initialize variables and timers related to Serving Grant Update Function when the secondary carrier is re-activated (or de-activated) similarly to initialization of them when Dual Cell E-DCH operation is configured.

Proposal 2: The UE shall initialize variables and timers related to Serving Grant Update function when the secondary carrier is re-activated (or de-activated).

3 Conclusion

For the correct operation of secondary carrier, the followings are proposed at secondary carrier de-activation or re-activation:

Proposal 1: The UE shall flush HARQ process buffer corresponding to the secondary carrier.

Proposal 2: The UE shall initialize variables and timers for Serving Grant Update function when the secondary carrier is re-activated (or de-activated).

A text proposal is attached in section 4.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00143

4 Appendix

11.8.1.3.2 Handling at start of E-DCH transmission

In CELL_DCH state when E-DCH transmission is started or Secondary Uplink Frequency is re-activated by lower layer, the UE shall on that carrier:

- activate all HARQ processes;
- if the IE's "Serving Grant value" and "Primary/Secondary Grant Selector" are provided by higher layers:
  - update the state variables and timers according to subclause 11.8.1.3.5.
- else:
  - initialise the state variable Serving_Grant to Zero_Grant;
  - initialise the state variable Primary_Grant_Available to "False";
  - initialise the state variable Stored_Secondary_Grant to "Zero_Grant".
- initialise the state variables reference_ETPR and reference_ETPR2 to "Minimum_Grant";
- initialise the state variable Maximum_Serving_Grant to the highest possible value (i.e. index 37 in table 9.2.5.2.1.1 or 9.2.5.2.1.2 as configured by higher layers).

Next Modified Section

11.8.1.10 De-activation on Secondary Uplink Frequency

If Secondary Uplink Frequency is de-activated by lower layer, the UE shall on the secondary carrier:

- deactivate all HARQ processes and flush all buffers;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00144

Title:	⌘	Agreements on Carrier Aggregation

Reason for change:	⌘	RAN2 has agreed some control plane aspects related to carrier aggregation
Summary of change:	⌘	In subclause 5.3.2.1 (new), transmission of CC specific system information on the BCCH of the CC is explained. In subclause 5.3.2.2 (new), details of the "special cell" are included. Usage of *RRCConnectionReconfiguration* message is also explained for the reconfiguration, addition and removal of CCs. Triggers agreed for re-establishment are also listed. In addition, editorial corrections are also included to subclause 5.1.
Consequences if not approved:	⌘	RAN2 agreements on Carrier Aggregation are not captured in 36.912.

Clauses affected:	⌘	5			
		Y	**N**		
Other specs affected:	⌘		X	Other core specifications	⌘
			X	Test specifications	
			X	O&M Specifications	
Other comments:	⌘				

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00145

5 Support of wider bandwidth

5.1 General

LTE-Advanced extends LTE Rel.-8 with support for *Carrier Aggregation*, where two or more *component carriers* (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz and for spectrum aggregation.

It shall be possible to configure all component carriers which are LTE Rel-8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are the same. Not all component carriers may necessarily be LTE Rel-8 compatible.

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.
- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.

Carrier aggregation is supported for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks in the frequency domain using the LTE Rel-8 numerology

It is possible to configure a UE to aggregate a different number of component carriers originating from the same eNB and of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same.

Component carriers originating from the same eNB need not to provide the same coverage.

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

5.2 User Plane

5.2.1 Structure

Compared to the Layer 2 structure of LTE Rel-8, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per CC. The Layer 2 structure for the downlink is depicted on Figured 5.2.1-1 below.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00146

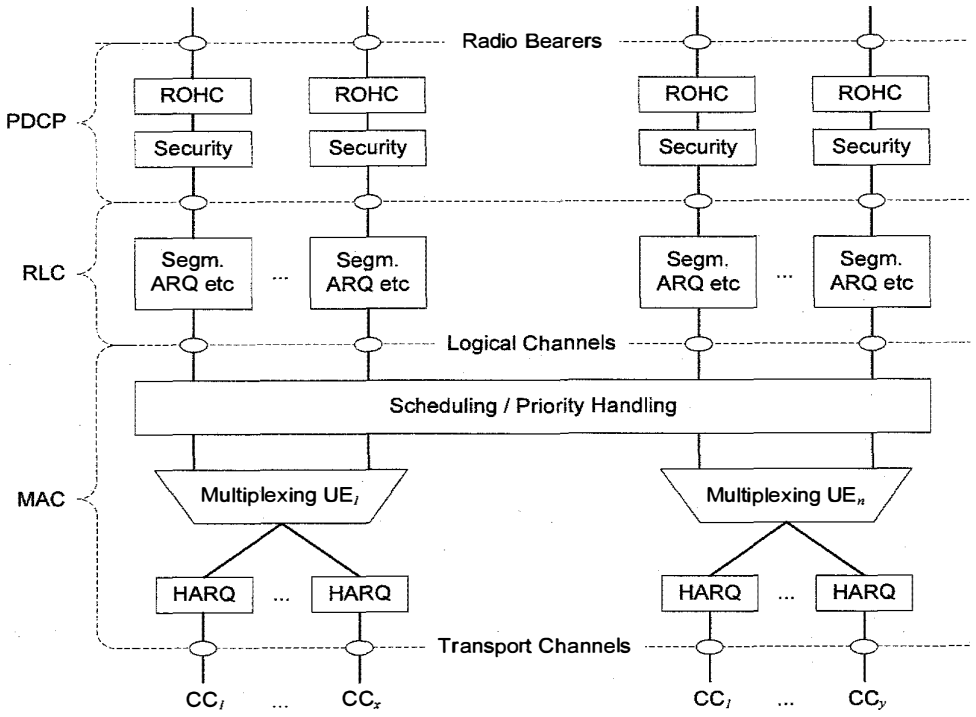


Figure 5.2.1-1: Layer 2 Structure for the DL

The Layer 2 structure for the uplink is depicted on Figured 5.2.1-2 below.

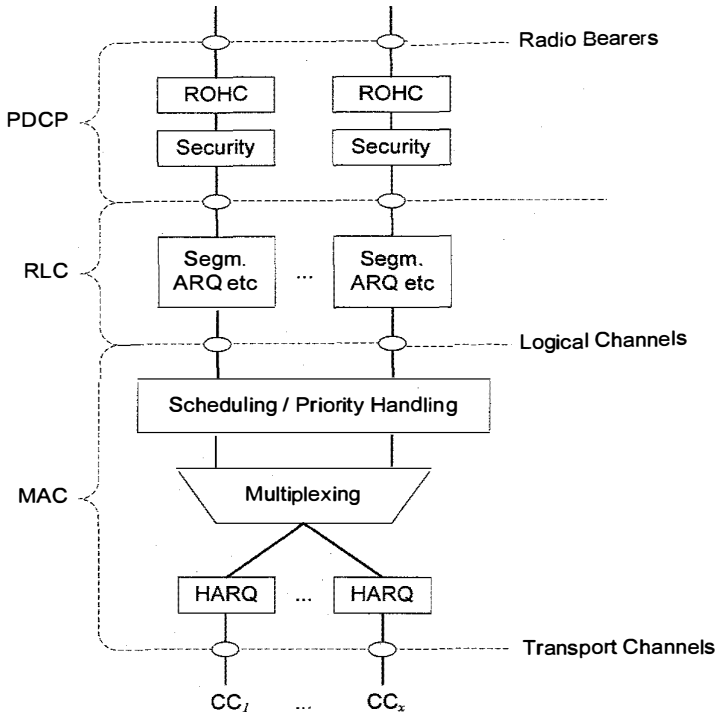


Figure 5.2.1-2: Layer 2 Structure for the UL

5.2.2 MAC

From a UE perspective, the Layer 2 aspects of HARQ are kept Rel-8 compliant unless modifications provide significant gains. There is one transport block (in absence of spatial multiplexing, up to two transport blocks in case of spatial

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00147

multiplexing) and one independent hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only where all possible HARQ retransmissions also take place. A UE may be scheduled over multiple component carriers simultaneously but at most one random access procedure shall be ongoing at any time.

5.2.3 RLC

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

5.2.4 PDCP

The PDCP protocol of LTE Rel-8 also applies to carrier aggregation.

5.3 Control plane

5.3.1 Structure

The C-Plane architecture of LTE Rel-8 also applies to carrier aggregation.

5.3.2 RRC procedures

5.3.2.1 System Information

Each CC provides on BCCH the system information which is specific to it. The handling of system information for extension carriers is FFS.

5.3.2.2 Connection Control

As in LTE Rel-8, the UE only has one RRC connection with the network. One cell - the "special cell" - provides the security input and the NAS mobility information (one ECGI, one PCI and one ARFCN). There is only one "special cell" per UE in connected mode.

After RRC connection establishment to the "special cell", the reconfiguration, addition and removal of CCs can be performed by *RRCConnectionReconfiguration* including *mobilityControlInfo* (i.e. "intra-cell handover"). *RRCConnectionReconfiguration* without *mobilityControlInfo* can also be used for the addition of CCs, and for the removal of CCs with the exception of the CC corresponding to the "special cell".

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

Detection of failure of one CC by the UE does not necessarily trigger a connection re-establishment. RRC connection re-establishment triggers at the UE include:

1) The failure of all CCs on which the UE is configured to receive PDCCH;

NOTE: FFS if re-establishment is triggered under more restrictive conditions.

2) The loss of all UL communication;

3) The indication from RLC that the maximum number of retransmissions has been reached (as in Rel-8).

5.3.3 Idle mode procedures

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00148

1 Introduction

At RAN2#67bis it was discussed whether the intention of the Rel-8 specification is to include, in the UEs Active Time, the time between triggering of an SR until the actual transmission of the SR; i.e., whether UE shall monitor PDCCH from the moment a SR is triggered or from the moment an SR is transmitted.

Some companies understood that to improve UE battery performance the UE need not monitor the PDCCH until the SR is transmitted. Others understood the Rel-8 intent is to have UE monitoring PDCCH also before the SR is transmitted and that this would be beneficial for latency reduction by means of 'pre-allocation'.

RAN2#67bis concluded that the Rel-8 intent was to have the UE monitor the PDCCH from the moment SR is triggered. However, it has been identified that this behaviour will severely impact UE DRX opportunity, in particular for VoIP traffic. This contribution highlights the DRX issue resulting from the Rel-8 Active Time definition w r t D-SR and proposes to clarify that the UE monitors PDCCH due to D-SR from the time the D-SR is transmitted on PUCCH.

2 DRX and D-SR induced PDCCH monitoring

It is understood that before the D-SR has been transmitted on PUCCH the eNB is not aware that new (higher priority) data has become available for transmission in the UE. Thus, assuming that UE is not in Active Time due to some other reason, an uplink grant would typically not be provided on PDCCH before D-SR has been transmitted. One exception to the rule would be the application of 'pre-allocation' of uplink resources blindly to the UE to optimize uplink latency. For pre-allocation the early PDCCH monitoring enables the UE to receive the 'unsolicited' uplink grants and reduces uplink latency. Thus, when the UE should start PDCCH monitoring (w r t D-SR) would appear to be a tradeoff between UE battery efficiency and pre-allocation efficiency.

2.1 UE battery efficiency

For traffic with periodic uplink transmissions where the data inter-arrival time is on the same order as the SR-trigger to UL-transmission latency, the behaviour confirmed at RAN2#67bis severely limits DRX opportunity and performance. In the following we consider the DRX performance for VoIP.

We assume an SR periodicity of 20ms, packet arrival uncorrelated to the SR opportunity and a constant packet inter-arrival time of 20ms. Because the size of the VoIP packet is rather small, the UE buffer becomes empty between the packets and each VoIP packet triggers a regular BSR and SR.

2.1.1 UE monitors PDCCH from SR trigger

With the 'confirmed' behaviour, the UE will monitor PDCCH

1. 0 – 20 ms from SR trigger until D-SR opportunity
2. at least 6 ms from D-SR opportunity until the SR is cancelled (transmission of SR, detection by eNB, immediate issue of uplink grant and UE pre-PUSCH-transmission processing)

Thus, for each VoIP packet, the minimum UE Active Time varies between 6 – 26 ms and is 16.8 ms on average if averaged over many sessions. This corresponds to a DRX potential of less than 25%. Note that during a session packets arrive in a very regular fashion and averaging per UE and session does not occur. We further note that this minimum Active Time does not include PDCCH monitoring for retransmissions, nor does it account for associated downlink traffic. Thus DRX opportunity may in practice be even more limited; possibly non-existent during the talk period of the UE .

The Active Time can be reduced by configuring the UE with a shorter D-SR periodicity. However, this requires more uplink resources to be allocated to PUCCH and is not always justified from a delay budget

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00149

point of view. Less resources will be available for PUSCH and capacity may be limited due to DRX considerations. To ensure that Active Time due to D-SR is less than half the VoIP packet inter-arrival time (i.e., below 10 ms), D-SR periodicity would need to be less than 5 ms.

2.1.2 UE monitors PDCCH from SR transmission

If UEs' monitoring of PDCCH would start at D-SR transmission, the waiting time for D-SR opportunity is eliminated and UEs' D-SR induced monitoring of PDCCH is independent of the D-SR periodicity. The decoupling of Active Time from the D-SR periodicity is a nice property, but more important is that the D-SR induced PDCCH monitoring becomes significantly reduced and UEs' DRX opportunity significantly improved. DRX potential is nearly 75% compared to less than 25% with PDCCH monitoring from SR trigger.

2.2 Pre-allocation efficiency

W r t pre-allocation it is envisioned that UEs' lesser availability between SR trigger and D-SR transmission can be compensated with a shorter DRX cycle. Efficient pre-allocation can be achieved by configuring a shorter DRX cycle.

3 Alternative approach

An alternative approach to changing the definition of the D-SR induced Active Time, as proposed in Subsection 2.1.1, would be to provide the eNB with detailed timing information about when the SR was triggered. This would allow the eNB to adjust the timing of periodic uplink grants so that they can be provided shortly after SR trigger and minimize the time until SR cancellation. The information could be provided with an uplink MAC Control element.

While this is a feasible alternative, it seems a little more complex than redefining the start of PDCCH monitoring w r t D-SR on PUCCH.

Another alterlative is for eNB to indicate whether the UE is allowed not to monitor PDCCH during the period from the trigger of D-SR to actual transmission of D-SR. For example, sr_drx_indicator can be defined. Thus, when eNB set sr_drx_indicator to allowed through RRC signaling, the UE can start monitoring of PDCCH only after transmission of D-SR and this means that active time does not include the time period from the trigger of D-SR to actual transmission of D-SR. Thus, when eNB set sr_drx_indicator to not-allowed through RRC signaling, the UE should start monitoring of PDCCH as soon as the triggering of D-SR and this means that active time include the time period from the trigger of D-SR to actual transmission of D-SR.

Or alternatively, skipping of monitoring during the period from the trigger of D-SR to actual transmission of D-SR.can be done if there is any configured VoIP service. Otherwise, the UE should monitor as soon as the triggering of D-SR.

Or alternatively, skipping of monitoring during the period from the trigger of D-SR to actual transmission of D-SR.can be done if there is any configured SPS(semi persistent scheduling or configured resources). Otherwise, the UE should monitor as soon as the triggering of D-SR.

4 Summary and conclusion

For traffic with periodic uplink transmissions the behaviour confirmed at RAN2#67bis severely limits DRX opportunity and performance. The problem is evident especially for VoIP traffic and when data inter-arrival time is on the same order as the latency between SR-trigger and actual uplink transmission. Unless a mechanism is introduced, which provides the eNB with accurate timing information about voice data arrival in the UE, DRX becomes virtually disabled. To achieve acceptable DRX performance, it is proposed to

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00150

revisit the assumption that UEs monitor PDCCH from SR trigger and discuss whether UEs should rather monitor PDCCH from D-SR transmission or a mechanism should be introduced to enable eNB to minimize UE Active Time due to D-SR. Based on our analysis updating the Active Time due to D-SR is simpler and preferred, but introducing an uplink MAC Control element with SR delay information is also doable.

Proposal 1: **It is proposed to discuss whether the poor DRX performance for, e.g., VoIP is acceptable.**

Proposal 2: **It is proposed to clarify that, w r t D-SR, UE Active Time begins at D-SR transmission.**

Proposal 3: **If proposal 2 is not agreeable, it is proposed to introduce an uplink MAC Control element with SR delay information in Rel-9.**

CRs corresponding to proposal 2 are provided in [1] and [2]. A CR corresponding to proposal 3 can be provided by Ericsson if proposal 3 is agreed.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00151

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00152

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".

[7] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[9] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

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 related to DRX operation, as defined in subclause 5.7, during which the UE monitors the PDCCH in PDCCH-subframes.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00153

mac-ContentionResolutionTimer: Specifies the number of consecutive subframe(s) during which the UE shall monitor the PDCCH after Msg3 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).

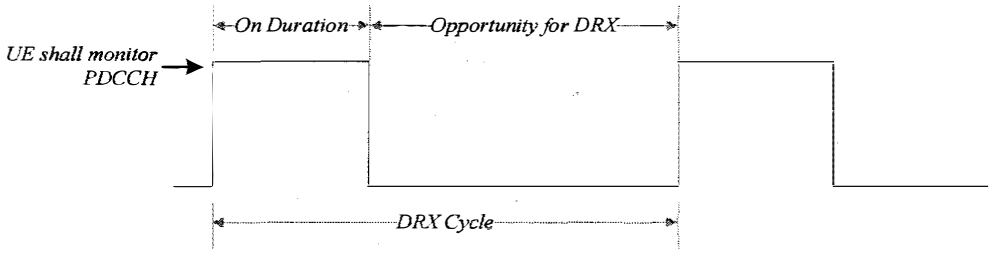


Figure 3.1-1: DRX Cycle

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

drxShortCycleTimer: Specifies the number of consecutive subframe(s) the UE shall follow the Short DRX cycle.

drxStartOffset: Specifies the subframe where the DRX Cycle starts.

HARQ information: HARQ information consists of New Data Indicator (NDI), Transport Block (TB) size. For DL-SCH transmissions the HARQ information also includes HARQ process ID. For UL-SCH transmission the HARQ info also includes Redundancy Version (RV). In case of spatial multiplexing on DL-SCH the HARQ information comprises a set of NDI and TB size for each transport block.

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

Msg3: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a random access procedure.

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

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

PRACH Resource Index: The index of a PRACH within a system frame [7]

***ra-PRACH-MaskIndex*:** Defines in which PRACHs within a system frame the UE can transmit a Random Access Preamble (see subclause 7.3).

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.

NOTE: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value.

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00154

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
LCG	Logical Channel Group
PHR	Power Headroom Report
PMI	Precoding Matrix Index
P-RNTI	Paging RNTI
RA-RNTI	Random Access RNTI
RI	Rank Indicator
RNTI	Radio Network Temporary Identifier
SI-RNTI	System Information RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbols
TB	Transport Block
TPC-PUCCH-RNTI	Transmit Power Control-Physical Uplink Control Channel-RNTI
TPC-PUSCH-RNTI	Transmit Power Control-Physical Uplink Shared Channel-RNTI

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.

Figure 4.2.1.1 illustrates one possible structure for the UE side MAC entity, and it should not restrict implementation.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00155

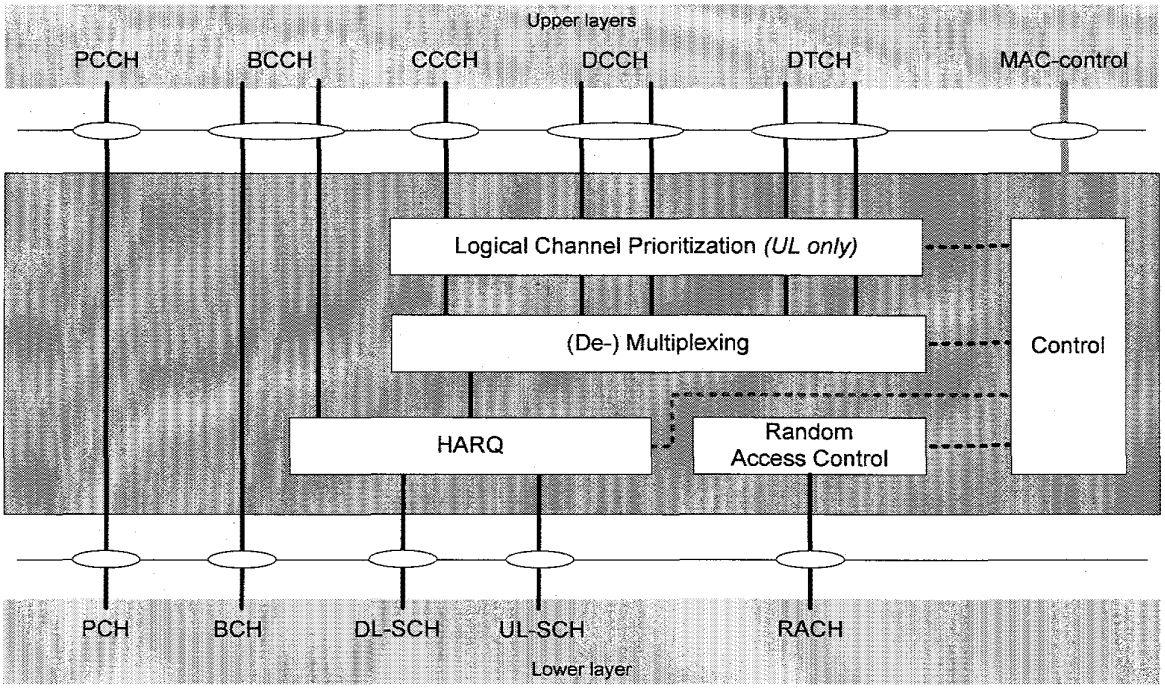


Figure 4.2.1.1: MAC structure overview, UE side

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;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00156

- 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.

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00157

MAC provides the control and traffic channels listed in Table 4.5.2-1 below.

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.

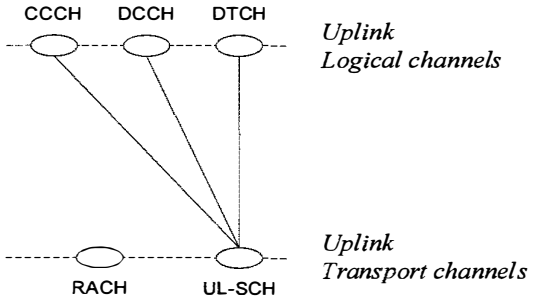


Figure 4.5.3.1-1

Table 4.5.3.1-1: Uplink channel mapping.

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

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00158

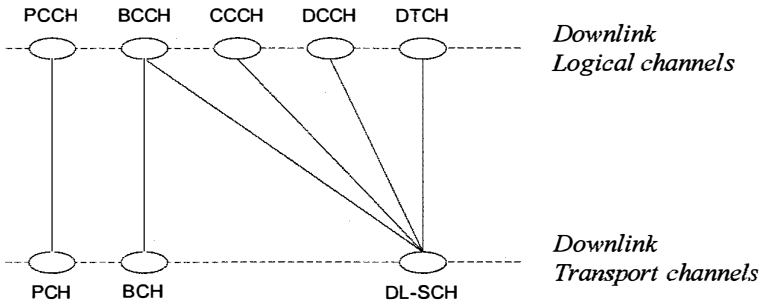


Figure 4.5.3.2-1

Table 4.5.3.2-1: Downlink channel mapping.

Logical channel \ Transport 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. If a UE receives a PDCCH transmission consistent with a PDCCH order [5] masked with its C-RNTI, it shall initiate a Random Access procedure. The PDCCH order or RRC optionally indicate *ra-PreambleIndex* and *ra-PRACH-MaskIndex*.

Before the procedure can be initiated, the following information is assumed to be available [8]:

- the available set of PRACH resources for the transmission of the Random Access Preamble, *prach-ConfigIndex*.
- the groups of Random Access Preambles and the set of available Random Access Preambles in each group:

  The preambles that are contained in Random Access Preambles group A and Random Access Preambles group B are calculated from the parameters *numberOfRA-Preambles* and *sizeOfRA-PreamblesGroupA*:

  If *sizeOfRA-PreamblesGroupA* is equal to *numberOfRA-Preambles* then there is no Random Access Preambles group B. The preambles in Random Access Preamble group A are the preambles 0 to *sizeOfRA-PreamblesGroupA* – 1 and, if it exists, the preambles in Random Access Preamble group B are the preambles *sizeOfRA-PreamblesGroupA* to *numberOfRA-Preambles* – 1 from the set of 64 preambles as defined in [7].
- if Random Access Preambles group B exists, the thresholds, *messagePowerOffsetGroupB* and *messageSizeGroupA*, the configured UE transmitted power, P_{CMAX} [10], and the offset between the preamble and Msg3, *deltaPreambleMsg3*, that are required for selecting one of the two groups of Random Access Preambles.
- the RA response window size *ra-ResponseWindowSize*.
- the power-ramping factor *powerRampingStep*.
- the maximum number of preamble transmission *preambleTransMax*.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00159

- the initial preamble power *preambleInitialReceivedTargetPower*.
- the preamble format based offset DELTA_PREAMBLE (see subclause 7.6).
- the maximum number of Msg3 HARQ transmissions *maxHARQ-Msg3Tx*.
- the Contention Resolution Timer *mac-ContentionResolutionTimer*.

NOTE: The above parameters may be updated from upper layers before each Random Access procedure is initiated.

The Random Access procedure shall be performed as follows:

- Flush the Msg3 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 selection procedure shall be performed as follows:

- If *ra-PreambleIndex* (Random Access Preamble) and *ra-PRACH-MaskIndex* (PRACH Mask Index) have been explicitly signalled and *ra-PreambleIndex* is not 000000:
  - the Random Access Preamble and the PRACH Mask Index are those explicitly signalled.
- else the Random Access Preamble shall be selected by the UE as follows:
  - If Msg3 has not yet been transmitted, the UE shall:
    - if Random Access Preambles group B exists and if the potential message size (data available for transmission plus MAC header and, where required, MAC control elements) is greater than *messageSizeGroupA* and if the pathloss is less than $P_{CMAX} - preambleInitialReceivedTargetPower - deltaPreambleMsg3 - messagePowerOffsetGroupB$, then:
      - select the Random Access Preambles group B;
    - else:
      - select the Random Access Preambles group A.
  - else, if Msg3 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 Msg3.
  - 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;
  - set PRACH Mask Index to 0.
- determine the next available subframe containing PRACH permitted by the restrictions given by the *prach-ConfigIndex*, the PRACH Mask Index (see subclause 7.3) and physical layer timing requirements [2] (a UE may take into account the possible occurrence of measurement gaps when determining the next available PRACH subframe);
- if the transmission mode is TDD and the PRACH Mask Index is equal to zero:
  - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00160

- randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe.

- else:

  - randomly select, with equal probability, one PRACH from the PRACHs available in the determined subframe and the next two consecutive subframes.

- else:

  - determine a PRACH within the determined subframe in accordance with the requirements of the PRACH Mask Index.

- 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:

- set PREAMBLE_RECEIVED_TARGET_POWER to *preambleInitialReceivedTargetPower* + DELTA_PREAMBLE + (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*;

- instruct the physical layer to transmit a preamble using the selected PRACH, corresponding RA-RNTI, preamble index and PREAMBLE_RECEIVED_TARGET_POWER.

5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap, the UE shall monitor the PDCCH for Random Access Response(s) identified by the RA-RNTI defined below, in the RA Response window which starts at the subframe that contains the end of the preamble transmission [7] plus three subframes and has length *ra-ResponseWindowSize* subframes. The RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

$$\text{RA-RNTI} = 1 + t\_id + 10 * f\_id$$

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

- If a downlink assignment for this TTI has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded, the UE shall regardless of the possible occurrence of a measurement gap:

  - 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 Advance Command (see subclause 5.2);

    - indicate the *preambleInitialReceivedTargetPower* and the amount of power ramping applied to the latest preamble transmission to lower layers (i.e., (PREAMBLE_TRANSMISSION_COUNTER – 1) * *powerRampingStep*);

    - process the received UL grant value and indicate it to the lower layers;

    - if *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00161

- 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 transmission is not being made for the CCCH logical channel, 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 Msg3 buffer.

NOTE: When an uplink transmission is required, e.g., for contention resolution, the eNB should not provide a grant smaller than 56 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 RA Response window, or if none of all received Random Access Responses contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the UE shall:

- increment PREAMBLE_TRANSMISSION_COUNTER by 1;

- If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:

  - indicate a Random Access problem to upper layers.

- if in this Random Access procedure, the Random Access Preamble was selected by MAC:

  - based on the backoff parameter in the UE, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;

  - delay the subsequent Random Access transmission by the backoff time;

- proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.5 Contention Resolution

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

Once Msg3 is transmitted, the UE shall:

- start *mac-ContentionResolutionTimer* and restart *mac-ContentionResolutionTimer* at each HARQ retransmission;

- regardless of the possible occurrence of a measurement gap, monitor the PDCCH until *mac-ContentionResolutionTimer* expires or is stopped;

- 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 Msg3:

    - 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 for a new transmission; or

    - if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00162

- consider this Contention Resolution successful;
- stop *mac-ContentionResolutionTimer*;
- discard the Temporary C-RNTI;
- consider this Random Access procedure successfully completed.

- else if the CCCH SDU was included in Msg3 and the PDCCH transmission is addressed to its Temporary C-RNTI:
  - if the MAC PDU is successfully decoded:
    - stop *mac-ContentionResolutionTimer*;
    - 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 Msg3:
      - 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;
      - discard the Temporary C-RNTI;
      - consider this Random Access procedure successfully completed.
    - else
      - discard the Temporary C-RNTI;
      - consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.

- if *mac-ContentionResolutionTimer* expires:
  - discard the Temporary C-RNTI;
  - consider the Contention Resolution not successful.
- if the Contention Resolution is considered not successful the UE shall:
  - flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer;
  - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
  - If PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax* + 1:
    - indicate a Random Access problem to upper layers.
  - based on the backoff parameter in the UE, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;
  - delay the subsequent Random Access transmission by the backoff time;
  - proceed to the selection of a Random Access Resource (see subclause 5.1.2).

5.1.6 Completion of the Random Access procedure

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

- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00163

5.2 Maintenance of Uplink Time Alignment

The UE has a configurable timer *timeAlignmentTimer* which is used to control how long the UE is considered uplink time aligned [8].

The UE shall:

- when a Timing Advance Command MAC control element is received:
  - apply the Timing Advance Command;
  - start or restart *timeAlignmentTimer*.
- when a Timing Advance Command is received in a Random Access Response message:
  - if the Random Access Preamble was not selected by UE MAC:
    - apply the Timing Advance Command;
    - start or restart *timeAlignmentTimer*.
  - else, if the *timeAlignmentTimer* is not running:
    - apply the Timing Advance Command;
    - start *timeAlignmentTimer*;
    - when the contention resolution is considered not successful as described in subclause 5.1.5, stop *timeAlignmentTimer*.
  - else:
    - ignore the received Timing Advance Command.
- when *timeAlignmentTimer* expires:
  - flush all HARQ buffers;
  - notify RRC to release PUCCH/SRS;
  - clear any configured downlink assignments and uplink grants.

5.3 DL-SCH data transfer

5.3.1 DL Assignment reception

Downlink assignments transmitted on the PDCCH indicate if there is a transmission on the DL-SCH for a particular UE and provide the relevant HARQ information.

When the UE has a C-RNTI, Semi-Persistent Scheduling C-RNTI, or Temporary C-RNTI, the UE shall for each TTI during which it monitors PDCCH:

- if a downlink assignment for this TTI has been received on the PDCCH for the UE's C-RNTI, or Temporary C-RNTI:
  - if this is the first downlink assignment for this Temporary C-RNTI:
    - consider the NDI to have been toggled.
  - if the downlink assignment is for UE's C-RNTI and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the UE's Semi-Persistent Scheduling C-RNTI or a configured downlink assignment:
    - consider the NDI to have been toggled regardless of the value of the NDI.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00164

- indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.

- else, if a downlink assignment for this TTI has been received on the PDCCH for the UE's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:
    - consider the NDI not to have been toggled;
    - indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity for this TTI.
  - else, if the NDI in the received HARQ information is 0:
    - if PDCCH contents indicate SPS release:
      - clear the configured downlink assignment (if any);
      - if *timeAlignmentTimer* is running:
        - indicate a positive acknowledgement for the downlink SPS release to the physical layer.
    - else:
      - store the downlink assignment and the associated HARQ information as configured downlink assignment;
      - initialise (if not active) or re-initialise (if already active) the configured downlink assignment to start in this TTI and to recur according to rules in subclause 5.10.1;
      - set the HARQ Process ID to the HARQ Process ID associated with this TTI;
      - consider the NDI bit to have been toggled;
      - indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

- else, if a downlink assignment for this TTI has been configured and there is no measurement gap in this TTI and this TTI is not an MBSFN subframe:
  - instruct the physical layer to receive, in this TTI, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;
  - set the HARQ Process ID to the HARQ Process ID associated with this TTI;
  - consider the NDI bit to have been toggled;
  - indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity for this TTI.

For configured downlink assignments, the HARQ Process ID associated with this TTI is derived from the following equation:

HARQ Process ID = [floor(CURRENT_TTI/(Downlink Semi-Persistent Scheduling Interval))] modulo Number of Configured SPS Processes,

where CURRENT_TTI=[(SFN * 10) + subframe number], Downlink Semi-Persistent Scheduling Interval is the periodicity of semi-persistent scheduling signalled via RRC and Number of Configured SPS Processes is the number of HARQ processes allocated for semi-persistent scheduling signalled via RRC.

When the UE needs to read BCCH, the UE may, based on the scheduling information from RRC:

- if a downlink assignment for this TTI has been received on the PDCCH for the SI-RNTI;
  - if the redundancy version is not defined in the PDCCH format:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00165

- the redundancy version of the received downlink assignment for this TTI is determined by RV_K = ceiling(3/2*k) modulo 4, where k depends on the type of system information message: for *SystemInformationBlockType1* message, k = (SFN/2) modulo 4, where SFN is the system frame number; for *SystemInformation* messages, $k=i$ modulo 4, i =0,1,..., n_s^w-1, where i denotes the subframe number within the SI window n_s^w;
- indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity for this TTI.

5.3.2 HARQ operation

5.3.2.1 HARQ Entity

There is one HARQ entity at the UE which maintains a number of parallel HARQ processes. Each HARQ process is associated with a HARQ process identifier. The HARQ entity directs HARQ information and associated TBs received on the DL-SCH to the corresponding HARQ processes (see subclause 5.3.2.2).

The number of DL HARQ processes is specified in [2], clause 7.

When the physical layer is configured for spatial multiplexing [2], one or two TBs are expected per subframe and they are associated with the same HARQ process. Otherwise, one TB is expected per subframe.

The UE shall:

- If a downlink assignment has been indicated for this TTI:
  - allocate the TB(s) received from the physical layer and the associated HARQ information to the HARQ process indicated by the associated HARQ information.
- If a downlink assignment has been indicated for the broadcast HARQ process:
  - 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 subframe where a transmission takes place for the HARQ process, one or two (in case of spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

- if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or
- if the HARQ process is equal to the broadcast process and if this is the first received transmission for the TB according to the system information schedule indicated by RRC; or
- if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):
  - consider this transmission to be a new transmission.
- else:
  - consider this transmission to be a retransmission.

The UE then shall:

- if this is a new transmission:
  - replace the data currently in the soft buffer for this TB with the received data.
- else if this is a retransmission:
  - if the data has not yet been successfully decoded:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00166

- combine the received data with the data currently in the soft buffer for this TB.
- if the TB size is different from the last valid TB size signalled for this TB:
  - the UE may replace the data currently in the soft buffer for this TB with the received data.
- attempt to decode the data in the soft buffer for this TB;
- if the data in the soft buffer was successfully decoded for this TB:
  - if the HARQ process is equal to the broadcast process:
    - deliver the decoded MAC PDU to upper layers.
  - else if this is the first successful decoding of the data in the soft buffer for this TB:
    - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.
  - generate a positive acknowledgement (ACK) of the data in this TB.
- else:
  - generate a negative acknowledgement (NACK) of the data in this TB.
- if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and the Contention Resolution is not yet successful (see subclause 5.1.5); or
- if the HARQ process is equal to the broadcast process; or
- if *timeAlignmentTimer* is stopped or expired:
  - do not indicate the generated positive or negative acknowledgement to the physical layer.
- else:
  - indicate the generated positive or negative acknowledgement for this TB to the physical layer.

The UE shall ignore NDI received in all downlink assignments on PDCCH for its Temporary C-RNTI when determining if NDI on PDCCH for its C-RNTI has been toggled compared to the value in the previous transmission.

5.3.3 Disassembly and demultiplexing

The UE shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.2.

5.4 UL-SCH data transfer

5.4.1 UL Grant reception

In order to transmit on the UL-SCH the UE must have a valid uplink grant (except for non-adaptive HARQ retransmissions) which it may receive dynamically on the PDCCH or in a Random Access Response or which may be configured semi-persistently. To perform requested transmissions, the MAC layer receives HARQ information from lower layers.

When *timeAlignmentTimer* is running and 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:
  - if the uplink grant is for UE's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the UE's Semi-Persistent Scheduling C-RNTI or a configured uplink grant:
    - consider the NDI to have been toggled regardless of the value of the NDI.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00167

- deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else, if an uplink grant for this TTI has been received on the PDCCH for the UE's Semi-Persistent Scheduling C-RNTI:
  - if the NDI in the received HARQ information is 1:
    - consider the NDI not to have been toggled;
    - deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.
  - else if the NDI in the received HARQ information is 0:
    - if PDCCH contents indicate SPS release:
      - clear the configured uplink grant (if any).
    - else:
      - store the uplink grant and the associated HARQ information as configured uplink grant;
      - initialise (if not active) or re-initialise (if already active) the configured uplink grant to start in this TTI and to recur according to rules in subclause 5.10.2;
      - consider the NDI bit to have been toggled;
      - deliver the configured 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:
  - consider the NDI bit to have been toggled;
  - deliver the configured uplink grant, 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 in a Random Access Response and a grant for its C-RNTI or Semi persistent scheduling C-RNTI requiring transmissions in the same UL subframe, the UE may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI or Semi persistent scheduling C-RNTI.

NOTE: When a configured uplink grant is indicated during a measurement gap and indicates an UL-SCH transmission during a measurement gap, the UE processes the grant but does not transmit on UL-SCH.

5.4.2 HARQ operation

5.4.2.1 HARQ entity

There is one HARQ entity at the UE, which maintains a number of parallel HARQ processes allowing transmissions to take place continuously while waiting for HARQ the feedback on the successful or unsuccessful reception of previous transmissions.

The number of parallel HARQ processes is specified in [2], clause 8.

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 received HARQ feedback (ACK/NACK information), MCS and resource, relayed by the physical layer, to the appropriate HARQ process.

When TTI bundling is configured, the parameter TTI_BUNDLE_SIZE provides the number of TTIs of a TTI bundle. TTI bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle HARQ retransmissions are non-adaptive and triggered without waiting for feedback from previous transmissions according to TTI_BUNDLE_SIZE. The HARQ feedback of a bundle is only received for the last TTI of the bundle (i.e the TTI corresponding to TTI_BUNDLE_SIZE), regardless of whether a

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00168

transmission in that TTI takes place or not (e.g. when a measurement gap occurs). A retransmission of a TTI bundle is also a TTI bundle.

For transmission of Msg3 during Random Access (see section 5.1.5) TTI bundling does not apply.

For each TTI, the HARQ entity shall:

- identify the HARQ process associated with this TTI;
- if an uplink grant has been indicated for this TTI:
  - if the received grant was not addressed to a Temporary C-RNTI on PDCCH and if the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this HARQ process; or
  - if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or
  - if the uplink grant was received in a Random Access Response:
    - if there is a MAC PDU in the Msg3 buffer and the uplink grant was received in a Random Access Response:
      - obtain the MAC PDU to transmit from the Msg3 buffer.
    - else:
      - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
    - deliver the MAC PDU and the uplink grant and the HARQ information to the identified HARQ process;
    - instruct the identified HARQ process to trigger a new transmission.
  - else:
    - deliver the uplink grant and the HARQ information (redundancy version) to the identified HARQ process;
    - instruct the identified 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 identified HARQ process to generate a non-adaptive retransmission.

When determining if NDI has been toggled compared to the value in the previous transmission UE shall ignore NDI received in all uplink grants on PDCCH for its Temporary C-RNTI.

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, and a state variable HARQ_FEEDBACK, which indicates the HARQ feedback 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 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is up-dated modulo 4.

New transmissions are performed on the resource and with the MCS indicated on PDCCH or Random Access Response. Adaptive retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH. 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 Msg3 HARQ transmissions by RRC: *maxHARQ-Tx* and *maxHARQ-Msg3Tx* respectively. For transmissions on all HARQ processes

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00169

and all logical channels except for transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Tx*. For transmission of a MAC PDU stored in the Msg3 buffer, the maximum number of transmissions shall be set to *maxHARQ-Msg3Tx*.

When the HARQ feedback is received for this TB, the HARQ process shall:

- set HARQ_FEEDBACK to the received value.

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;
- store the uplink grant received from the HARQ entity;
- set HARQ_FEEDBACK to NACK;
- generate a transmission as described below.

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

- increment CURRENT_TX_NB by 1;
- if the HARQ entity requests an adaptive retransmission:
  - store the uplink grant received from the HARQ entity;
  - set CURRENT_IRV to the index corresponding to the redundancy version value provided in the HARQ information;
  - set HARQ_FEEDBACK to NACK;
  - generate a transmission as described below.
- else if the HARQ entity requests a non-adaptive retransmission:
  - if HARQ_FEEDBACK = NACK:
    - generate a transmission as described below.

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

NOTE: When no UL-SCH transmission can be made due to the occurrence of a measurement gap, no HARQ feedback can be received and a non-adaptive retransmission follows.

To generate a transmission, the HARQ process shall:

- if the MAC PDU was obtained from the Msg3 buffer; or
- if there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer in this TTI:
  - instruct the physical layer to generate a transmission according to the stored uplink grant with the redundancy version corresponding to the CURRENT_IRV value;
  - increment CURRENT_IRV by 1;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00170

- if there is a measurement gap at the time of the HARQ feedback reception for this transmission and if the MAC PDU was not obtained from the Msg3 buffer:
  - set HARQ_FEEDBACK to ACK at the time of the HARQ feedback reception for this transmission.

After performing above actions, the HARQ process then shall:

- if CURRENT_TX_NB = maximum number of transmissions – 1:
  - flush the HARQ buffer;

5.4.3 Multiplexing and assembly

5.4.3.1 Logical channel prioritization

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

RRC controls the scheduling of uplink data by signalling for each logical channel: *priority* where an increasing *priority* value indicates a lower priority level, *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR), *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

The UE shall maintain a variable Bj for each logical channel j. Bj shall be initialized to zero when the related logical channel is established, and incremented by the product PBR × TTI duration for each TTI, where PBR is Prioritized Bit Rate of logical channel j. However, the value of Bj can never exceed the bucket size and if the value of Bj is larger than the bucket size of logical channel j, it shall be set to the bucket size. The bucket size of a logical channel is equal to PBR × BSD, where PBR and BSD are configured by upper layers.

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 steps:
  - Step 1: All the logical channels with Bj > 0 are allocated resources in a decreasing priority order. 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);
  - Step 2: the UE shall decrement Bj by the total size of MAC SDUs served to logical channel j in Step 1

  NOTE: The value of Bj can be negative.

  - Step 3: if any resources remain, all the logical channels are served in a strict decreasing priority order (regardless of the value of Bj) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.
- 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;
  - UE should maximise the transmission of data.

The UE shall not transmit data for a logical channel corresponding to a radio bearer that is suspended (the conditions for when a radio bearer is considered suspended are defined in [8]).

For the Logical Channel Prioritization procedure, the UE shall take into account the following relative priority in decreasing order:

- MAC control element for C-RNTI or data from UL-CCCH;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00171

- MAC control element for BSR, with exception of BSR included for padding;
- MAC control element for PHR;
- data from any Logical Channel, except data from UL-CCCH;
- MAC control element for BSR included for padding.

5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The UE shall multiplex MAC control elements and MAC SDUs in a MAC PDU according to subclauses 5.4.3.1 and 6.1.2.

5.4.4 Scheduling Request

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

When an SR is triggered, it shall be considered as pending until it is cancelled.

If an SR is triggered and there is no other SR pending, the UE shall set the SR_COUNTER to 0.

As long as one SR is pending, the UE shall for each TTI:

- if no UL-SCH resources are available for a transmission in this TTI:
  - if the UE has no valid PUCCH resource for SR configured in any TTI: initiate a Random Access procedure (see subclause 5.1) and cancel all pending SRs;
  - else if the UE has a valid PUCCH resource for SR configured for this TTI and if this TTI is not part of a measurement gap:
    - if SR_COUNTER < *dsr-TransMax*:
      - increment SR_COUNTER by 1;
      - instruct the physical layer to signal the SR on PUCCH;
    - else:
      - notify RRC to release PUCCH/SRS;
      - clear any configured downlink assignments and uplink grants;
      - initiate a Random Access procedure (see subclause 5.1) and cancel all pending SRs.
- else if UL-SCH resources are available for a new transmission in this TTI, cancel all pending SR(s).

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 available for transmission in the UL buffers of the UE. RRC controls BSR reporting by configuring the two timers *periodicBSR-Timer* and *retxBSR-Timer* and by, for each logical channel, optionally signalling *logicalChannelGroup* which allocates the logical channel to an LCG [8].

For the Buffer Status reporting procedure, the UE shall consider all radio bearers which are not suspended and may consider radio bearers which are suspended.

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

- UL data, for a logical channel which belongs to a LCG, becomes available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively) and either the data belongs to a logical channel with higher priority than the priorities of the logical channels which belong to any LCG and for which data is already available for transmission, or there is no data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00172

- UL resources are allocated and number of padding bits is equal to or larger than the size of the Buffer Status Report MAC control element plus its subheader, in which case the BSR is referred below to as "Padding BSR";
- *retxBSR-Timer* expires and the UE has data available for transmission for any of the logical channels which belong to a LCG, in which case the BSR is referred below to as "Regular BSR";
- *periodicBSR-Timer* expires, in which case the BSR is referred below to as "Periodic BSR".

For Regular and Periodic BSR:

- if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Long BSR;
- else report Short BSR.

For Padding BSR:

- if the number of padding bits is equal to or larger than the size of the Short BSR plus its subheader but smaller than the size of the Long BSR plus its subheader:
  - if more than one LCG has data available for transmission in the TTI where the BSR is transmitted: report Truncated BSR of the LCG with the highest priority logical channel with data available for transmission;
  - else report Short BSR.
- else if the number of padding bits is equal to or larger than the size of the Long BSR plus its subheader, report Long BSR.

If the Buffer Status reporting procedure determines that at least one BSR has been triggered since the last transmission of a BSR or if this is the first time that at least one BSR is triggered:

- 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;
  - start or restart *periodicBSR-Timer* except when the BSR is a Truncated BSR;
  - start or restart *retxBSR-Timer*.
- else if a Regular BSR has been triggered:
  - a Scheduling Request shall be triggered.

A MAC PDU shall contain at most one MAC BSR control element, even when multiple events trigger a BSR by the time a BSR can be transmitted in which case the Regular BSR and the Periodic BSR shall have precedence over the padding BSR.

The UE shall restart *retxBSR-Timer* upon indication of a grant for transmission of new data on UL-SCH.

All triggered BSRs shall be cancelled in case the UL grant can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the BSR MAC control element plus its subheader. All triggered BSRs shall be cancelled when a BSR is included in a MAC PDU for transmission.

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 nominal UE maximum transmit power and the estimated power for UL-SCH transmission. The reporting period, delay and mapping of Power Headroom are defined in subclause 9.1.8 of [9]. RRC controls Power Headroom reporting by configuring the two timers *periodicPHR-Timer* and *prohibitPHR-Timer*, and by signalling *dl-PathlossChange* which sets the change in measured downlink pathloss to trigger a PHR [8].

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

- *prohibitPHR-Timer* expires or has expired and the path loss has changed more than *dl-PathlossChange* dB since the transmission of a PHR when UE has UL resources for new transmission;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00173

- *periodicPHR-Timer* expires;
- upon configuration or reconfiguration of the power headroom reporting functionality by upper layers [8], which is not used to disable the function.

If the UE has UL resources allocated for new transmission for this TTI:

- if it is the first UL resource allocated for a new transmission since the last MAC reset, start *periodicPHR-Timer*;
- if the Power Headroom reporting procedure determines that at least one PHR has been triggered since the last transmission of a PHR or this is the first time that a PHR is triggered, and;
- if the allocated UL resources can accommodate a PHR MAC control element plus its subheader as a result of logical channel prioritization:
  - obtain the value of the power headroom from the physical layer;
  - instruct the Multiplexing and Assembly procedure to generate and transmit a PHR MAC control element based on the value reported by the physical layer;
  - start or restart *periodicPHR-Timer*;
  - start or restart *prohibitPHR-Timer*;
  - cancel all triggered PHR(s).

5.5 PCH reception

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

- 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 upper 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 upper layers.

5.7 Discontinuous Reception (DRX)

The UE may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the UE's C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI and Semi-Persistent Scheduling C-RNTI (if configured). When in RRC_CONNECTED, if DRX is configured, the UE is allowed to monitor the PDCCH discontinuously using the DRX operation specified in this subclause; otherwise the UE monitors the PDCCH continuously. When using DRX operation, the UE shall also monitor PDCCH according to requirements found in other subclauses of this specification. RRC controls DRX operation by configuring the timers *onDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimer* (one per DL HARQ process except for the broadcast process), the *longDRX-Cycle*, the value of the *drxStartOffset* and optionally the *drxShortCycleTimer* and *shortDRX-Cycle*. A HARQ RTT timer per DL HARQ process (except for the broadcast process) is also defined (see subclause 7.7).

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

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00174

- *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
- a Scheduling Request sent on PUCCH is pending (as described in subclause 5.4.4); or
- an uplink grant for a pending HARQ retransmission can occur and there is data in the corresponding HARQ buffer; or
- a PDCCH indicating a new transmission addressed to the C-RNTI of the UE has not been received after successful reception of a Random Access Response for the preamble not selected by the UE (as described in subclause 5.1.4).

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

- If the Short DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*shortDRX-Cycle*) = (*drxStartOffset*) modulo (*shortDRX-Cycle*); or
- if the Long DRX Cycle is used and [(SFN * 10) + subframe number] modulo (*longDRX-Cycle*) = *drxStartOffset*:
  - start *onDurationTimer*.
- 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-RetransmissionTimer* for the corresponding HARQ process.
- if a DRX Command MAC control element is received:
  - stop *onDurationTimer*;
  - stop *drx-InactivityTimer*.
- if *drx-InactivityTimer* expires or a DRX Command MAC control element is received in this subframe:
  - if the Short DRX cycle is configured:
    - start or restart *drxShortCycleTimer*;
    - use the Short DRX Cycle.
  - else:
    - use the Long DRX cycle.
- if *drxShortCycleTimer* expires in this subframe:
  - use the Long DRX cycle.
- during the Active Time, for a PDCCH-subframe, if the subframe is not required for uplink transmission for half-duplex FDD UE operation and if the subframe is not part of a configured measurement gap:
  - monitor the PDCCH;
  - if the PDCCH indicates a DL transmission or if a DL assignment has been configured for this subframe:
    - start the HARQ RTT Timer for the corresponding HARQ process;
    - stop the *drx-RetransmissionTimer* for the corresponding HARQ process.
  - if the PDCCH indicates a new transmission (DL or UL):
    - start or restart *drx-InactivityTimer*.
- when not in Active Time, CQI/PMI/RI on PUCCH 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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00175

NOTE: A UE may optionally choose to not send CQI/PMI/RI reports on PUCCH and/or SRS transmissions for up to 4 subframes following a PDCCH indicating a new transmission (UL or DL) received in the last subframe of active time. The choice not to send CQI/PMI/RI reports on PUCCH and/or SRS transmissions is not applicable for subframes where *onDurationTimer* is running.

5.8 MAC reconfiguration

When a reconfiguration of the MAC entity is requested by upper layers, the UE shall:

- for timers apply the new value when the timer is (re)started;
- when counters are initialized apply the new maximum parameter value;
- for other parameters, apply immediately the configurations received from upper layers.

5.9 MAC Reset

If a reset of the MAC entity is requested by upper layers, the UE shall:

- initialize Bj for each logical channel to zero;
- stop (if running) all timers;
- consider *timeAlignmentTimer* as expired and perform the corresponding actions in subclause 5.2;
- set the NDIs for all uplink HARQ processes to the value 0;
- stop, if any, ongoing RACH procedure;
- discard explicitly signalled *ra-PreambleIndex* and *ra-PRACH-MaskIndex*, if any;
- flush Msg3 buffer;
- cancel, if any, triggered Scheduling Request procedure;
- cancel, if any, triggered Buffer Status Reporting procedure;
- cancel, if any, triggered Power Headroom Reporting procedure;
- flush the soft buffers for all DL HARQ processes;
- for each DL HARQ process, consider the next received transmission for a TB as the very first transmission;
- release, if any, Temporary C-RNTI.

5.10 Semi-Persistent Scheduling

When Semi-Persistent Scheduling is enabled by RRC, the following information is provided [8]:

- Semi-Persistent Scheduling C-RNTI;
- Uplink Semi-Persistent Scheduling interval *semiPersistSchedIntervalUL* and number of empty transmissions before implicit release *implicitReleaseAfter*, if Semi-Persistent Scheduling is enabled for the uplink;
- Whether *twoIntervalsConfig* is enabled or disabled for uplink, only for TDD;
- Downlink Semi-Persistent Scheduling interval *semiPersistSchedIntervalDL* and number of configured HARQ processes for Semi-Persistent Scheduling *numberOfConfSPS-Processes*, if Semi-Persistent Scheduling is enabled for the downlink;

When Semi-Persistent Scheduling for uplink or downlink is disabled by RRC, the corresponding configured grant or configured assignment shall be discarded.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00176

5.10.1 Downlink

After a Semi-Persistent downlink assignment is configured, the UE shall consider that the assignment recurs in each subframe for which:

- (10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * *semiPersistSchedIntervalDL*] modulo 10240, for all N>0.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured downlink assignment were (re-)initialised.

5.10.2 Uplink

After a Semi-Persistent Scheduling uplink grant is configured, the UE shall:

- if *twoIntervalsConfig* is enabled by upper layer:
  - set the Subframe_Offset according to Table 7.4-1.
- else:
  - set Subframe_Offset to 0.
- consider that the grant recurs in each subframe for which:
  - (10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * *semiPersistSchedIntervalUL* + Subframe_Offset * (N modulo 2)] modulo 10240, for all N>0.

Where $SFN_{start\ time}$ and $subframe_{start\ time}$ are the SFN and subframe, respectively, at the time the configured uplink grant were (re-)initialised.

The UE shall clear the configured uplink grant immediately after *implicitReleaseAfter* [8] number of consecutive new MAC PDUs each containing zero MAC SDUs have been provided by the Multiplexing and Assembly entity, on the Semi-Persistent Scheduling resource.

NOTE: Retransmissions for Semi-Persistent Scheduling can continue after clearing the configured uplink grant.

5.11 Handling of unknown, unforeseen and erroneous protocol data

When a MAC entity receives a MAC PDU for the UE's C-RNTI or Semi-Persistent Scheduling C-RNTI, or by the configured downlink assignment, containing reserved or invalid values, the MAC entity shall:

- discard the received PDU.

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00177

The UE shall ignore the value of Reserved bits in downlink MAC PDUs.

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

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 subheaders; each subheader corresponds 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 subheaders for fixed sized MAC control elements consist solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

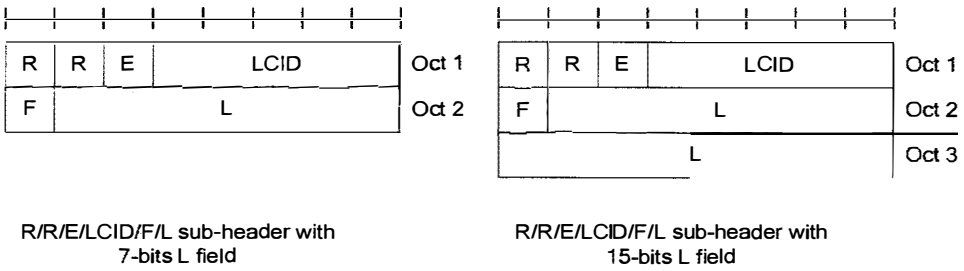


Figure 6.1.2-1: R/R/E/LCID/F/L MAC subheader

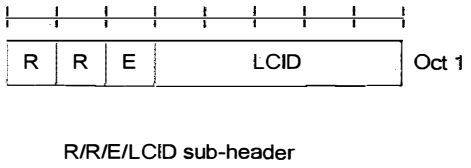


Figure 6.1.2-2: R/R/E/LCID MAC subheader

MAC PDU subheaders have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements are always placed before any MAC SDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the UE shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB per UE.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00178

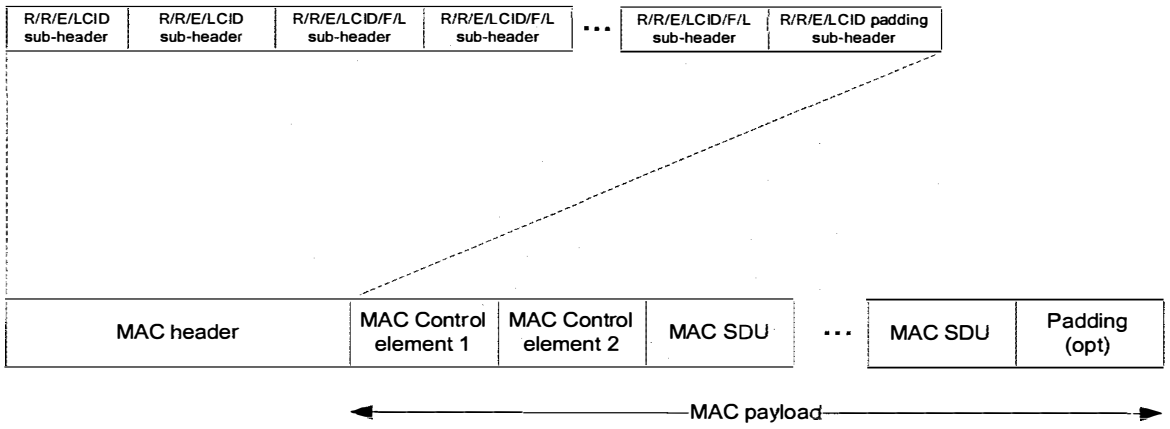


Figure 6.1.2-3: Example of MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding

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 and Truncated BSR format: one LCG ID field and one corresponding Buffer Size field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #0 through #3 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1-2.

The fields LCG ID and Buffer Size 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 6.1.3.1-1.

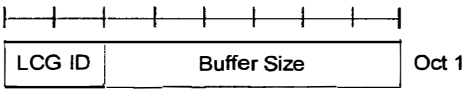


Figure 6.1.3.1-1: Short BSR and Truncated BSR MAC control element

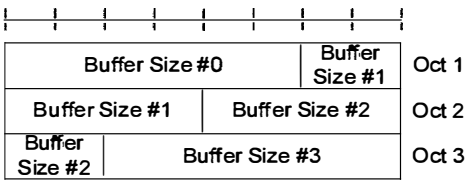


Figure 6.1.3.1-2: Long BSR MAC control element

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00179

Table 6.1.3.1-1: Buffer size levels for BSR

Index	Buffer Size (BS) value [bytes]	Index	Buffer Size (BS) value [bytes]
0	BS = 0	32	1132 < BS <= 1326
1	0 < BS <= 10	33	1326 < BS <= 1552
2	10 < BS <= 12	34	1552 < BS <= 1817
3	12 < BS <= 14	35	1817 < BS <= 2127
4	14 < BS <= 17	36	2127 < BS <= 2490
5	17 < BS <= 19	37	2490 < BS <= 2915
6	19 < BS <= 22	38	2915 < BS <= 3413
7	22 < BS <= 26	39	3413 < BS <= 3995
8	26 < BS <= 31	40	3995 < BS <= 4677
9	31 < BS <= 36	41	4677 < BS <= 5476
10	36 < BS <= 42	42	5476 < BS <= 6411
11	42 < BS <= 49	43	6411 < BS <= 7505
12	49 < BS <= 57	44	7505 < BS <= 8787
13	57 < BS <= 67	45	8787 < BS <= 10287
14	67 < BS <= 78	46	10287 < BS <= 12043
15	78 < BS <= 91	47	12043 < BS <= 14099
16	91 < BS <= 107	48	14099 < BS <= 16507
17	107 < BS <= 125	49	16507 < BS <= 19325
18	125 < BS <= 146	50	19325 < BS <= 22624
19	146 < BS <= 171	51	22624 < BS <= 26487
20	171 < BS <= 200	52	26487 < BS <= 31009
21	200 < BS <= 234	53	31009 < BS <= 36304
22	234 < BS <= 274	54	36304 < BS <= 42502
23	274 < BS <= 321	55	42502 < BS <= 49759
24	321 < BS <= 376	56	49759 < BS <= 58255
25	376 < BS <= 440	57	58255 < BS <= 68201
26	440 < BS <= 515	58	68201 < BS <= 79846
27	515 < BS <= 603	59	79846 < BS <= 93479
28	603 < BS <= 706	60	93479 < BS <= 109439
29	706 < BS <= 826	61	109439 < BS <= 128125
30	826 < BS <= 967	62	128125 < BS <= 150000
31	967 < BS <=1132	63	BS > 150000

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.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00180

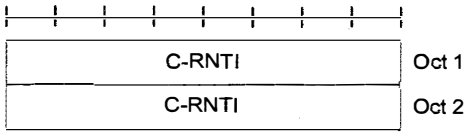


Figure 6.1.3.2-1: C-RNTI MAC control element

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.

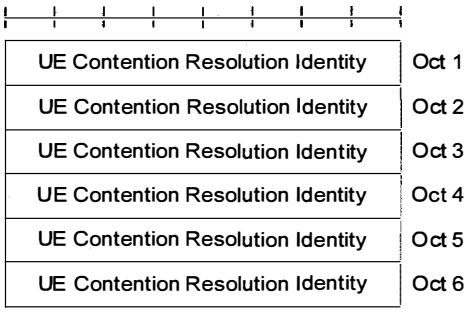


Figure 6.1.3.4-1: UE Contention Resolution Identity MAC control element

6.1.3.5 Timing Advance Command MAC Control Element

The Timing Advance Command 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 octet defined as follows (figure 6.1.3.5-1):

- R: reserved bit, set to "0";
- Timing Advance Command: This field indicates the index value T_A (0, 1, 2... 63) used to control the amount of timing adjustment that UE has to apply (see subclause 4.2.3 of [2]). The length of the field is 6 bits.

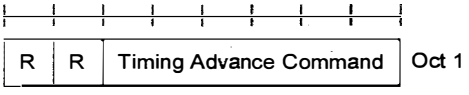


Figure 6.1.3.5-1: Timing Advance Command MAC control element

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 6.2.1-2. It has a fixed size and consists of a single octet defined as follows (figure 6.1.3.6-1):

- R: reserved bit, set to "0";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00181

- Power Headroom (PH): this field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.6-1 below (the corresponding measured values in dB can be found in subclause 9.1.8.4 of [9]).

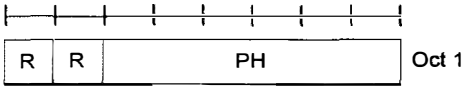


Figure 6.1.3.6-1: Power Headroom MAC control element

Table 6.1.3.6-1: Power Headroom levels for PHR

PH	Power Headroom Level
0	POWER_HEADROOM_0
1	POWER_HEADROOM_1
2	POWER_HEADROOM_2
3	POWER_HEADROOM_3
...	...
60	POWER_HEADROOM_60
61	POWER_HEADROOM_61
62	POWER_HEADROOM_62
63	POWER_HEADROOM_63

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.

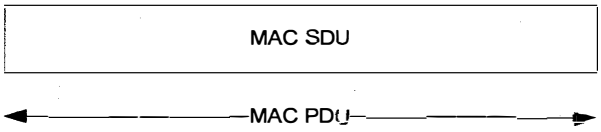


Figure 6.1.4-1: Example of MAC PDU (transparent MAC)

6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of a MAC header and zero or more MAC Random Access Responses (MAC RAR) and optionally padding 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 subheaders; each subheader corresponding to a MAC RAR except for the Backoff Indicator subheader. If included, the Backoff Indicator subheader is only included once and is the first subheader included within the MAC PDU 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 four fields R/Timing Advance Command/UL Grant/Temporary C-RNTI (as described in figure 6.1.5-3).

Padding may occur after the last MAC RAR. Presence and length of padding is implicit based on TB size, size of MAC header and number of RARs.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00182

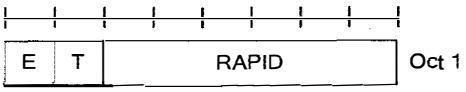


Figure 6.1.5-1: E/T/RAPID MAC subheader

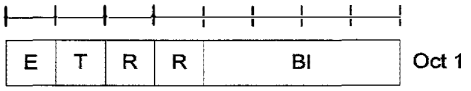


Figure 6.1.5-2: E/T/R/R/BI MAC subheader

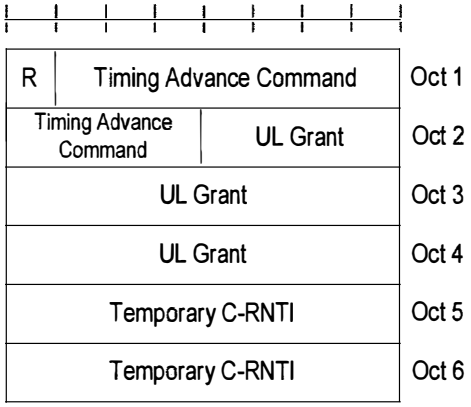


Figure 6.1.5-3: MAC RAR

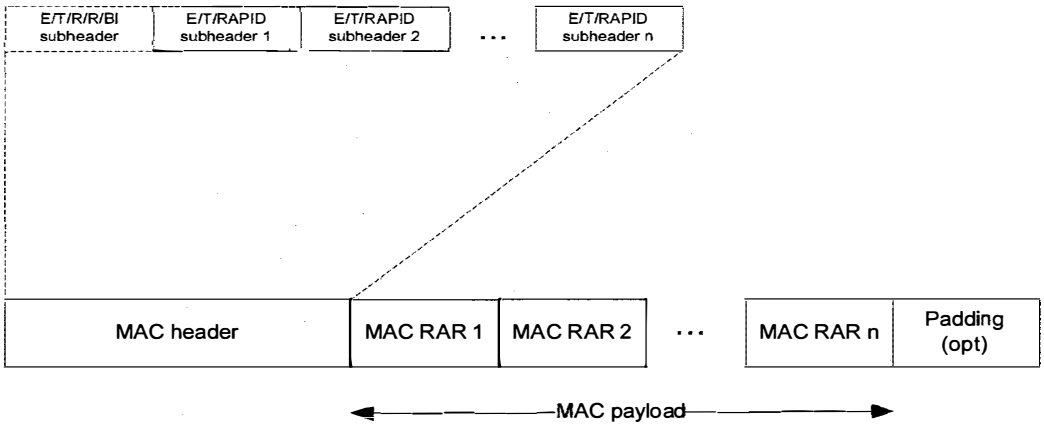


Figure 6.1.5-4: Example of MAC PDU consisting of a MAC header and MAC RARs

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. In addition to that, one or two additional LCID fields are included in 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. The LCID field size is 5 bits;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00183

- L: The Length field indicates the length of the corresponding MAC SDU in bytes. There is one L field per MAC PDU subheader except for the last subheader and subheaders 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 subheaders corresponding to fixed-sized MAC control elements. The size of the F field is 1 bit. If the size of the MAC SDU 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 bit, set to "0".

The MAC header and subheaders are octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-11011	Reserved
11100	UE Contention Resolution Identity
11101	Timing Advance Command
11110	DRX Command
11111	Padding

Table 6.2.1-2 Values of LCID for UL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-11001	Reserved
11010	Power Headroom Report
11011	C-RNTI
11100	Truncated BSR
11101	Short BSR
11110	Long BSR
11111	Padding

Table 6.2.1-3 Values of F field:

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

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 at least another set of E/T/RAPID fields follows. The E field is set to "0" to indicate that a MAC RAR or padding 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, set to "0";

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00184

- 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 IDentifier 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 subheaders 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:

- R: Reserved bit, set to "0";
- Timing Advance Command: The Timing Advance Command field indicates the index value T_A (0, 1, 2... 1282) used to control the amount of timing adjustment that UE has to apply (see subclause 4.2.3 of [2]). The size of the Timing Advance Command field is 11 bits;
- UL Grant: The UpLink Grant field indicates the resources to be used on the uplink (see subclause 6.2 of [2]). The size of the UL Grant field is 20 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.

7 Variables and constants

7.1 RNTI values

RNTI values are presented in Table 7.1-1 and their usage and associated Transport Channels and Logical Channels are presented in Table 7.1-2.

Table 7.1-1: RNTI values.

Value (hexa-decimal)	RNTI
0000	N/A
0001-003C	RA-RNTI, C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI and TPC-PUSCH-RNTI (see note)
003D-FFF3	C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI and TPC-PUSCH-RNTI
FFF4-FFFD	Reserved for future use
FFFE	P-RNTI
FFFF	SI-RNTI

NOTE: The values corresponding to the RA-RNTI values of a cell's PRACH configuration are not used in the cell for any other RNTI (C-RNTI, Semi-Persistent Scheduling C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI or TPC-PUSCH-RNTI).

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00185

Table 7.1-2: RNTI usage.

RNTI	Usage	Transport Channel	Logical Channel
P-RNTI	Paging and System Information change notification	PCH	PCCH
SI-RNTI	Broadcast of System Information	DL-SCH	BCCH
RA-RNTI	Random Access Response	DL-SCH	N/A
Temporary C-RNTI	Contention Resolution (when no valid C-RNTI is available)	DL-SCH	CCCH
Temporary C-RNTI	Msg3 transmission	UL-SCH	CCCH, DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	DL-SCH, UL-SCH	DCCH, DTCH
C-RNTI	Triggering of PDCCH ordered random access	N/A	N/A
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (activation, reactivation and retransmission)	DL-SCH, UL-SCH	DCCH, DTCH
Semi-Persistent Scheduling C-RNTI	Semi-Persistently scheduled unicast transmission (deactivation)	N/A	N/A
TPC-PUCCH-RNTI	Physical layer Uplink power control	N/A	N/A
TPC-PUSCH-RNTI	Physical layer Uplink power control	N/A	N/A

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
13	Reserved
14	Reserved
15	Reserved

The reserved values of the backoff parameter if received by the current release version UEs shall be taken as 960 ms.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00186

7.3 PRACH Mask Index values

Table 7.3-1: PRACH Mask Index values

PRACH Mask Index	Allowed PRACH (FDD)	Allowed PRACH (TDD)
0	All	All
1	PRACH Resource Index 0	PRACH Resource Index 0
2	PRACH Resource Index 1	PRACH Resource Index 1
3	PRACH Resource Index 2	PRACH Resource Index 2
4	PRACH Resource Index 3	PRACH Resource Index 3
5	PRACH Resource Index 4	PRACH Resource Index 4
6	PRACH Resource Index 5	PRACH Resource Index 5
7	PRACH Resource Index 6	Reserved
8	PRACH Resource Index 7	Reserved
9	PRACH Resource Index 8	Reserved
10	PRACH Resource Index 9	Reserved
11	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, even PRACH opportunity 1st PRACH Resource Index in subframe
12	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe	Every, in the time domain, odd PRACH opportunity 1st PRACH Resource Index in subframe
13	Reserved	1st PRACH Resource Index in subframe
14	Reserved	2nd PRACH Resource Index in subframe
15	Reserved	3rd PRACH Resource Index in subframe

7.4 Subframe_Offset values

Subframe_Offset values are presented in Table 7.4-1.

Table 7.4-1: Subframe_Offset values

TDD UL/DL configuration	Position of initial Semi-Persistent grant	Subframe_Offset value (ms)
0	N/A	0
1	Subframes 2 and 7	1
	Subframes 3 and 8	-1
2	Subframe 2	5
	Subframe 7	-5
3	Subframes 2 and 3	1
	Subframe 4	-2
4	Subframe 2	1
	Subframe 3	-1
5	N/A	0
6	N/A	0

7.5 TTI_BUNDLE_SIZE value

The parameter TTI_BUNDLE_SIZE is 4.

7.6 DELTA_PREAMBLE values

The DELTA_PREAMBLE preamble format based power offset values are presented in Table 7.6-1.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00187

Table 7.6-1: DELTA_PREAMBLE values.

Preamble Format	DELTA_PREAMBLE value
0	0 dB
1	0 dB
2	-3 dB
3	-3 dB
4	8 dB

Where the Preamble Format is given by *prach-ConfigIndex* [7].

7.7 HARQ RTT Timer

For FDD the HARQ RTT Timer is set to 8 subframes. For TDD the HARQ RTT Timer is set to k + 4 subframes, where k is the interval between the downlink transmission and the transmission of associated HARQ feedback, as indicated in Table 10.1-1 of [2].

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00188

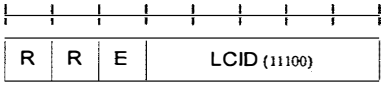
Annex A (normative): Handling of measurement gaps

In a subframe that is part of a measurement gap, the UE shall not perform the transmission of HARQ feedback and CQI/PMI/RI, and SRS shall not be reported.

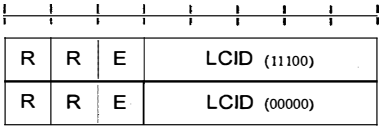
IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00189

Annex B (informative): Contention resolution for RACH access

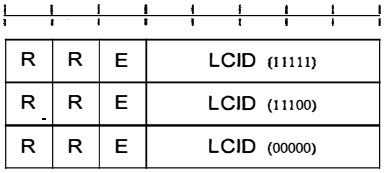
When checking whether contention resolution was successful a UE considers the MAC header structures shown below for the processing of a MAC PDU containing a UE Contention Resolution Identity MAC control element.



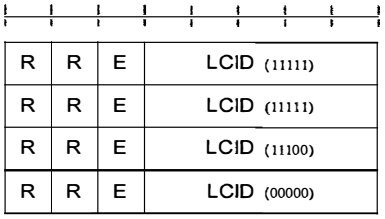
Case 1: MAC subheader for MAC control element



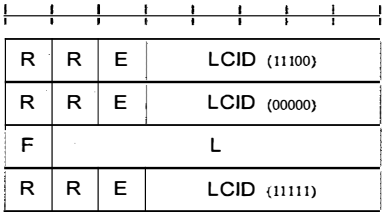
Case 2: MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



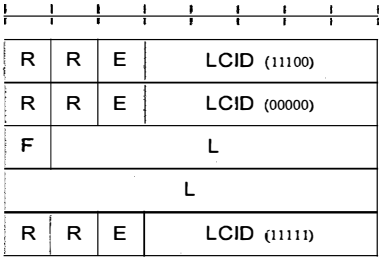
Case 3: MAC subheader for single-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 4: MAC subheaders for two-byte padding + MAC subheader for MAC control element + MAC subheader for MAC SDU (CCCH)



Case 5: MAC subheader for MAC control element + MAC subheader (7-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding



Case 6: MAC subheader for MAC control element + MAC subheader (15-bits L-field) for MAC SDU (CCCH) + MAC subheader for padding

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00190

Annex C (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	RP-38	RP-070917			Clean version, presented at TSG RAN-38 for approval	1.3.0	2.0.0
2007-12	RP-38	-			Approved at TSG RAN-38 and placed under change control	2.0.0	8.0.0
2008-03	RP-39	RP-080162	0001	2	CR to 36.321 with E-UTRA MAC protocol specification update	8.0.0	8.1.0
2008-05	RP-40	RP-080410	0002	1	36.321 CR covering agreements of RAN2 #61bis and RAN2#62	8.1.0	8.2.0
2008-09	RP-41	RP-080690	0003	-	Clarification on data available for transmission for BSR triggering	8.2.0	8.3.0
	RP-41	RP-080690	0004	-	CR to 36.321 on failure indication after maximum number of HARQ transmissions	8.2.0	8.3.0
	RP-41	RP-080690	0005	4	Clarifications and Corrections of DL and UL Data Transfer (SCH, RACH and SR)	8.2.0	8.3.0
	RP-41	RP-080690	0006	-	CR to 36.321 on Buffer size levels for BSR	8.2.0	8.3.0
	RP-41	RP-080690	0007	-	Clarifications on DRX	8.2.0	8.3.0
	RP-41	RP-080690	0008	-	Clarification on UE behavior for DRX and configured measurement gaps	8.2.0	8.3.0
	RP-41	RP-080690	0009	3	Correction to MAC Padding BSR	8.2.0	8.3.0
	RP-41	RP-080690	0010	-	Correction to UE transmission power headroom report for LTE	8.2.0	8.3.0
	RP-41	RP-080690	0011	-	Corrections on BSR	8.2.0	8.3.0
	RP-41	RP-080690	0012	-	CR to 36.321 REL-8 on Format of UL grant in Message 2	8.2.0	8.3.0
	RP-41	RP-080690	0015	-	CR to 36.321 REL-8 on PUSCH PUCCH Power Control RNTIs	8.2.0	8.3.0
	RP-41	RP-080690	0016	-	CR to 36.321 REL-8 on RACH uniform random backoff	8.2.0	8.3.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00191

	RP-41	RP-080690	0017	1	E-UTRA MAC protocol specification update	8.2.0	8.3.0
	RP-41	RP-080690	0020	-	TP for number of HARQ processes and MIMO	8.2.0	8.3.0
	RP-41	RP-080690	0022	-	Update of MAC dedicated preamble expiry	8.2.0	8.3.0
	RP-41	RP-080690	0027	-	Handling of Semi-Persistent grants and assignments	8.2.0	8.3.0
	RP-41	RP-080690	0051	1	Corrections relating to RACH	8.2.0	8.3.0
	RP-41	RP-080690	0058	1	UL Channel Prioritisation	8.2.0	8.3.0
	RP-41	RP-080690	0071	2	Corrections relating to RACH partitioning	8.2.0	8.3.0
	RP-41	RP-080690	0091	-	Correction on Random Access Response reception behaviour	8.2.0	8.3.0
	RP-41	RP-080690	0103	-	Upper limit of logical channel id	8.2.0	8.3.0
	RP-41	RP-080690	0104	-	Clarifications and Corrections for HARQ operation at TAT expiry and RACH contention resolution	8.2.0	8.3.0
2008-12	RP-42	RP-081018	0105	-	CR0105 to 36.321 [Rel-8] on PHR Periodic Timer Start	8.3.0	8.4.0
	RP-42	RP-081018	0106	1	Proposed R1 of CR0106 to 36.321 [Rel-8] on PHR Reference	8.3.0	8.4.0
	RP-42	RP-081018	0107	1	CR 0107 to 36.321 Interactions between measurement gap and Msg3 transmission	8.3.0	8.4.0
	RP-42	RP-081018	0108	2	Proposed R1 of CR0108 to 36.321 [Rel-8] on PHR Reporting Values	8.3.0	8.4.0
	RP-42	RP-081018	0109	-	Correction relating to equal priorities	8.3.0	8.4.0
	RP-42	RP-081018	0110	-	CR 0110 to 36.321 on Correction to PHR	8.3.0	8.4.0
	RP-42	RP-081018	0112	1	CR0112r1 to 36.321 [Rel-8] Correction to BCCH Reception procedure	8.3.0	8.4.0
	RP-42	RP-081018	0113	-	Contention Resolution Timer	8.3.0	8.4.0
	RP-42	RP-081018	0114	-	PCH reception	8.3.0	8.4.0
	RP-42	RP-081018	0115	-	Correction to reception of assignments and grants	8.3.0	8.4.0
	RP-42	RP-081018	0116	-	Correction on Contention Resolution	8.3.0	8.4.0
	RP-42	RP-081018	0117	2	Proposed R1 of CR0117 to 36.321 [Rel-8] on on SR Clarifications and Repetitions	8.3.0	8.4.0
	RP-42	RP-081078	0118	2	Clarification on Padding value	8.3.0	8.4.0
	RP-42	RP-081018	0119	-	CR 0119 to 36.321 Correction and Clarification on TTI Bundling	8.3.0	8.4.0
	RP-42	RP-081018	0120	1	Clarification of DRX Active Time	8.3.0	8.4.0
	RP-42	RP-081018	0121	4	Text Proposal for Dedicated Preamble Assignment	8.3.0	8.4.0
	RP-42	RP-081018	0122	-	CR0122 to 36.321 [Rel-8] on Message 3 Definition	8.3.0	8.4.0
	RP-42	RP-081018	0123	1	Correction to prevent wrong contention resolution by adaptive retransmission command	8.3.0	8.4.0
	RP-42	RP-081018	0124	-	Bucket Size Parameter	8.3.0	8.4.0
	RP-42	RP-081018	0125	2	CR0125r2 to 36.321 [Rel-8] Correction to Multiple BSR	8.3.0	8.4.0
	RP-42	RP-081018	0127	-	CR0127 to 36.321 [Rel-8] RACH preambles labelling	8.3.0	8.4.0
	RP-42	RP-081018	0128	1	CR0128r1 to 36.321 [Rel-8] merging CR0126r0 and CR0128r0	8.3.0	8.4.0
	RP-42	RP-081018	0129	1	CR0129r1 to 36.321 [Rel-8] Correction to PDU Format	8.3.0	8.4.0
	RP-42	RP-081018	0130	-	CQI/ SRS/PMI/RI transmission during active time	8.3.0	8.4.0
	RP-42	RP-081018	0131	1	NDI and Msg4 Carrying Contention Resolution ID	8.3.0	8.4.0
	RP-42	RP-081018	0132	1	CR0132 to 36.321 [Rel-8] on MAC BSR trigger	8.3.0	8.4.0
	RP-42	RP-081018	0133	-	Clarification about Restarting the Periodic BSR Timer	8.3.0	8.4.0
	RP-42	RP-081018	0134	-	Correction to RA procedure initiated by eNB PDCCH order	8.3.0	8.4.0
	RP-42	RP-081018	0135	1	Correction on PHR triggering condition	8.3.0	8.4.0
	RP-42	RP-081018	0136	-	CR 0136 to 36.321 on Correction to UL HARQ Process for the transmission of Msg3	8.3.0	8.4.0
	RP-42	RP-081018	0137	2	SPS occasions	8.3.0	8.4.0
	RP-42	RP-081018	0138	-	Robustness of Buffer Status Reporting	8.3.0	8.4.0
	RP-42	RP-081018	0139	-	Proposed CR to 36.321 [Rel-8] on UL HARQ and Measurement Gaps	8.3.0	8.4.0
	RP-42	RP-081018	0142	1	TAT and RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0143	1	SRS and CQI Resources Release upon TAT Expiry	8.3.0	8.4.0
	RP-42	RP-081018	0157	1	Proposed CR to 36.321 Correction to RACH procedure	8.3.0	8.4.0
	RP-42	RP-081018	0162	1	BSR format for reporting empty buffers	8.3.0	8.4.0
	RP-42	RP-081018	0165	-	TTI Bundling Configuration	8.3.0	8.4.0
	RP-42	RP-081018	0166	1	Corrections to semi-persistent scheduling	8.3.0	8.4.0
	RP-42	RP-081018	0167	2	Priotitization of MAC control elements	8.3.0	8.4.0
	RP-42	RP-081018	0168	-	Correction to starting of TA timer	8.3.0	8.4.0
	RP-42	RP-081018	0173	1	Proposed CR to 36.321 SPS implicit release on UL	8.3.0	8.4.0
	RP-42	RP-081018	0174	-	Proposed CR to 36.321 Measurement gaps and SPS	8.3.0	8.4.0
	RP-42	RP-081018	0175	-	Proposed CR to 36.321 Setting reserved bits to zero	8.3.0	8.4.0
	RP-42	RP-081018	0185	-	Proposed CR to 36.321 [Rel-8] MAC ResetReconfig Option 2	8.3.0	8.4.0
	RP-42	RP-081018	0188	2	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0189	-	Corrections to Random Access Procedure	8.3.0	8.4.0
	RP-42	RP-081018	0198	-	Number of HARQ processes for MIMO	8.3.0	8.4.0
	RP-42	RP-081018	0201	-	Corrections to power control and random access	8.3.0	8.4.0
	RP-42	RP-081018	0206	-	Correction on the definition of the PDCCH-subframe	8.3.0	8.4.0
	RP-42	RP-081018	0211	1	Correction to the coexist of SPS-RNTI and SI-RNTI or RA-RNTI	8.3.0	8.4.0
	RP-42	RP-081018	0220	-	Explicit release of SPS	8.3.0	8.4.0
	RP-42	RP-081018	0225	2	Linking HARQ process ID with the SPS resource	8.3.0	8.4.0
	RP-42	RP-081018	0231	-	Bucket Parameter Update	8.3.0	8.4.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00192

	RP-42	RP-081018	0232	1	Clarification on "PDCCH indicates a new transmission" for DRX	8.3.0	8.4.0
	RP-42	RP-081018	0233	1	Editorial corrections to MAC	8.3.0	8.4.0
	RP-42	RP-081018	0236	-	RB suspension and BSR contents	8.3.0	8.4.0
	RP-42	RP-081018	0239	-	RV setting	8.3.0	8.4.0
	RP-42	RP-081018	0240	2	Preamble group selection	8.3.0	8.4.0
	RP-42	RP-081018	0241	-	Use of dedicated preambles after HO complete	8.3.0	8.4.0
	RP-42	RP-081018	0242	-	Introduction of HARQ RTT Timer	8.3.0	8.4.0
	RP-42	RP-081018	0243	-	Correction to DRX configuration	8.3.0	8.4.0
2009-03	RP-43	RP-090128	0245	-	CR to 36.321 on BSR clarification	8.4.0	8.5.0
	RP-43	RP-090128	0246	2	Freeing of reserved RNTIs	8.4.0	8.5.0
	RP-43	RP-090128	0247	-	Correction to MAC reset	8.4.0	8.5.0
	RP-43	RP-090128	0248	-	Correction to Initialization of Prioritization	8.4.0	8.5.0
	RP-43	RP-090128	0249	-	Local NACKing Optionality MAC CR	8.4.0	8.5.0
	RP-43	RP-090128	0250	1	Position of the Backoff Indicator subheader	8.4.0	8.5.0
	RP-43	RP-090128	0251	-	Missing reserved bit setting	8.4.0	8.5.0
	RP-43	RP-090128	0252	-	Expired TAT and PUSCH transmission	8.4.0	8.5.0
	RP-43	RP-090128	0253	-	Expired TAT and HARQ feedback	8.4.0	8.5.0
	RP-43	RP-090128	0254	1	Counter proposal to R2-090969 on Management for HARQ buffer with TAT	8.4.0	8.5.0
	RP-43	RP-090128	0255	-	HARQ Feedback and Contention Resolution	8.4.0	8.5.0
	RP-43	RP-090128	0256	-	Corrections to redundancy version control for system information	8.4.0	8.5.0
	RP-43	RP-090128	0257	-	Mapping of the RNTIs to different transport channels	8.4.0	8.5.0
	RP-43	RP-090128	0258	-	DRX and UL Retransmissions	8.4.0	8.5.0
	RP-43	RP-090128	0259	-	Definition of DRX Short Cycle Timer	8.4.0	8.5.0
	RP-43	RP-090128	0260	-	Small corrections to RACH	8.4.0	8.5.0
	RP-43	RP-090128	0261	-	Processing of contention resolution message	8.4.0	8.5.0
	RP-43	RP-090128	0262	-	Corrections to power control and random access	8.4.0	8.5.0
	RP-43	RP-090128	0263	-	Missing condition for unsuccessful reception of Msg2	8.4.0	8.5.0
	RP-43	RP-090128	0264	1	Corrections relating to Random Access required inputs	8.4.0	8.5.0
	RP-43	RP-090128	0265	-	Bucket Parameter Update	8.4.0	8.5.0
	RP-43	RP-090128	0266	2	Correction to Handling of triggered PHR	8.4.0	8.5.0
	RP-43	RP-090128	0267	-	SPS resource release on D-SR failure	8.4.0	8.5.0
	RP-43	RP-090128	0269	2	NDI handling when measurement gap and SPS occassion collide	8.4.0	8.5.0
	RP-43	RP-090128	0270	-	Correction relating to PDCCH order	8.4.0	8.5.0
	RP-43	RP-090128	0271	-	Error Handling	8.4.0	8.5.0
	RP-43	RP-090128	0272	-	Various clarifications/corrections to TS36.321	8.4.0	8.5.0
	RP-43	RP-090128	0273	1	Disassembly, Demultiplexing and Multiplexing functions	8.4.0	8.5.0
	RP-43	RP-090128	0274	1	Miscellaneous corrections to MAC	8.4.0	8.5.0
	RP-43	RP-090128	0275	2	CR on Interactions between Msg3 transmission and TTI bundling	8.4.0	8.5.0
	RP-43	RP-090128	0276	-	TTI Bundling	8.4.0	8.5.0
	RP-43	RP-090128	0278	1	Correction to BSR trigger at serving cell change	8.4.0	8.5.0
	RP-43	RP-090128	0279	1	Correction to Release of SPS	8.4.0	8.5.0
	RP-43	RP-090128	0280	2	Usage of RRC Parameters	8.4.0	8.5.0
	RP-43	RP-090128	0281	-	Clarification of MAC Timer status	8.4.0	8.5.0
	RP-43	RP-090128	0282	1	Correction on MAC PDU subheader description	8.4.0	8.5.0
	RP-43	RP-090128	0283	1	UE behaviour at CURRENT_TX_NB reaches maximum value	8.4.0	8.5.0
	RP-43	RP-090128	0285	-	Reporting During DRX	8.4.0	8.5.0
	RP-43	RP-090128	0289	-	NDI handling after random access procedure	8.4.0	8.5.0
	RP-43	RP-090128	0290	1	Dedicated preamble handling after random access failure	8.4.0	8.5.0
	RP-43	RP-090128	0292	-	NDI and grant in Message 2	8.4.0	8.5.0
	RP-43	RP-090128	0293	1	Correction relating to BCCH HARQ	8.4.0	8.5.0
	RP-43	RP-090128	0300	1	Corrections to Msg3 definition and usage	8.4.0	8.5.0
	RP-43	RP-090128	0303	-	PRACH selection must use prach-ConfigurationIndex	8.4.0	8.5.0
	RP-43	RP-090128	0305	-	Clarification on RETX_BSR_TIMER	8.4.0	8.5.0
	RP-43	RP-090128	0307	3	MAC Structure in UE Side	8.4.0	8.5.0
	RP-43	RP-090128	0308	-	Clarification on Random Access Procedure	8.4.0	8.5.0
	RP-43	RP-090128	0314	-	Clarification on the CR timer	8.4.0	8.5.0
	RP-43	RP-090128	0316	-	Correction on BSR	8.4.0	8.5.0
	RP-43	RP-090128	0318	1	Clarification on MAC reconfiguration of timers and counters	8.4.0	8.5.0
	RP-43	RP-090128	0320	-	HARQ feedback, CQI/PMI/RI and SRS transmissions and measurement gaps	8.4.0	8.5.0
	RP-43	RP-090128	0324	-	MAC PDU subheader corresponding to padding	8.4.0	8.5.0
	RP-43	RP-090128	0333	-	CR On Backoff table	8.4.0	8.5.0
	RP-43	RP-090128	0334	3	TTI Bundling Operation	8.4.0	8.5.0
	RP-43	RP-090128	0341	1	Enforcing new transmission after flushing HARQ process	8.4.0	8.5.0
2009-06	RP-44	RP-090513	0342	-	Correction on HARQ feedback transmission	8.5.0	8.6.0
	RP-44	RP-090513	0343	1	Clarification on the DL assignment/UL grant reception in SPS	8.5.0	8.6.0
	RP-44	RP-090513	0344	1	PHR timer handling after handover	8.5.0	8.6.0
	RP-44	RP-090513	0346	2	MAC PDU for Msg2	8.5.0	8.6.0
	RP-44	RP-090513	0347	2	MAC Error handling	8.5.0	8.6.0
	RP-44	RP-090513	0348	-	Correction on SR cancellation	8.5.0	8.6.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00193

	RP-44	RP-090513	0349	1	Correction to RETX_BSR_TIMER	8.5.0	8.6.0
	RP-44	RP-090513	0350	1	CR to 36.321 on UL SPS Implicit Release	8.5.0	8.6.0
	RP-44	RP-090513	0351	2	Various correction to MAC	8.5.0	8.6.0
	RP-44	RP-090513	0369	-	Correction to Uplink grant by temporary C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0370	-	Clarification on simultaneous reception of RA-RNTI and C-RNTI	8.5.0	8.6.0
	RP-44	RP-090513	0374	-	Correction on timeAlignmentTimer validity in MAC	8.5.0	8.6.0
	RP-44	RP-090513	0376	1	CR for MAC padding	8.5.0	8.6.0
	RP-44	RP-090513	0377	-	Correction to duplicate reception of TA command (2nd method)	8.5.0	8.6.0
2009-09	RP-45	RP-090906	0379	-	Correction to NDI semantics	8.6.0	8.7.0
	RP-45	RP-090906	0380	1	Minor corrections to 36.321	8.6.0	8.7.0
	RP-45	RP-090906	0381	2	UE behaviour when MBSFN subframe and a configured downlink assignment collide	8.6.0	8.7.0
	RP-45	RP-090906	0399	-	Correction to HARQ process ID for DL SPS retransmissions	8.6.0	8.7.0

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00194

Title: Reconfiguration in CA

Document for: Discussion, Decision

1. Introduction

After discussion in Miyazaki, following is agreed as TP to 36.912.

5.3.2.2 Connection Control

As in LTE Rel-8, the UE only has one RRC connection with the network. One cell - the "special cell" - provides the security input and the NAS mobility information (one ECGI, one PCI and one ARFCN). There is only one "special cell" per UE in connected mode.

After RRC connection establishment to the "special cell", the reconfiguration, addition and removal of CCs can be performed by *RRCConnectionReconfiguration* including *mobilityControlInfo* (i.e. "intra-cell handover"). *RRCConnectionReconfiguration* without *mobilityControlInfo* can also be used for the addition of CCs, and for the removal of CCs with the exception of the CC corresponding to the "special cell".

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

In addition, following can be found in the minutes of Miyazaki meeting.

What other CC reconfigurations may be possible without performing a handover is FFS

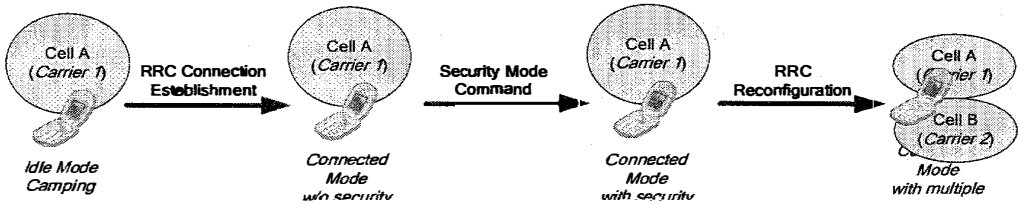
2. Discussion

According to the RRC procedure of LTE, there seem two cases when (re-)keying is performed:

1. In LTE, when a UE receives Security Mode Command message, the UE calculate KeNB using the PCI of the cell from which Security Mode Command message is received.

   Even in LTE-A, it is likely that first activation of additional carrier is performed only after security context is established between eNB and UE. Before establishment of security context, user plane data transmission is not likely to occur. Having multiple CCs without possible data transmission seems not logical.

   Thus, at the time when Security Mode Command is received, there will be only one DL carrier. Thus, without ambiguity, UE can use the PCI of this DL carrier as security input.

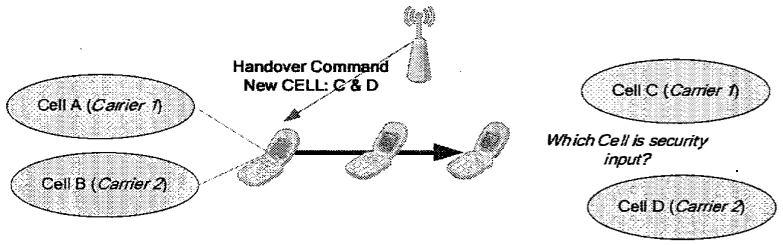


Conclusion 1: Activation of additional carrier is done after SMC is finished.

2. In LTE, when a UE receives *RRC Connection Re-configuration with mobility information* message, the UE calculate KeNB using the PCI of the cell to which the UE should be switched to.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00195

If only one carrier is activated when serving eNB is changed, there will be no difference between LTE-A and LTE. I.e., the only DL carrier included in the handover message will serve as input to KeNB calculation.

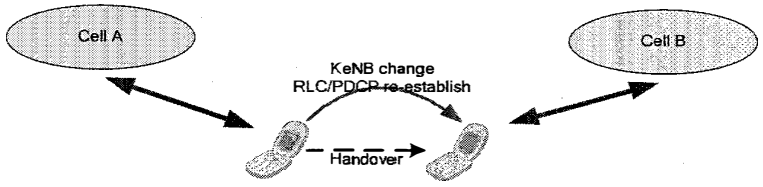


However, though it has not been discussed yet, it is likely that more than one carrier can be configured at the time of handover. In this case, it is not clear which cell should be served as input for security setting. Simply, the Handover Command message sent by eNB can explicitly indicate which DL carrier should be used as input.

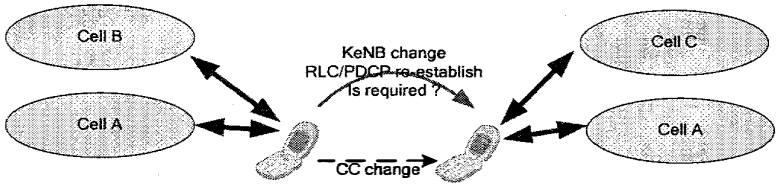
The above approach where eNB can indicate 'the specific cell' can be generally used even for intra-eNB reconfiguration. I.e., whenever there is an ambiguity regarding which carrier should be used as input for NAS system information or as input for KeNB generation, eNB can indicate the specific carrier via the RRC message. Based on the indicated carrier, a UE know which carrier is used for KeNB generation. Furthermore, eNB can re-key without change of CCs by just indicating one of active CCs as new special cell.

Conclusion 2: eNB can indicate which cell is the "special cell" that provides security input and NAS SIB when it transmits RRC messages.

In Rel-8, every handover leads to PDCP/RLC re-establishment and re-keying, regardless of whether the handover is performed within a same eNB or not. Thus, UE in LTE network experiences interruption of data transfer whenever there is a handover.



In Rel-10 with LTE-A, a UE can be configured with multiple DL/UL carriers. This means that a UE has to prepare for not only Rel-8 cell change procedures but also DL/UL carrier change procedures. If each (re-)configuration of additional carrier is considered as handover, the UE will experience much more data interruption. Unless some smart mechanism is introduced, user perception will be worse in LTE-A than in LTE.



First of all, we need to decide which procedure will be used for the (re-) configuration of activated component carriers. In LTE, there are two RRC messages that eNB can use to adjust radio parameter for the given UE. First one is *RRC Connection Reconfiguration with mobility information* message and the other one is *RRC Connection Reconfiguration without mobility information* message.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00196

Following is extracted from TS36.331:

5.3.5.3 Reception of an *RRCConnectionReconfiguration* not including the *mobilityControlInfo* by the UE

If the *RRCConnectionReconfiguration* message does not include the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

…

1> else:

2> if the *RRCConnectionReconfiguration* message includes the *radioResourceConfigDedicated*:

3> perform the radio resource configuration procedure as specified in 5.3.10;

5.3.5.4 Reception of an *RRCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover)

…

1> reset MAC;

1> re-establish PDCP for all RBs that are established;

1> re-establish RLC for all RBs that are established;

…

1> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *mobilityControlInfo*;

…

1> else:

2> update the K_{eNB} key based on the current K_{eNB} or the NH, using the *nextHopChainingCount* value indicated in the *securityConfigHO*, as specified in TS 33.401 [32];

As can be seen in the above text, *RRC Connection Reconfiguration with mobility information* message always requires a UE to re-establish RLC/PDCP and change of KeNB. In this case, data interruption is unavoidable. On the other hand, *RRC Connection Reconfiguration without mobility information* message does not introduce this behavior.

Activation or deactivation of component carrier may be used to dynamically meet QoS requirement of established bearers rather than to respond to cell quality change caused by UE's actual mobility. If the actual move of a UE triggers eNB's action, the eNB may choose to change serving cell on the same frequency rather than to (de-)activate another component carrier. In this case, re-establishment is natural consequence. However, if a UE demands for higher data rate without change of location, the eNB may just increase the number of used component carrier. In this case, re-establishment is over-reaction.

Overall, there seem two cases. First case is to reconfigure activated CC without re-establishment or security change and the second case is to reconfigure activated CC with re-establishment or security change. Support of these two scenarios can be easily done. I.e., it seems enough to introduce a new Information Elements related to component carrier configuration into *RRC Connection Reconfiguration* message. Based on whether the new IE is included with *mobility information* or not, the UE can easily identify whether it needs to re-establish security context when it reconfigures activated components carrier.

Conclusion 3: When *RRC Connection Reconfiguration* message which (re-)configures component carriers is received, PDCP/RLC re-establishment and re-keying of security context depends on whether the message includes *mobility information* or not.

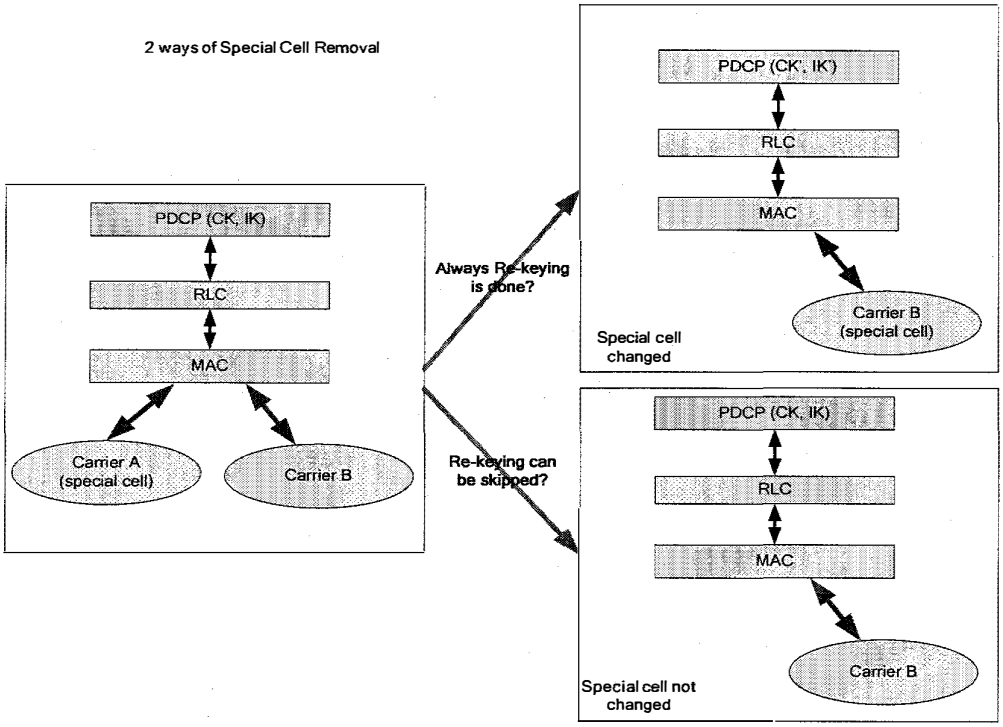
IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00197

In general, the question is when change of 'special cell' can be declared or when 'special cell' provides security input to PDCP. According to the above conclusions, eNB can control when a rekeying is performed. I.e., by deciding whether to include 'mobility information' or not, eNB can decided whether to trigger re-keying or not. At this moment when re-keying is performed, it become important which cell should be considered as 'special cell' which provides security input. If eNB decides not to re-synchronize security keys, it seems not so important which cell is special cell.

Then, we can link change of 'serving cell' to the rekeying procedure. I.e., whenever re-keying is performed, 'special cell change' is declared. Then, even if 'special cell' before reconfiguration is same as the 'special cell' after reconfiguration, we have to consider it as 'special cell change'. However, this seems not a problem because we consider 'intra-cell handover'' as a 'handover'.

Conclusion 4: 'Special cell' is considered as being changed when security re-keying occurs.

Currently, it is not yet decided whether removal of "special cell" can be done without handover procedure. For the reconfiguration procedure within same eNB, to request re-calculation of security parameter for each removal of special cell seems to be too restrictive. If it is possible to remove 'special cell' either by intra-handover procedure or by reconfiguration without handover, to allow both option is to give more flexibility to eNB. I.e., if eNB sees a need to security re-synchronization while performing special cell removal, it can use 'intra-handover' procedure. And, if eNB does not want to change security setting while performing special cell removal, it can use 'reconfiguration without handover' procedure.



Though 'special cell' provides security input to PDCP, it does not necessarily mean that security parameter used in PDCP always should be from the one of the activated carrier. As a matter of fact, PDCP layer which is in charge of security protection does not know to which carrier/cell it is connected. Thus, practically, there is no problem even if used security parameter is not associated with any active carriers/cells. In this sense, removal of serving cell should be allowed without involving a handover procedure. By not performing rekeying at each removal of special cell, data interruption can be minimized.

Conclusion 5: 'Special cell' can be removed from activated CCs with RRC reconfiguration procedure without handover.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00198

3. Proposal

It is proposed to agree on the following:

Proposal 1: Activation of additional carrier is done after SMC is finished.

Proposal 2: eNB can indicate which cell is the "special cell" which provides security input and NAS system information via RRC signaling.

Proposal 3: When *RRC Connection Reconfiguration* message which (re-)configures component carriers is received, PDCP/RLC re-establishment and re-keying of security context depends on whether the message includes *mobility information* or not.

Proposal 4: 'Special cell' is considered as being changed when security re-keying occurs.

Proposal 5: 'Special cell' can be removed from activated CCs with RRC reconfiguration procedure without handover.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00199

Title: SR procedure and DRX procedure.

Document for: Discussion, Decision

1. Introduction

SR procedure is used to request radio resource for UL transmission and DRX procedure is used to increase battery efficiency. According to section 5.7 of TS36.321, SR procedure affects DRX as follows:

> When a DRX cycle is configured, the Active Time includes the time while:
>
> - *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
> - a Scheduling Request sent on PUCCH is pending (as described in subclause 5.4.4); or

2. Discussion

According to section 5.4.4, pending SR is cancelled when a relevant BSR has been transmitted. Regarding SR procedure, elements that constitute active time are shown in the following figure 1.

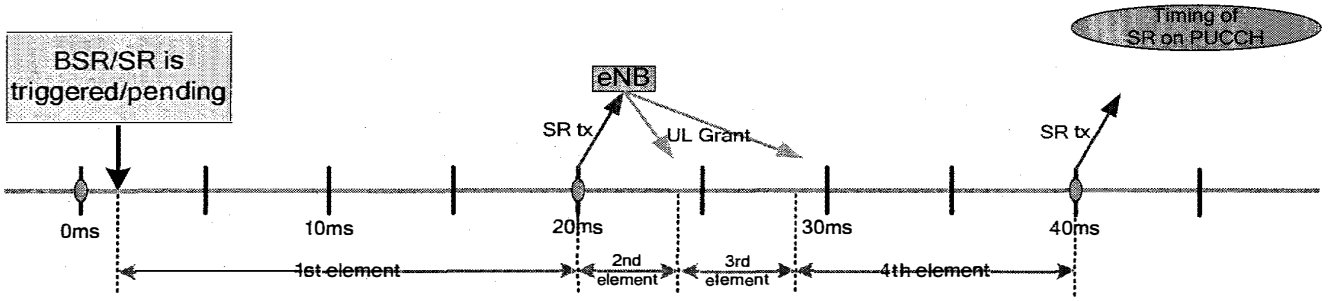


Fig 1 Elements of DRX Active time

UE is in active time as long as SR is pending. The component of active time in figure 1 is as following:

- Element 1: This is the period from when a SR is triggered to when SR on PUCCH is firstly available. I.e., this element is related to how often SR on PUCCH resource is available.
- Element 2: This is the period from when transmission over SR on PUCCH is made to when earliest UL Grant can be received. I.e., this element is related to UL/DL RTT plus eNB's minimum processing time.
- Element 3: This is the period when eNB may transmit UL Grant to the UE, with the condition that the eNB had successfully decoded UE's transmission of SR over PUCCH. This is related to how much scheduling flexibility eNB wants to have in response to SR request of a UE.
- Element 4: this is the period from when the UE has to wait until next available SR on PUCCH after previous transmission of SR over PUCCH has failed. This is the case when previous transmission of SR over PUCCH didn't reach eNB.

Regarding whether a UE is required to monitor PDCCH while SR is pending, following analysis can be made for each elements:

- Element 1: eNB does not know whether SR has been triggered at the UE side. Thus, eNB will not give any UL Grant to the UE. In this sense, PDCCH monitoring by UE is meaningless during this period.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00200

- Element 2: Even if the transmission of SR over PUCCH is successful, the UE will not receive any UL grant due to propagation delay and eNB processing. Thus, there is no need for the UE to monitor PDCCH during this period.
- Element 3: Even if eNB successfully detects SR transmission over PUCCH by a UE, the eNB may not immediately allocate UL grant for the UE. A UE must monitor PDCCH during this period due to the scheduling flexibility of eNB. However, as this period gets longer, UE battery performance will be more impacted.
- Element 4: When SR is pending, UE monitors PDCCH to receive UL grant. The assumption behind this is that eNB successfully receives transmission of SR over PUCCH. If SR transmission over PUCCH has not reached eNB, there is no reason for the UE to listen PDCCH. Thus, UE does not need to monitor during this period.

According to the above analysis, it is meaningful for the UE to monitor DL channels only during element 3. Under current specification, it is evident that UE monitors DL channels unnecessarily longer.

3. Proposal

In this contribution, we analyzed the relation of SR and DRX. To prevent unnecessary UE monitoring during SR procedure, it is proposed to relax the definition of DRX Active time so that UE is required to monitor PDCCH only during when possible UL Grant can be received.

If agreement is reached, LG is happy to provide CR for the next meeting.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00201

Title : SI Providing for CA

Document for : Discussion and Decision

1 SI providing for non-extension carrier

[All background information can be found in annex or 3GPP TS 36.300, 3GPP TS36.321, 3GPP TS TS36.331, TR36.912]

SI providing at CC addition (i.e. at CC configuration)

As identified so far, we have two options: when a CC (Component Carrier) is added,

1. Option 1: the UE receives the system information by common signalling, i.e. broadcast.

   (+) less signalling overhead

2. Option 2: the UE receives the system information by dedicated signalling.

   (+) no delay to use the CC as no extra time to read SI is required

In option1, the eNB may need to conservatively take the delay until the use of the CC as it is difficult to expect when SI reading is finished by the UE. We think it is not desirable to introduce such delay at CC addition.

In option 2, we think that the signalling overhead would not be an issue in LTE-A system to provide data with higher rate, considering the LTE Rel-8 system already supports to provide SI by the dedicated signalling at handover.

Proposal 1: It is proposed to support dedicated signalling to provide system information at CC addition

SI providing at SI change

As identified so far, we have two options: to know the SI change of each DL CC

1. Option 1: the UE periodically checks paging or SIB1 on every DL CC.

   (+) simple

2. Option 2: the UE can periodically check paging or SIB1 on only a certain DL CC, e.g. CC specific *systemInfoModification* in paging message or CC specific *systemInfoValueTag* in SIB1.

   (+) UE power saving

As this issue is about an UE power saving aspect, we think it is quite related to DRX and CC activation/de-activation for CA being discussed.

In non-DRX case, as the UE may be required to monitor paging or SIB1 on each DL CC where it is receiving data, there would not be an issue in terms of the UE power saving.

In DRX case, we currently have two signalling solutions for CC activation/de-activation: RRC signalling and PDCCH signalling [1-4].

If RRC signalling is used, due to the nature of RRC signalling, we think that there would be several DL CCs the UE is monitoring in DRX. In this case, the UE in option 1 would wake up more often to monitor paging or SIB1 than in option 2. So, we think that option 2 is useful.

If PDCCH signalling is used, as the eNB can dynamically manage CCs of the UE, we think that there would be one (or small number of) DL CC the UE is monitoring in DRX. In this case, there would not be an issue for option 2. However, we may need to consider how the UE will manage SI for de-activated CCs. If the UE needs to maintain up-to-date SI even for de-activated CC, i.e. monitors paging/SIB1 on the de-activated CCs, we think option 2 is useful as the UE in option1 needs to wake up for monitoring paging/SIB1 on the de-activated CCs. Otherwise if the UE receives the updates SI by dedicated signalling when the CC is re-activated, we think option 1 is enough.

Alternatively,

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00202

1. the eNB can request the UE to read system information by sending the UE an indication in the PDCCH, MAC, or RRC signalling. The indication also includes which DL CC the UE reads system information on.
2. The UE, after receiving the indication, starts reading the system information on the indicated DL CC.
3. The UE, after completing the system information reading, indicates the completion of the system information reading to the eNB.

For example ,

1. The eNB configures the several DL CCs to the UE for CA functionality (assume DL CC 1 and DL CC2).
2. And the eNB activates those two DL CCs.
3. Afterwards, the eNB de-activates the DL CC 2.
4. The SI of DL CC 2 is changed.
5. Afterwards, the eNB re-activated the DL CC2.
6. Also, the eNB sends the indication to the UE to request the UE to read the system information on the DL CC2.
7. The UE, after completing the system information reading, indicates the completion of the system information reading of DL CC2 to the eNB.

Subject: Summary of SI, MAC RLF and DRX for CA

The following are the Inventors' opinions.

SI for CA

- For non-extension carrier

* For SI acquisition at CC addition

  * By dedicated signaling

[Young] I think that the UE may directly read the SI upon CC addition. The eNB may perform scheduling taking into consideration the time required for the UE to read the SI.

* For SI acquisition at ST change

[Sung Duck] I think this section is assocaited with activation/deactivation although I am not sure if "addition" is different from "activation". Should the UE first acquire SI if a carrier is dynamically activated over a PDCCH? Alternatively, should the UE manage SI of each carrier and perform "up-to-date follow up", regardless of whether it is activated or deactivated? I think that these questions can be applied to each option.

* Option 1 (baseline): Like LTE R8, the UE checks the paging msg. or value tag on each CC and then acquires the updated SI on each CC.

[sung Duck]: When an SIB of a CC has changed, an SIB of another CC does not necessarily change. This may be the most efficient strategy.

[Young] I think that, in the case of a value tag of an SIB1, it may also be possible that a value tag of the current CC and only a common value tag of neighbor CCs are transmitted.

Section 8

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00203

Is an individual value tag of each CC indispensible if the number of aggregated CCs is small? I think the individual value tag of each CC is unnecessary, especially when only the SI of an activated/configured carrier is tracked (or searched for).

Of course, a common SI modification indication of neighbor CCs may also be considered for paging.

In addition, I think that it will be preferable that the common SI remain unchanged when changes of the SI of other neighbor CCs are indicated through paging of the current CC.

If the following *paging ASN. 1* structure is employed, it will be possible for the UE to determine change of the common SI merely by tracking change of the SI of the current CC (a SIB1 value tag of a specific CC also includes common SI modification)

The following is a summary of my opinions.

```
Paging ::=                SEQUENCE {
    pagingRecordList                PagingRecordList                OPTIONAL,  -- Need ON
    systemInfoModification              ENUMERATED {true}               OPTIONAL,  -- Need ON  =>
An R10 UE recognizes this section as SI modification of the current CC (The SI of the current CC
includes the common SI)
    etws-Indication                 ENUMERATED {true}               OPTIONAL,  -- Need ON
    nonCriticalExtension            Paging-v10x0-IEs                OPTIONAL   -- Need OP  =>
Only SI modification information of each neighbor CC is used for the R10 UE (excluding modification
of the common SI of each CC)
}
Paging-v10x0-IEs ::=        SEQUENCE {
    V10x0NonCricticalExtensions     SEQUENCE {
      CCspecific-systemInfoModification             BIT STRING (SIZE(1..maxCC-1))      =>
SI modification of each CC is indicated through bitmap. Bitmap bit matching of each CC is indicated
through SIB1 or SIB2 (excluding modification of the common SI)
        or
      CCcommon-systemInfoModification               ENUMERATED {true}                  => SI
modification information of all neighbor CCs is indicated using 1 bit.

    },
```

- \+ simple
- \- required to acquire SI on all CCs even if the common SI (as opposed to CC specific SI) is only changed (**point 1**)
- \- required to monitor/decode paging msg. and value tag on all CCs (**point 2**)

◆Option 2 (optimization to **point 1**): the paging msg. and/or SIB1 contain "no CC specific SI change info". Then, the UE who acquired the updated common SI on a certain carrier can avoid to acquire the common SI on other CCs in case CC specific SI is not changed.

[Sung Duck] Question about option 2/3: What is the definition of "CC specific SI". Is this a new SIB message? The current LTE does not include the CC specific SI. Isn't there a backward compatibility problem with the Rel-8 LTE UE, provided that the new SIB is defined? (This has already been mentioned in other issues...)

[Young] Although I am not sure if I correctly understand the intention, I think that the problem raised in the ASN.1 structure will be overcome in Option 1. I think we can also consider another method in which a common SI modification indication or a common SI value tag is created and common SI modification (or change) is not indicated through an SI modification indication or a value tag included in a current CC.

◆Option 3 (optimization to **point 2**): the paging msg. and/or SIB1 contains all CC changes info. Then, the UE is only required to monitor/decode the paging msg. and/or SIB1 on a certain carrier

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00204

[Young] Although I am not sure if I correctly understand the intention, I think that it will be possible to achieve the object, especially without adding additional details to the SIB1 and the paging message. That is, the Rel-8 UE determines that SI modification in paging and an SIB1 value tag indicates SI change of the current CC and the Rel-10 UE understands that all CCs have been changed.

```
Paging ::=                  SEQUENCE {
    pagingRecordList                PagingRecordList                OPTIONAL,  -- Need ON
    systemInfoModification              ENUMERATED {true}               OPTIONAL,  -- Need ON  =>
The R10 UE recognizes this section as SI modification of all CCs.
    etws-Indication                     ENUMERATED {true}           OPTIONAL,  -- Need ON
    nonCriticalExtension            Paging-v10x0-IEs                OPTIONAL   -- Need OP
```

◆ Option 4 (optimization to **point 1 and point 2)**: option 2+option3

- For extension carrier if needed
  - For SI acquisition at CC addition
    - ◆ By dedicated signaling
  - For SI acquisition at SI change
    - ◆ By dedicated signaling

[Sung Duck] I think that the extension carrier is not a cell but is rather simply a carrier which provides a higher data rate to a connected mode UE.

While the cell provides (or broadcasts) SI, it is not normal that such an entity, which is not a cell, provides (or broadcasts) SI. That is, SI is not present in the extension carrier (Ex).

[Young] I think that whether or not SIB2 is included in the extension carrier is important.

If the extension carrier uses a common resource such as an RACH or includes an MBSFN subframe, SIB2 will be needed and therefore SIB1 will also be needed.

I think that DL/UL BW may be provided (broadcast) through dedicated signaling if common resources and an MBSFN subframe are not present.

However, it will be necessary to provide an MIB for the extension carrier due to the SFN.

MAC RLF for CA

- Assumptions
  - multiple RACH carriers
  - RACH dedicated preamble (re-)transmissions are only available on the concerned CC
  - RACH non-dedicated preamble (re-)transmissions are available on all available RACH carriers

[Sung Duck] Carrier jump will cause a TX power setting problem as mentioned previously.

[Young] Maybe, there will be no problem in adjacent UL carriers.

- Proposal 1: if RACH preamble hits max, consider all uplinks broken

[Young] The following are my opinions.

1. If the UE has performed current preamble transmission counting only for a specific UL CC in multiple RACH carrier environments (if the preamble transmission counter is CC-specific),

-> This is not the RLF but instead is carrier failure according to our current RLF assumptions.

-> The operation of the UE in this case is as follows.

1. In any way, the problem is reported to the eNB. For example, when RA for UL CC addition has failed, such failure is reported through a UL SCH of a neighbor CC.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00205

2. No action is taken for other UL CCs since other UL CCs are safe. Nonetheless, since the problem still exists, it is desirable that the problem be reported.

3. RA is reattempted in other UL CCs since other UL CCs are safe.

-> When the case of 3 is considered in more detail, it may not be possible to apply the approach if the purpose is to access only a specific CC (for example, if the purpose is to perform UL CC addition).

In other cases (for example in the case of SR transmission), it will be possible to define a CC specific counter and a counter for all CCs.

In addition, when the CC specific counter has reached the maximum value, RA is reattempted in other UL CCs and RLF is declared only when the counter for all CCs has reached the maximum value.

2. If current preamble transmission counting has been attempted in a number of UL CCs in multiple RACH carrier environments (if the preamble transmission counter is CC-common),

-> This is the RLF so that the connection re-establishment procedure will be triggered.

- Proposal 2: if RACH dedicated preamble hits max, FFS if another RACH carrier. if any, can be considered alive.

[Young] It will be possible to consider a CC specific counter and a counter for all CCs described above, assuming that the dedicated preamble has been allocated to a specific UL CC.

If a CC specific counter has reached the maximum value in the specific CC using the dedicated preamble, RA is reattempted using a non-dedicated preamble in another UL CC (until the counter for all CCs reaches the maximum value).

Activation/De-activation with DRX

- Combination
  - RRC + common DRX (선호?)
  - RRC + CC specific DRX
  - PDCCH + common DRX (선호?)
  - PDCCH + CC specific DRX (x)

Other issue?:

- does the UE need to monitor e..g paging/SI on the de-activated carriers?
  - If no, how does the UE get the SI, if changed, on deactivated ➔ activated carriers?

[Young] I think that the UE does not need to monitor the deactivated carrier. I think that the UE only needs to directly read SI of the channel when the channel is activated.

The eNB only needs to perform scheduling taking into consideration the time required for the UE to read the SI.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00206

As a result of discussion, we see the solutions for SI providing at SI change have dependency with CC activation/de-activation. Thus, we would propose to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

Proposal 2: It is proposed to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

2 SI providing for extension carrier

We feel that RAN2 has a difficulty to expect the existence of the extension carrier in CA without inputs from RAN1/4. Also if it exists, it is also unclear in RAN2 whether or not the extension carrier will provide the system information. Basically, one of requirement of a "cell" is to broadcast a system information. Thus, if an extension carrier broadcast a system information, it is not just a 'carrier' but it is a 'cell'.

In this situation, we don't think that CA work with extension carrier is worthwhile. Therefore, we would propose to defer the extension carrier aspects until the details of the extension carrier are somewhat clear.

Proposal 3: It is proposed to defer the extension carrier aspects for SI until the details of the extension carrier are somewhat clear

3 Conclusions

For SI providing for non-extension carrier,

Proposal 1: It is proposed to support dedicated signalling to provide system information at CC addition

Proposal 2: It is proposed to further investigate the solutions for SI providing at SI change with CC activation/de-activation.

For SI providing for extension carrier,

Proposal 3: It is proposed to defer the extension carrier aspects for SI until the details of the extension carrier are somewhat clear

Annex A: Prior Art: system information

5.2 System information

5.2.1 Introduction

5.2.1.1 General

System information is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs). The MIB includes a limited number of most essential and most frequently transmitted parameters that are needed to acquire other information from the cell, and is transmitted on BCH. SIBs other than *SystemInformationBlockType1* are carried in *SystemInformation* (SI) messages and mapping of SIBs to SI messages is flexibly configurable by *schedulingInfoList* included in *SystemInformationBlockType1*, with restrictions that: each SIB is contained only in a single SI message, only SIBs having the same scheduling requirement (periodicity) can be mapped to the same SI message, and *SystemInformationBlockType2* is always mapped to the SI message that corresponds to the first entry in the list of SI messages in *schedulingInfoList*. There may be multiple SI messages transmitted with the same periodicity. *SystemInformationBlockType1* and all SI messages are transmitted on DL-SCH.

5.2.1.2 Scheduling

The MIB uses a fixed schedule with a periodicity of 40 ms and repetitions made within 40 ms. The first transmission of the MIB is scheduled in subframe #0 of radio frames for which the SFN mod 4 = 0, and repetitions are scheduled in subframe #0 of all other radio frames.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00207

The *SystemInformationBlockType1* uses a fixed schedule with a periodicity of 80 ms and repetitions made within 80 ms. The first transmission of *SystemInformationBlockType1* is scheduled in subframe #5 of radio frames for which the SFN mod 8 = 0, and repetitions are scheduled in subframe #5 of all other radio frames for which SFN mod 2 = 0.

The SI messages are transmitted within periodically occurring time domain windows (referred to as SI-windows) using dynamic scheduling. Each SI message is associated with a SI-window and the SI-windows of different SI messages do not overlap. That is, within one SI-window only the corresponding SI is transmitted. The length of the SI-window is common for all SI messages, and is configurable. Within the SI-window, the corresponding SI message can be transmitted a number of times in any subframe other than MBSFN subframes, uplink subframes in TDD, and subframe #5 of radio frames for which SFN mod 2 = 0. The UE acquires the detailed time-domain scheduling (and other information, e.g. frequency-domain scheduling, used transport format) from decoding SI-RNTI on PDCCH (see TS 36.321 [6]).

A single SI-RNTI is used to address *SystemInformationBlockType1* as well as all SI messages.

SystemInformationBlockType1 configures the SI-window length and the transmission periodicity for the SI messages.

5.2.1.3 System information validity and notification of changes

Change of system information (other than for ETWS and CMAS) only occurs at specific radio frames, i.e. the concept of a modification period is used. System information may be transmitted a number of times with the same content within a modification period, as defined by its scheduling. The modification period boundaries are defined by SFN values for which SFN mod m= 0, where m is the number of radio frames comprising the modification period. The modification period is configured by system information.

When the network changes (some of the) system information, it first notifies the UEs about this change, i.e. this may be done throughout a modification period. In the next modification period, the network transmits the updated system information. These general principles are illustrated in figure 5.2.1.3-1, in which different colours indicate different system information. Upon receiving a change notification, the UE acquires the new system information immediately from the start of the next modification period. The UE applies the previously acquired system information until the UE acquires the new system information.

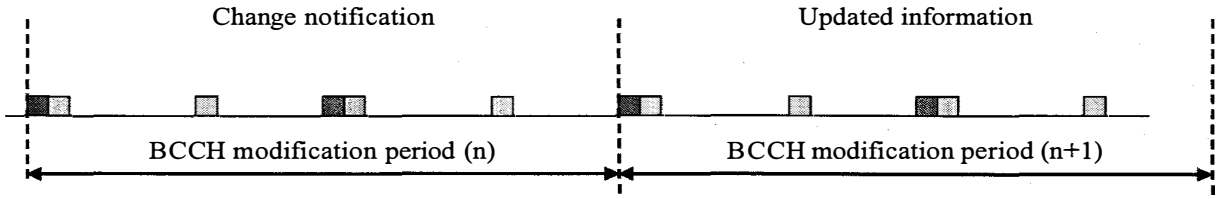


Figure 5.2.1.3-1: Change of system Information

The *Paging* message is used to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change. If the UE receives a *Paging* message including the *systemInfoModification*, it knows that the system information will change at the next modification period boundary. Although the UE may be informed about changes in system information, no further details are provided e.g. regarding which system information will change.

SystemInformationBlockType1 includes a value tag, *systemInfoValueTag*, that indicates if a change has occurred in the SI messages. UEs may use *systemInfoValueTag*, e.g. upon return from out of coverage, to verify if the previously stored SI messages are still valid. Additionally, the UE considers stored system information to be invalid after 3 hours from the moment it was successfully confirmed as valid, unless specified otherwise.

E-UTRAN may not update *systemInfoValueTag* upon change of some system information e.g. ETWS information, CMAS information, regularly changing parameters like CDMA2000 system time (see 6.3). Similarly, E-UTRAN may not include the *systemInfoModification* within the *Paging* message upon change of some system information.

The UE verifies that stored system information remains valid by either checking *systemInfoValueTag* in *SystemInformationBlockType1* after the modification period boundary, or attempting to find the *systemInfoModification* indication at least *modificationPeriodCoeff* times during the modification period in case no paging is received, in every modification period. If no paging message is received by the UE during a modification period, the UE may assume that no change of system information will occur at the next modification period boundary. If UE in RRC_CONNECTED, during a modification period, receives one paging message, it may deduce from the presence/ absence of *systemInfoModification* whether a change of system information other than ETWS information will occur in the next modification period or not.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00208

ETWS and/or CMAS capable UEs in RRC_CONNECTED shall attempt to read paging at least once every *defaultPagingCycle* to check whether ETWS and/or CMAS notification is present or not.

5.2.2 System information acquisition

5.2.2.1 General

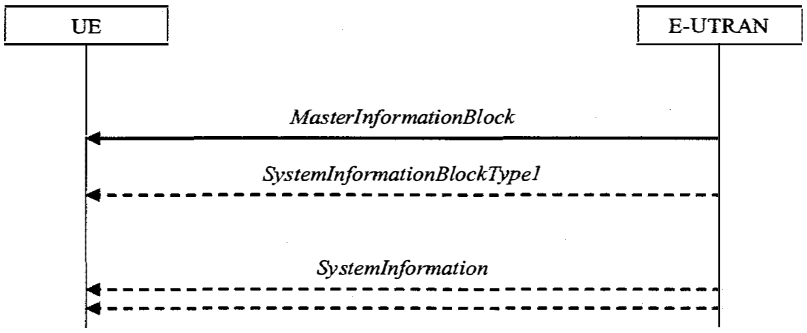


Figure 5.2.2.1-1: System information acquisition, normal

The UE applies the system information acquisition procedure to acquire the AS- and NAS- system information that is broadcasted by the E-UTRAN. The procedure applies to UEs in RRC_IDLE and UEs in RRC_CONNECTED.

5.2.2.2 Initiation

The UE shall apply the system information acquisition procedure upon selecting (e.g. upon power on) and upon re-selecting a cell, after handover completion, after entering E-UTRA from another RAT, upon return from out of coverage, upon receiving a notification that the system information has changed, upon receiving an indication about the presence of an ETWS notification, upon receiving an indication about the presence of a CMAS notification, upon receiving a request from CDMA2000 upper layers and upon exceeding the maximum validity duration. Unless explicitly stated otherwise in the procedural specification, the system information acquisition procedure overwrites any stored system information, i.e. delta configuration is not applicable for system information and the UE discontinues using a field if it is absent in system information unless explicitly specified otherwise.

5.2.2.3 System information required by the UE

The UE shall:

1> ensure having a valid version, as defined below, of (at least) the following system information, also referred to as the 'required' system information:

2> if in RRC_IDLE:

3> the *MasterInformationBlock* and *SystemInformationBlockType1* as well as *SystemInformationBlockType2* through *SystemInformationBlockType8*, depending on support of the concerned RATs;

2> if in RRC_CONNECTED:

3> the *MasterInformationBlock*, *SystemInformationBlockType1* and *SystemInformationBlockType2* as well as *SystemInformationBlockType8*, depending on support of CDMA2000;

1> delete any stored system information after 3 hours from the moment it was confirmed to be valid as defined in 5.2.1.3, unless specified otherwise;

1> consider any stored system information except *SystemInformationBlockType10* and *SystemInformationBlockType11* to be invalid if *systemInfoValueTag* included in the *SystemInformationBlockType1* is different from the one of the stored system information;

5.2.2.4 System information acquisition by the UE

The UE shall:

1> apply the specified BCCH configuration defined in 9.1.1.1;

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00209

1> if the procedure is triggered by a system information change notification:

2> start acquiring the required system information, as defined in 5.2.2.3, from the beginning of the modification period following the one in which the change notification was received;

NOTE 1: The UE continues using the previously received system information until the new system information has been acquired.

1> if the UE is in RRC_IDLE and enters a cell for which the UE does not have stored a valid version of the system information required in RRC_IDLE, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_IDLE, as defined in 5.2.2.3;

1> following successful handover completion to a cell for which the UE does not have stored a valid version of the system information required in RRC_CONNECTED, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in RRC_CONNECTED, as defined in 5.2.2.3;

2> upon acquiring the concerned system information:

3> discard the corresponding radio resource configuration information included in the *radioResourceConfigCommon* previously received in a dedicated message, if any;

1> following a request from CDMA2000 upper layers:

2> acquire *SystemInformationBlockType8*, as defined in 5.2.3;

1> neither initiate the RRC connection establishment procedure nor initiate transmission of the *RRCConnectionReestablishmentRequest* message until the UE has a valid version of the *MasterInformationBlock* and *SystemInformationBlockType1* messages as well as *SystemInformationBlockType2* ;

1> if the UE is ETWS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, the current values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType11*;

2> when the UE acquires *SystemInformationBlockType1* following ETWS indication, upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> if *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

4> start acquiring *SystemInformationBlockType10* immediately;

3> if *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

4> start acquiring *SystemInformationBlockType11* immediately;

NOTE 2: UEs shall start acquiring *SystemInformationBlockType10* and *SystemInformationBlockType11* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

1> if the UE is CMAS capable:

2> upon entering a cell during RRC_IDLE, following successful handover or upon connection re-establishment:

3> discard any previously buffered *warningMessageSegment*;

3> clear, if any, stored values of *messageIdentifier* and *serialNumber* for *SystemInformationBlockType12* associated with the discarded *warningMessageSegment* ;

2> when the UE acquires *SystemInformationBlockType1* following CMAS indication, upon entering a cell during RRC_IDLE, following successful handover and upon connection re-establishment:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00210

3> if *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

4> aquire *SystemInformationBlockType12*;

NOTE 3: UEs shall start acquiring *SystemInformationBlockType12* as described above even when *systemInfoValueTag* in *SystemInformationBlockType1* has not changed.

The UE may apply the received SIBs immediately, i.e. the UE does not need to delay using a SIB until all SI messages have been received. The UE may delay applying the received SIBs until completing lower layer procedures associated with a received or a UE originated RRC message, e.g. an ongoing random access procedure.

NOTE 4: While attempting to acquire a particular SIB, if the UE detects from *schedulingInfoList* that it is no longer present, the UE should stop trying to acquire the particular SIB.

5.3.2 Paging

5.3.2.1 General



Figure 5.3.2.1-1: Paging

The purpose of this procedure is:

- to transmit paging information to a UE in RRC_IDLE and/ or;
- to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change and/ or;
- to inform about an ETWS primary notification and/ or ETWS secondary notification and/ or;
- to inform about a CMAS notification.

The paging information is provided to upper layers, which in response may initiate RRC connection establishment, e.g. to receive an incoming call.

5.3.2.2 Initiation

E-UTRAN initiates the paging procedure by transmitting the *Paging* message at the UE's paging occasion as specified in TS 36.304 [4]. E-UTRAN may address multiple UEs within a *Paging* message by including one *PagingRecord* for each UE. E-UTRAN may also indicate a change of system information, and/ or provide an ETWS notification or a CMAS notification in the *Paging* message.

5.3.2.3 Reception of the *Paging* message by the UE

Upon receiving the *Paging* message, the UE shall:

1> if in RRC_IDLE, for each of the *PagingRecord*, if any, included in the *Paging* message:

2> if the *ue-Identity* included in the *PagingRecord* matches one of the UE identities allocated by upper layers:

3> forward the *ue-Identity* and the *cn-Domain* to the upper layers;

1> if the *systemInfoModification* is included:

2> re-acquire the required system information using the system information acquisition procedure as specified in 5.2.2.

1> if the *etws-Indication* is included and the UE is ETWS capable:

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00211

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType10* is present:

3> acquire *SystemInformationBlockType10*;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType11* is present:

3> acquire *SystemInformationBlockType11*;

1> if the *cmas-Indication* is included and the UE is CMAS capable:

2> re-acquire *SystemInformationBlockType1* immediately, i.e., without waiting until the next system information modification period boundary as specified in 5.2.1.5;

2> if the *schedulingInfoList* indicates that *SystemInformationBlockType12* is present:

3> acquire *SystemInformationBlockType12*;

– *Paging*

The *Paging* message is used for the notification of one or more UEs.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: PCCH

Direction: E-UTRAN to UE

Paging message

```
-- ASN1START

Paging ::=                  SEQUENCE {
    pagingRecordList                PagingRecordList                    OPTIONAL,   -- Need ON
    systemInfoModification          ENUMERATED {true}                   OPTIONAL,   -- Need ON
    etws-Indication                 ENUMERATED {true}                   OPTIONAL,   -- Need ON
    nonCriticalExtension            Paging-v9x0-IEs                     OPTIONAL    -- Need OP
}

PagingRecordList ::=            SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord

PagingRecord ::=                SEQUENCE {
    ue-Identity                     PagingUE-Identity,
    cn-Domain                       ENUMERATED  {ps, cs},
    ...
}

PagingUE-Identity ::=           CHOICE {
    s-TMSI                          S-TMSI,
    imsi                            IMSI,
    ...
}

IMSI ::=                        SEQUENCE (SIZE (6..21)) OF IMSI-Digit

IMSI-Digit::=                   INTEGER (0..9)

Paging-v9x0-IEs ::=         SEQUENCE {
    v9x0NonCricticalExtensions      SEQUENCE {
        cmas-Indication                 ENUMERATED {true}               OPTIONAL    -- Need ON
    },
    nonCriticalExtension            SEQUENCE {}                         OPTIONAL    -- Need OP
}

-- ASN1STOP
```


IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00212

Paging field descriptions
cn-Domain Indicates the origin of paging.
ue-Identity Provides the NAS identity of the UE that is being paged.
systemInfoModification If present: indication of a BCCH modification other than SIB10, SIB11 and SIB12.
etws-Indication If present: indication of an ETWS primary notification and/ or ETWS secondary notification.
cmas-Indication If present: indication of a CMAS notification.
imsi The International Mobile Subscriber Identity, a globally unique permanent subscriber identity, see TS 23.003 [27]. The first element contains the first IMSI digit, the second element contains the second IMSI digit and so on.

– *SystemInformationBlockType1*

SystemInformationBlockType1 contains information relevant when evaluating if a UE is allowed to access a cell and defines the scheduling of other system information.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: BCCH

Direction: E-UTRAN to UE

***SystemInformationBlockType1* message**

```
-- ASN1START

SystemInformationBlockType1 ::=     SEQUENCE {
    cellAccessRelatedInfo               SEQUENCE {
        plmn-IdentityList                   PLMN-IdentityList,
        trackingAreaCode                    TrackingAreaCode,
        cellIdentity                        CellIdentity,
        cellBarred                          ENUMERATED {barred, notBarred},
        intraFreqReselection                ENUMERATED {allowed, notAllowed},
        csg-Indication                      BOOLEAN,
        csg-Identity                        BIT STRING (SIZE (27))  OPTIONAL    -- Need OR
    },
    cellSelectionInfo                   SEQUENCE {
        q-RxLevMin                          Q-RxLevMin,
        q-RxLevMinOffset                    INTEGER (1..8)          OPTIONAL    -- Need OP
    },
    p-Max                               P-Max                       OPTIONAL,           -- Need OP
    freqBandIndicator                   INTEGER (1..64),
    schedulingInfoList                  SchedulingInfoList,
    tdd-Config                          TDD-Config                  OPTIONAL,   -- Cond TDD
    si-WindowLength                     ENUMERATED {
                                            ms1, ms2, ms5, ms10, ms15, ms20,
                                            ms40},
    systemInfoValueTag                  INTEGER (0..31),
    nonCriticalExtension                SystemInformationBlockType1-v9x0-IEs
    OPTIONAL    -- Need OP
}

PLMN-IdentityList ::=                   SEQUENCE (SIZE (1..6)) OF PLMN-IdentityInfo

PLMN-IdentityInfo ::=                   SEQUENCE {
    plmn-Identity                           PLMN-Identity,
    cellReservedForOperatorUse              ENUMERATED {reserved, notReserved}
}

SchedulingInfoList ::= SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo

SchedulingInfo ::=  SEQUENCE {
    si-Periodicity                      ENUMERATED {
                                            rf8, rf16, rf32, rf64, rf128, rf256, rf512},
    sib-MappingInfo                     SIB-MappingInfo
}
```


IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00213

```
SIB-MappingInfo ::= SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type

SIB-Type ::=                        ENUMERATED {
                                      sibType3, sibType4, sibType5, sibType6,
                                      sibType7, sibType8, sibType9, sibType10,
                                      sibType11, sibType12, spare6, spare5,
                                      spare4, spare3, spare2, spare1, ...}

SystemInformationBlockType1-v9x0-IEs::= SEQUENCE {
    v9x0NonCricticalExtensions        SEQUENCE {
        imsEmergencySupportIndicator    ENUMERATED {supported}          OPTIONAL    -- Need OP
    },
    nonCriticalExtension              SEQUENCE {}                       OPTIONAL    -- Need OP
}

-- ASN1STOP
```

***SystemInformationBlockType1* field descriptions**
plmn-IdentityList List of PLMN identities. The first listed *PLMN-Identity* is the primary PLMN.
cellReservedForOperatorUse As defined in TS 36.304 [4].
trackingAreaCode A *trackingAreaCode* that is common for all the PLMNs listed.
cellBarred 'barred' means the cell is barred, as defined in TS 36.304 [4].
intraFreqReselection Used to control cell reselection to intra-frequency cells when the highest ranked cell is barred, or treated as barred by the UE, as specified in TS 36.304 [4].
csg-Indication If set to TRUE the UE is only allowed to access the cell if the CSG identity matches an entry in the allowed CSG list that the UE has stored.
q-RxLevMinOffset Parameter $Q_{rxlevminoffset}$ in 36.304 [4]. Actual value $Q_{rxlevminoffset}$ = IE value * 2 [dB]. If absent, apply the (default) value of 0 [dB] for $Q_{rxlevminoffset}$. Affects the minimum required Rx level in the cell.
p-Max Value applicable for the cell.
freqBandIndicator Defined in TS 36.101 [42, table 5.5-1].
si-Periodicity Periodicity of the SI-message in radio frames, such that rf8 denotes 8 radio frames, rf16 denotes 16 radio frames, and so on.
sib-MappingInfo List of the SIBs mapped to this *SystemInformation* message.There is no mapping information of SIB2; it is always present in the first *SystemInformation* message listed in the *schedulingInfoList* list.
si-WindowLength Common SI scheduling window for all SIs. Unit in milliseconds, where ms1 denotes 1 millisecond, ms2 denotes 2 milliseconds and so on.
systemInfoValueTag Common for all SIBs other than MIB, SIB1, SIB10 and SIB11.
csg-Identity Identity of the Closed Subscriber Group within the primary PLMN the cell belongs to. The IE is present in a CSG cell.
imsEmergencySupportIndicator Indicates whether the cell supports IMS emergency bearer services for UEs in limited service mode. If absent, IMS emergency call is not supported by the network in the cell for UEs in limited service mode.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00214

Conditional presence	Explanation
TDD	This field is mandatory present for TDD; it is not present for FDD and the UE shall delete any existing value for this field.

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].

1xRTT	CDMA2000 1x Radio Transmission Technology
AM	Acknowledged Mode
ASN.1	Abstract Syntax Notation.1
ARQ	Automatic Repeat Request
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
CCCH	Common Control Channel
CCO	Cell Change Order
CMAS	Commercial Mobile Alert Service
CP	Control Plane
C-RNTI	Cell RNTI
CSG	Closed Subscriber Group
DCCH	Dedicated Control Channel
DRB	(user) Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DL	Downlink
DL-SCH	Downlink Shared Channel
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
ENB	Evolved Node B
EPC	Enhanced Packet Core
EPS	Enhanced Packet System
FDD	Frequency Division Duplex
FFS	For Further Study
GERAN	GSM/EDGE Radio Access Network
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat Request
HRPD	CDMA2000 High Rate Packet Data
IE	Information element
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
kB	Kilobyte (1000 bytes)
L1	Layer 1
L2	Layer 2
L3	Layer 3
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MIB	Master Information Block
N/A	Not Applicable
NACC	Network Assisted Cell Change
NAS	Non Access Stratum
PCCH	Paging Control Channel
PDU	Protocol Data Unit
PDCP	Packet Data Convergence Protocol
PLMN	Public Land Mobile Network
QoS	Quality of Service
RACH	Random Access CHannel
RAT	Radio Access Technology

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00215

RB	Radio Bearer
RLC	Radio Link Control
RNTI	Radio Network Temporary Identifier
RRC	Radio Resource Control
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSSI	Received Signal Strength Indicator
SAE	System Architecture Evolution
SAP	Service Access Point
SFN	System Frame Number
SI	System Information
SIB	System Information Block
SI-RNTI	System Information RNTI
SPS	Semi-Persistent Scheduling
SRB	Signalling Radio Bearer
S-TMSI	SAE Temporary Mobile Station Identifier
TA	Tracking Area
TDD	Time Division Duplex
TM	Transparent Mode
TPC-RNTI	Transmit Power Control RNTI
UE	User Equipment
UICC	Universal Integrated Circuit Card
UL	Uplink
UM	Unacknowledged Mode
UL-SCH	Uplink Shared Channel
UP	User Plane
UTRAN	Universal Terrestrial Radio Access Network

Annex B: Prior Art: Carrier Aggregation

LTE-Advanced extends LTE Rel.-8 with support for C*arrier Aggregation*, where two or more *component carriers* (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz and for spectrum aggregation.

It shall be possible to configure all component carriers which are LTE Rel-8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are same. Not all component carriers may necessarily be LTE Rel-8 compatible.

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.

Carrier aggregation is supported for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks in the frequency domain using the LTE Rel-8 numerology

It is possible to configure a UE to aggregate a different number of component carriers originating from the same eNB and of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same.

Component carriers originating from the same eNB need not to provide the same coverage.

5.2 User Plane

5.2.1 Structure

Compared to the Layer 2 structure of LTE Rel-8, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per CC. The Layer 2 structure for the downlink is depicted on Figured 5.2.1-1 below.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00216

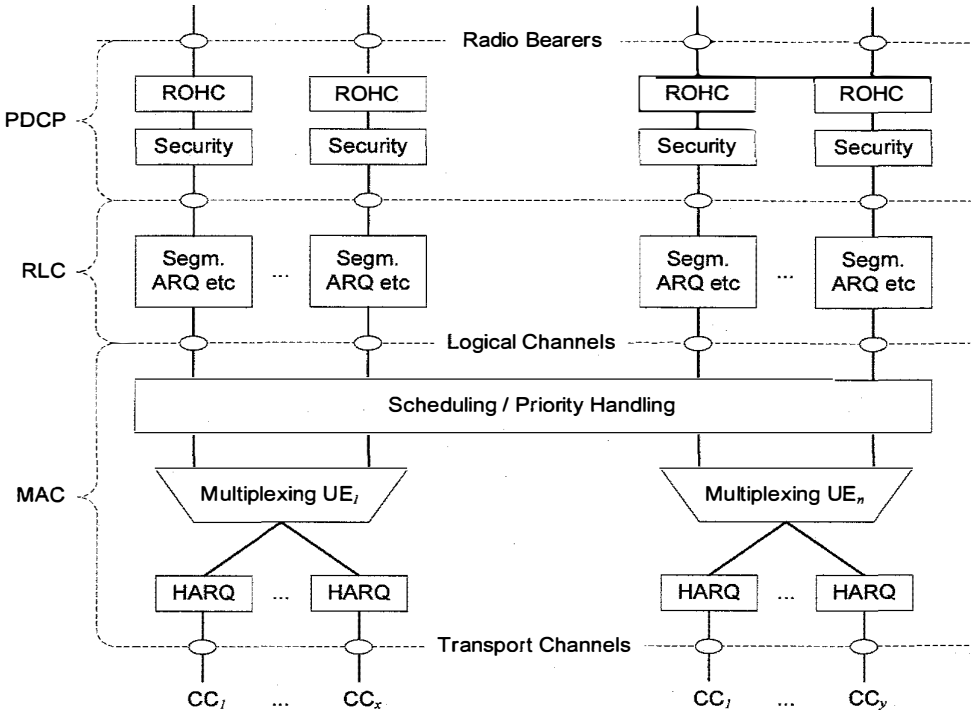


Figure 5.2.1-1: Layer 2 Structure for the DL

The Layer 2 structure for the uplink is depicted on Figured 5.2.1-2 below.

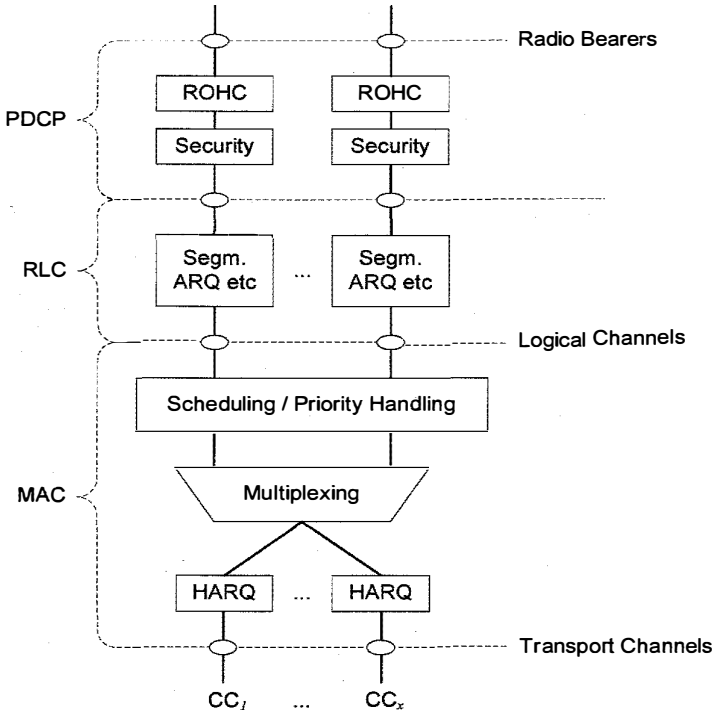


Figure 5.2.1-2: Layer 2 Structure for the UL

5.2.2 MAC

From a UE perspective, the Layer 2 aspects of HARQ are kept Rel-8 compliant unless modifications provide significant gains. There is one transport block (in absence of spatial multiplexing, up to two transport blocks in case of spatial

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00217

multiplexing) and one independent hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only where all possible HARQ retransmissions also take place. A UE may be scheduled over multiple component carriers simultaneously but at most one random access procedure shall be ongoing at any time.

5.2.3 RLC

Apart from a potential issue with the RLC SN size, the RLC protocol of LTE Rel-8 also applies to carrier aggregation.

5.2.4 PDCP

The PDCP protocol of LTE Rel-8 also applies to carrier aggregation.

5.3 Control Plane

5.3.1 Structure

The C-Plane architecture of LTE Rel-8 also applies to carrier aggregation.

5.3.2 RRC procedures

After RRC connection establishment, the configuration and/or activation of additional component carriers is performed by dedicated signaling. At intra-LTE handover, multiple CCs can be included in the "handover command" for usage in the target cell.

5.3.3 Idle mode procedures

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

4

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00218

Title: The best cell selection method for reading and reporting system information

1. Abstract

A UE can read system information of the target CSG or Hybrid and then report it to the network prior to perform handover. In this case, the UE has to choose only one (best cell) target CSG or Hybrid cells to read and report system information. Since there is no detailed procedure for selecting the best CSG or Hybrid cell for reading and reporting system information, the UE may choose one among detected CSG or Hybrid cells with best effort manner or comparison manner based on radio quality. However, the current best cell selection does not consider the Probability of CSG/Hybrid cell handover success. Therefore, we present the best cell selection method for reading and reporting system information considering handover success.

2. Background

2.1 Inbound Mobility

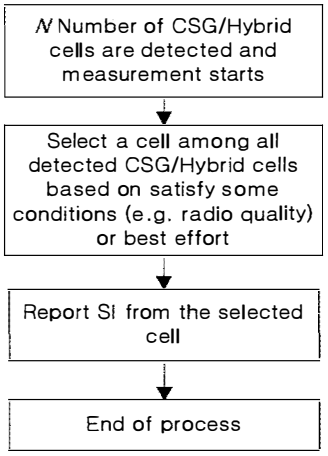
If a UE detects CSG or Hybrid cells which satisfies inbound mobility conditions (e.g. fingerprint match), the UE may read target system information during DRX. If it is possible, the UE includes system information in the measurement report message. If reading system information during DRX is not possible, the UE sends the measurement report message without system information, but includes a "likely or non-likely" bit which is based on the target's membership history. For example, if the target cell is the previously visited cell, the UE should have the result of preliminary access check. If the result was failure of Handover since the target was non-member cell, the target would be marked as "non-likely." After reception of the measurement report message without system information, the network may order the UE to read system information. As soon as the UE receives the system information reading command, starts to read system information, and then sends second measurement report message with acquired system information to the network.

2.2 Current cell selection for reading and reporting target system information

Currently, a UE can detect more than one CSG or Hybrid cell which satisfies inbound mobility conditions, but the UE can report only one target CSG or Hybrid cell's system information to the network. Therefore, the best target CSG or Hybrid cell to read and report system information is decided by a random procedure (best effort) or radio quality based procedure.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00219

The details of the above procedure are described as follows.



3 Problem of current art

3.1 Problem of current method

The whole purpose of reading target system information for inbound mobility prior to receiving network reading system information command (i.e. reading target system information during DRX), is reducing inbound mobility delay. If the UE can acquire system information during DRX, the UE does not have to use a gap to read system information of the target cell. However, this advantage is meaningful only if the handover is successful. Even if the UE acquires system information of the target cell, the target may not be the member cell. Therefore, the UE cannot perform handover successfully. The current best cell selection from detected CSG or Hybrid cells for reading and sending system information overlooks handover success aspect, so the new best cell selection method which increases the handover success rate is needed.

4. Invention

4.1 Invention General

In the proposed scheme, the UE detects CSG or Hybrid target cells and then it has to choose the best cell based on "likely/non-likely" information. "likely/non-likely" information is based on UE's history information, so if the UE choose only "likely" cell to read system information and then report it to the network, the handover success rate should be high comparing to reading system information of "non-likely" cell. If there is no likely cell among detected cells, the best cell may be selected from the non-likely target cells.

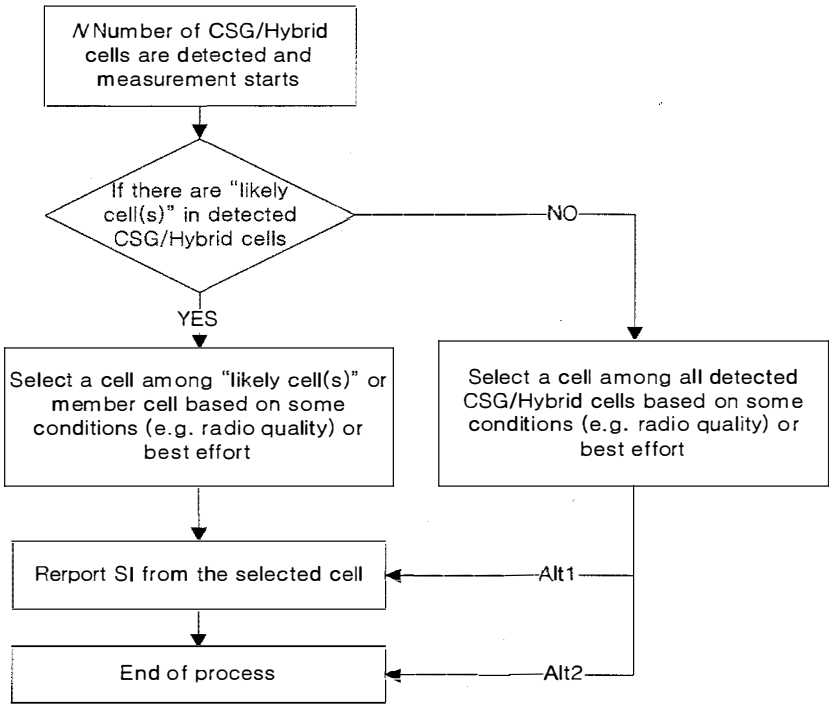
The second way is using membership information acquired from system information. "likely/non-likely" information may not entirely be trusted, so the UE read system information of target

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00220

CSG/Hybrid with the best effort manner. If there are more than one cells has system information, choose one that is the member cell.

4.2 Invention Details

The detail of proposed scheme is described as below flow chart:



To facilitate the description of invention, terminology definition is first suggested:

- CSG cell
  - It is defined in [1].
- Hybrid cell
  - It is defined in [2].
- Member CSG/Hybrid cell
  - Member CSG/Hybrid cell is that the target cell's CSG-id is in UE's allowed CSG list
- Non Member CSG/Hybrid cell
  - Non Member CSG/Hybrid cell is that the target cell's CSG-id is not in UE's allowed CSG list
- Likely bit
  - Likely bit is set for the target CSG or Hybrid cells which the UE already visited the target cells and the UE was a member of the target cells.
- Non-Likely bit
  - Non-Likely bit is set for the target CSG or Hybrid cells which the UE already visited the target cells and the UE was a non member of the target cells.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00221

The details of proposed scheme are described as follows:

UE aspect-likely/non-likely

- If a UE detects a CSG or Hybrid target cells which satisfy handover conditions (e.g. matching fingerprint).
  - If the target cell(s) is(are) "likely" cells
    - If there is more than one "likely" cells
      - Select the best radio quality cell as the best cell among likely cells; or
      - Select one arbitrarily as the best cell among likely cells (best effort).
    - Else (If there is only one "likely cell")
      - Select the likely cell as the best cell.
  - Else (If there is no "likely" cell among detected CSG/Hybrid cells)
    - Select the best radio quality cell as the best cell among non-likely cells; or
    - Select one arbitrarily as the best cell among non-likely cells (best effort); or
    - Do not include system information of the target CSG/Hybrid cells (end of process).
  - Read system information of the best target cell and send the information in the measurement report message; or
  - Send the information of the best target cell in the measurement report message (we may assume that the reading system information is already done when the UE starts to measure the target cell).
-

UE aspect-member/non-member

- If a UE detects a CSG or Hybrid target cells which satisfy handover conditions (e.g. matching fingerprint).
  - If the target cell(s) is(are) member which system information are already acquired.
    - If there is more than one member cells
      - Select the best radio quality cell as the best cell among member cells; or
      - Select one arbitrarily as the best cell among member cells (best effort).
    - Else (If there is only one member cell)
      - Select the member cell as the best cell.
  - Else (If there is no member cell among detected CSG/Hybrid cells)
    - Select the best radio quality cell as the best cell among non-member cells; or
    - Select one arbitrarily as the best cell among non-member cells (best effort); or
    - Do not include system information of the target CSG/Hybrid cells (end of process).
  - Send the information of the best target cell in the measurement report message.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00222

Title: Handling of unsuccessful SI reading

1. Introduction

For inbound mobility to be triggered, NW should get the required information for HO preparation. For this purpose, NW can let UE to initiate SI acquisition. Currently it is FFS what if UE fails to read SI acquisition.

2. Discussion

2.1 Current status and remaining issue

Regarding SI acquisition on request by NW, we agreed the following during RAN2 #67bis:

- we will specify a timer to limit the maximum duration for SI acquisition (LTE + UMTS)

It is FFS what UE should do if the timer expires, i.e., UE has failed to acquire SI. This document aims at resolving the FFS by suggesting possible candidates for UE behaviors.

2.2 UE actions at the failure of SI acquisition

For the case of UE that has failed to read system information from the concerned cell, we can consider the following UE behaviors:

- **Alt.1: UE sends MR including null SI to NW**
  - From the lack of SI in the reported MR, NW detects that UE failed SI acquisition.
  - If SI reading failure is infrequent, this approach is acceptable
  - Typically it is expected that NW would not issue HO command in response to the MR including null SI, since eNB has not obtained information for triggering HO. As a result, HO would not be triggered.
- **Alt.2: UE does not send measurement.**
  - Radio resource can be saved. The saving is however meaningful only if SI reading failure is not infrequent.
  - From the absence of reporting, NW should be able to detect that UE failed SI acquisition
  - Typically it is expected that NW would not issue HO command in response to the MR including null SI, since eNB has not obtained information for triggering HO. As a result, HO would not be triggered. (Same as Alt.1)
- **Alt.3: UE sends MR including stored SI, if available, to NW.**
  - The stored SI means the SI that was obtained and stored from the previous visit of the concerned cell.
  - If the stored SI not available for the concerned cell, UE sends MR including null SI to NW as it does in Alt1.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00223

- From the UE side, UE may not ensure that the stored system information is 100% valid. From the NW perspective, NW should be able to know whether the included SI is a version of either actually read SI or stored SI at previous visit. To assist NW to be aware of this, it is sufficient for UE to include 'likely/non-likely' indication in the MR instead of 'member/non-member' indication.
- Depending on 'likely/non-likely' indication in the MR, NW could decide whether it issues HO command or not. (Different from Alt.1 and Alt.2)
- For some target CSG cell, the required time to read

Among the three options, alt.3 seems to have advantages over others from the following reasons:

- Mostly HO would be successful in case the target cell is what UE has previously visited.
- UE is highly likely to have valid system information of the target cell which UE already visited before.
- No performance degradation in HO expected compared to Alt1 and Alt2.
- Since NW can receive required SI for suitable HO preparation, HO could be triggered even in case UE has failed to read SI due to e.g., insufficient time to read SI.

Proposal 1 If UE fails to read SI within given time duration, UE sends MR including stored SI, if available, to NW.

Proposal 2 When UE sends MR including stored SI to NW, it includes 'likely/non-likely' indication instead of 'member/non-member' indication

3. Conclusion

We summary our proposals regarding UE behaviors at the failure of SI reading:

Proposal 1 If UE fails to read SI within given time duration, UE sends MR including stored SI, if available, to NW.

Proposal 2 When UE sends MR including stored SI to NW, it includes 'likely/non-likely' indication instead of 'member/non-member' indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00224

Title: On applying inboundHO-support indication

1. Introduction

It was previously agreed that NW can control inbound HO support. This is currently implemented by introducing an indicator 'inboundHO-support'[1] which can be included in e.g., RRCConnectionReconfiguration. In this document we try to clarify what the scope of the indication should be.

2. Discussion

2.1 Different results of inboundHO-support set to 'non-support'

If UE was configured that *inboundHO-support* is set to 'non-support'

- **Case 1**: Inter-frequency case with no previously configured measConfig at UE:
  - No proximity indication sent ➔ No measurement performed on the concerned freq ➔ No non-SI MR sent ➔ No inter-f HO occurs
- **Case 2**: Inter-frequency case with previously configured measConfig at UE:
  - No proximity indication sent ➔ Measurement performed on the concerned freq ➔ Non-SI MR sent if triggered ➔ ... ➔ Inter-frequency HO can occur
- **Case 3**: Intra-frequency case:
  - No proximity indication sent (N/A) ➔ Measurement performed on the serving freq ➔ Non-SI MR sent if triggered ➔ ... ➔ Intra-frequency HO can occur

It is observed that with the common configuration of inboundHO-support set to 'non-support', inbound HO can or cannot occur depending on whether the HO is deemed for inter-frequency or intra-frequency or whether the UE has measConfig for the concerned frequency. We are not sure if it would be good to have different UE behaviors for each case. This issue can be viewed at different angle by asking the following question:

Question: What is the scope of the inboundHO-support indication?

2.2 Scope of inboundHO-support

Regarding this scope of the indicator, there seems to be three possible approaches:

- **Alt1.** InboundHO-support indication is applied only for case 1
  - No change required in UE functionality.
  - The indication is only used to suppress proximity indication.
  - Need to clarify its scope of the indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00225

- **Alt2.** InboundHO-support indication shall be applied for inter-frequency cases, i.e., case 1 and case 2
  - Non-SI MR should not be triggered if the inboundHO-support is configured as 'non-support'.
  - No inter-frequency HO occurs if the indication is set to 'non-support'
  - Need to clarify its scope of the indication

- **Alt3.** InboundHO-support indication shall be applied for every case, i.e., both for intra/inter-frequency cases, including case1, 2 and 3.
  - Non-SI MR should not be triggered if the inboundHO-support is configured as 'non-support'
  - No intra-frequency HO occurs if the indication is set to 'non-support'
  - No inter-frequency HO occurs if the indication is set to 'non-support'

If NW only wants to suppress proximity indication from UE while it allows inbound HO which does involve transmission of proximity indication, then Alt1 should be adopted.

On the other hand, alternative 3 seems to be the most in line with the name 'inboundHO-support' itself. Unless NW wants to control the inboundHO-support for each case independently, alternative 3 could be adopted.

3. Conclusion

In this document, we ask what the scope of inboundHO-support is. Regarding this question, following alternatives are suggested:

Case definition:

- Case 1: Inter-frequency case with no previously configured measConfig at UE:
- Case 2: Inter-frequency case with previously configured measConfig at UE:
- Case 3: Intra-frequency case:

Alternatives:

- **Alt1.** InboundHO-support indication is applied only for case 1
- **Alt2.** InboundHO-support indication shall be applied for inter-frequency cases, i.e., case 1 and case 2
- **Alt3.** InboundHO-support indication shall be applied for every case, i.e., both for intra/inter-frequency cases, including case1, 2 and 3.

Note that 'applied' would mean that any signaling from UE to facilitate inbound HO can be suppressed by the indication

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00226

Proposal 1: RAN2 is kindly requested to discuss what the scope of inboundHO-support is.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00227

Title: Radio Link Failure considering carrier aggregation

1. Introduction

This document aims at establishing further requirements and clarification for detection criterion of radio link failure with consideration of carrier aggregation.

2. Discussion

2.1 Current agreement

During RAN2 #67bis, following agreements were made:

Radio downlink failure

A. Problem detection on one CC does not necessarily imply re-establishment triggering
B. Re-establishment is triggered if all PDCCH CCs fail
C. FFS if re-establishment is even triggered under more restrictive conditions (e.g. in case of problems on an even smaller subset of CC's).

Radio uplink failure

D. Re-establishment is triggered when we lose all UL communication
E. RLC layer re-establishment triggering remains the same as Rel-8.

2.2 Remaining issues for downlink failure detection

Question 1: What if not all PDCCH CCs are concerned for PDCCH monitoring?

Regarding the agreement B, we note that it is possible that UE monitors PDCCH of part of CCs having PDCCH. For example, UE is configured with three CCs and all three CCs have PDCCH. If UE is configured to monitor PDCCH of only a single CC, then the failure of the CC should trigger re-establishment. This observation requires small clarification of the agreement B as follows:

Proposal 1: Re-establishment is triggered if all CCs including PDCCH which UE is monitoring fail

Next question is related to the 'more restrictive conditions' which is captured in agreement C.

Question 2: Should UE declare RLF if a security CC (having provided EARFCN for security) fails?

There would be a 'security CC' which provides EARFCN used for security derivation. Based on the EARFCN, security in PDCP is established, and the PDCP is shared by several CCs. From the attribute of the source of security parameter, we may think that the special CC should be given a special status than other CCs, e.g., by arguing that the failure of security CC should always trigger re-establishment.

From the PDCP perspective, however, once security is established, every CC that is connected to the

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00228

PDCP is considered to be possible transmission path, each having the same importance. If failure of security CC is just a loss of one transmission path, and thus this would not always abrupt whole downlink transmissions, then it is clear that the failure of security CC is not *necessary* condition to declare RLF. So we propose that:

Proposal 2: Re-establishment is not triggered if a security CC which UE is monitoring fails while there is at least one alive CC including PDCCH which UE is monitoring

Question 3: Is any other restrictive condition required to declare RLF?

If proposal 2 is agreeable, then it would be natural to accept that unless there is no alive PDCCH CC which UE is monitoring, the failure of any CC should not lead to RLF declaration. So we propose that:

Proposal 3: Re-establishment is not triggered if a non-security-CC fails while there is at least one alive CC including PDCCH which UE is monitoring

It should be noted that, if proposal 1, 2 and 3 are all agreed, then the failure of all CCs including PDCCG which UE is monitoring becomes a necessary and sufficient condition to declare radio *downlink* failure, and thus to trigger re-establishment. So we propose that:

Proposal 4: Remove FFS for 'other restrictive conditions' for RLF declaration from previous agreements

Question 4: Is per DL CC failure detection supported?

When it comes to supportability of per DL CC failure detection, it should be first decided whether in/out-of sync from L1 is per CC indication or joint indication spanning several CCs. Regarding this question, it is noted that since we have a well defined mechanism for failure detection of a single CC exists in REL-8, we should be able to reuse this mechanism as much as possible.

The most straightforward extension of existing mechanism into CA could be to inherit the existing mechanism for failure detection of *each* CC. Then LTE-A UE would naturally have per-CC DL failure detection mechanism, where in-sync/out-of-sync is independently indicated per each CC. The in/out-of-sync is determined based on hypothetical PDCCH decoding error rate, and common reference signal strength is used to calculate the PDCCH error rate. Since every carrier has the common reference signals, REL-8 mechanism to detect a failure of (DL) CC can be applied for CC failure detection for any carrier type without any modification. That is, LTE-A UE declares the failure of concerned DL CC failure upon the expiry of e.g., T310 which needs to be defined per CC. So we propose:

Proposal 5: per DL CC failure detection is supported, and the criteria of DL CC failure is the same

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00229

as REL-8 mechanism

2.3 Remaining issues for uplink failure detection

Uplink failure can be detected upon the failure of RLC transmission failure or RACH transmission failure. Regarding the RLC transmission failure, since we have a common RLC, it was sufficient and thus agreed in the previous meeting to reuse RLC layer indication as re-establishment trigger.

Regarding the RACH transmission failure, it is still too early to decide anything since there is no agreed behaviors for RACH transmission, and several documents are being proposed to settle this. [1]. In spite of this, if there is only one RACH CC available to UE, it is obvious the MAC indication due to the consecutive RACH transmission failures should trigger re-establishment, since UE has no other option to recover from the failure. So, in case of only one RACH CC available, LTE-A UE should act the same as REL-8 regarding how to detect RACH problem and when concerned MAC indicates the failure to RRC.

Proposal 6: In case there is only one RACH CC available, re-establishment is triggered if RACH problem is detected, as is done in REL-8

Proposal 7: It is FFS for the case of more than one RACH CCs available.

3. Conclusion

Regarding radio link failure considering carrier aggregation, followings are proposed:

Radio downlink failure

Proposal 1: Re-establishment is triggered if all CCs including PDCCH which UE is monitoring fail (Clarification of previous agreement by adding highlighted phrases)

Proposal 2: Re-establishment is not triggered if a security CC which UE is monitoring fails while there is at least one alive CC including PDCCH which UE is monitoring

Proposal 3: Re-establishment is not triggered if a non-security-CC fails while there is at least one alive CC including PDCCH which UE is monitoring

Proposal 4: Remove FFS for other restrictive conditions for RLF declaration from previous agreements

Proposal 5: per DL CC failure detection is supported, and the criteria of DL CC failure is the same as REL-8 mechanism

Radio uplink failure

Proposal 6: In case there is only one RACH CC available, re-establishment is triggered if RACH problem is detected, as is done in REL-8

Proposal 7: It is FFS for the case of more than one RACH CCs available.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00230

Title: CSG cell detection

1. Introduction

Currently detection CSG cell is mostly up to UE implementation. Depending on NW deployment and UE implementation, UE may not have sufficiently fine resolution of finger print for CSG cell detection. In this document, it is suggested that the poor resolution would result in waste of UE battery by leading to useless measurement and even necessary SI reading and reporting. To remedy this, we propose that PCI matching of target CSG cell be mandatory implemented in CSG cell detection.

2. Discussion

2.1 Background of CSG cell detection

Currently UE is relying on autonomous search to detect its possibly allowed CSG cells. The autonomous search consists of finger print test where UE's position (in general sense) is estimated based on some geo-reference data, e.g., measurement result of macro cells, GPS, etc. Since which finger print mechanism is totally up to UE implementation, unified and consistent resolution of each finger print mechanism cannot be expected among UEs and even among NW deployment scenario.

For example, if UE counts on macro cell measurement for finger print implementation, the resolution of finger print is quite affected by NW environment, e.g., how densely the macro cells are deployed. When UE is operating under non-crowded area, e.g., rural place, UE may experience and measure quite small number of macro cells. In the worst scenario from finger print perspective, the case that only a single cell can be seen by the UE cannot be excluded. The less neighbor macro cells are seen, the less the finger print resolution would be.

In the current inbound mobility procedure, the detection of CSG cell by finger print test is informed to NW, in the name of proximity indication, by UE when necessary. Since the triggering of the signaling is totally up to UE implementation, NW cannot expect general behaviors regarding the proximity indication, and some bad UE implementation cause a flood of proximity indication, wasting network resource. So it was agreed that NW should be able to protect possibly a flood of such signaling from the poor UE which may not have any malicious will though.

The problem of poor finger print resolution is not the issue of NW side only. If the resolution of finger print is not sufficiently fine, UE can waste its battery to perform measurement and report SI even when those further measurement and reporting are highly likely to be unnecessary.

2.2 Problem of rough finger print from UE perspective

According to the understanding generally understood in RAN2, if finger print of macro cell(s) is matched, UE performs measurement based on measurement configuration. (Measurement

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00231

configuration can be involved in between.) If the resolution of the finger print is rough, the results from UE perspective would be that:

- More frequently UE sends proximity indication to NW, resulting in wasting radio resource
- More frequently UE performs measurement of CSG cells, resulting in wasting UE current drain.

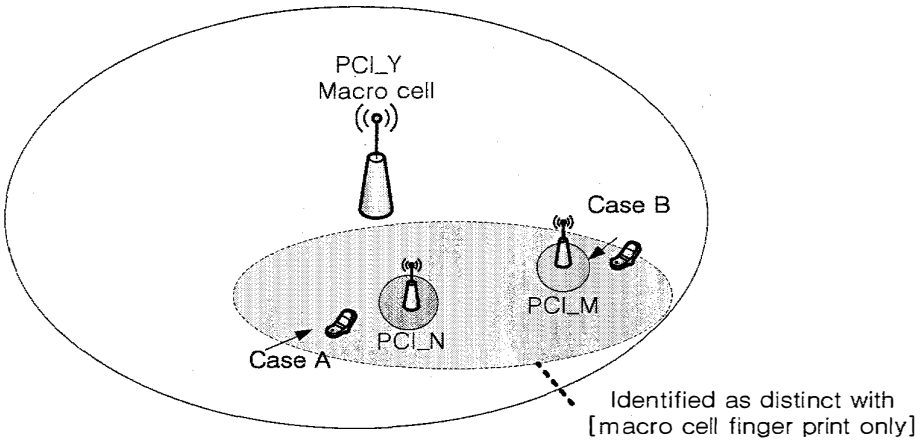


Figure 1 CSG cell detection based on macro cell finger print

For example, UE in figure 1 has a rough finger print resolution where two CSG cells are identified to be located in the same finger print. When UE is approaching to location A, finger print becomes matched, and measurement report is triggered afterward. In this case, CSG cell with PCI_N would trigger measurement report. When UE is approaching to location B, finger print becomes matched, and measurement report is triggered. In this case, CSG cell with PCI_M would trigger measurement report. If CSG cell with PCI_N is an allowed CSG cell and CSG cell with PCI_M is not allowed CSG cell,

- **Assumption**
  - UE ever visited the CSG cell with PCI_N and recorded the macro finger print when it visited there. That is, the finger print is bound to CSG cell with PCI_N which must ever be allowed for the UE.
  - CSG cell with PCI_N is an allowed CSG cell
  - CSG cell with PCI_M is non-allowed CSG cell. We can assume that this cell is ever visited by the UE and identified as non-allowed. No finger print was recorded. So this cell is equivalent to the cell which is unknown to the UE.

- **Case A: If UE is approaching to CSG cell**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print.
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_N, and then measurement report is triggered on the CSG cell with PCI_N

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00232

- NW lets UE to read system information required for HO preparation
- UE obtains the required system information for the CSG cell with PCI_N and reports it to NW
- NW issues HO command.

- **Case B: If UE is approaching to CSG cell with PCI_M**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print. Note that the matched finger print is not actually bound to the CSG cell with PCI_M, but to the CSG cell with PCI_N
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_M, and then measurement report is triggered on the CSG cell with PCI_M
  - NW may let UE to read system information required for HO preparation
  - UE obtains the required system information for the CSG cell with PCI_M and reports it to NW. UE indicates 'non-member' in the report.
  - NW does not issue HO command.

As shown in the sequence of UE behaviors for the case B, both UE measurement/measurement report and SI acquisition turn out to be in vain, since HO is not triggered at the end. Since the finger print area is serving as virtually the area forcing the UE to perform active measurement for CSG cells. This waste mainly comes from the fact that:

A. Single finger print is covering several CSG cells. Equivalently, the finger print is not sufficiently fine to distinguish CSG cell with PCI_N from the CSG cell with PCI_M
B. Not all CSG cells under the same finger print are allowed for the UE.

2.3 Enhancement of finger print resolution

To enhance the possibility of enhancement of finger print resolution, we review two facts that cause the waste.

Since the fact B suggested above is kind of NW environment to the UE and is something *given* to UE, UE cannot change this. Nothing else for the UE to break B seems to exist.

Regarding the fact A, we could think of PCI matching step to be a complementary remedy to the existing macro cell finger print matching. Even though this PCI matching is quite simple, it is sufficiently enhance finger print resolution, by which UE avoids useless measurement and unnecessary SI reading. More specifically, followings can be considered to enhance finger print resolution:

- UE tests finger print matching based on macro cell measurement and stored finger print

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00233

- If the finger print matching passes, UE would further attempt to read the PCI of the target cell
- If the PCI is read, the UE makes a test of PCI matching, where UE compares the PCI read from the target cell with the PCI of the cell which is bound to the matching finger print

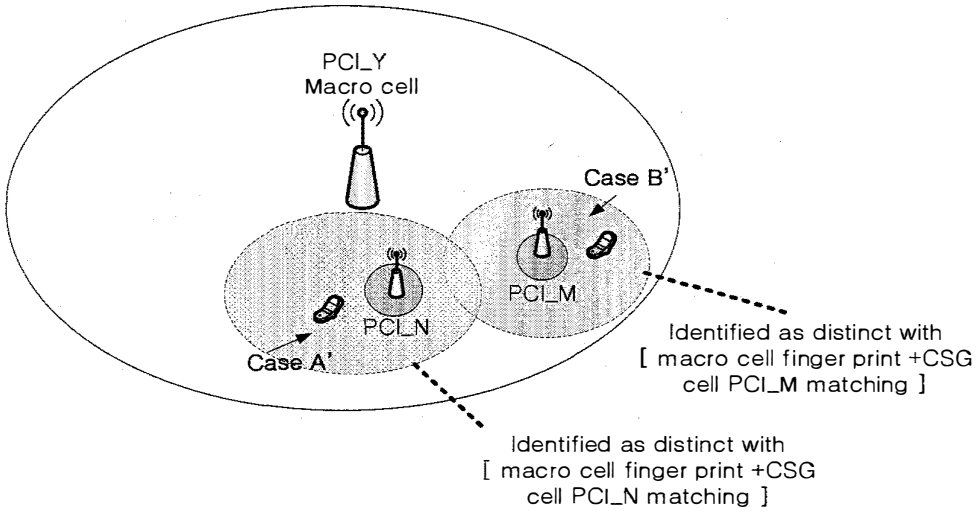


Figure 2 CSG cell detection based on macro cell finger print + CSG cell PCI matching

We describe expected UE behaviors for inbound handover assuming PCI matching is also implemented in addition to macro cell finger print matching mechanism for CSG cell detection.

- **Assumption (same as above in figure 1)**
  - UE recorded the macro finger print when it visited CSG cell with PCI_N. That is, the finger print is bound to CSG cell with PCI_N which is allowed for the UE.
  - CSG cell with PCI_N is an allowed CSG cell
  - CSG cell with PCI_M is non-allowed CSG cell.

- **Case A': If UE is approaching to CSG cell with PCI_N**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print.
  - *UE makes PCI matching test, where UE attempt to read PCI of the target cell, e.g., by cell search procedure, and checks if the PCI read from the target cell is matching with stored PCI information associated to the finger print*
  - *UE sees PCI matching, and thus it considers that wrong CSG cell is detected. The CSG cell is then discarded. No further step for inbound mobility proceeded.*

  (following behaviors are the same as above)
  - UE may send proximity indication
  - UE performs measurement
  - Measurement event is met for CSG cell with PCI_N, and then measurement report is triggered on the CSG cell with PCI_N

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00234

- NW lets UE to read system information required for HO preparation
- UE obtains the required system information for the CSG cell with PCI_N and reports it to NW
- NW issues HO command.

- **Case B': If UE is approaching to CSG cell with PCI_M**
  - UE detects that macro cell measurement is matching with stored finger macro cell finger print. Note that the matched finger print is not actually bound to the CSG cell with PCI_M, but to the CSG cell with PCI_N
  - *UE makes PCI matching test, where UE attempt to read PCI of the target cell, e.g., by cell search procedure, and checks if the PCI read from the target cell is matching with stored PCI information associated to the finger print*
  - *UE sees PCI not matching, and thus it considers that wrong CSG cell is detected. The CSG cell is then discarded. No further step for inbound mobility proceeded.*

(following behaviors are not performed)

- ~~UE may send proximity indication~~
- ~~UE performs measurement~~
- ~~Measurement event is met for CSG cell with PCI_M, and then measurement report is triggered on CSG cell with PCI_N~~
- ~~NW may let UE to read system information required for HO preparation~~
- ~~UE obtains the required system information for the CSG cell with PCI_N and reports it to NW. UE indicates 'non-member' in the report.~~
- ~~NW does not issue HO command.~~

Figure 2 is illustrating the effect of the implemented PCI matching, where it is observed that finger print resolution is highly increased.

With the simple PCI matching implemented into CSG cell detection, we see that UE can filter out the case where the UE is approaching non-allowed CSG cell, equivalently unknown CSG cell. UE then performs measurement only when it detects allowed CSG cell in the vicinity of where macro finger print has matched. Then UE can avoid unnecessary measurement of non-allowed CSG cell. The UE also avoids useless SI reading and reporting.

We note that PCI reading is mostly equivalent to cell search, and therefore it must be very quick and efficient. This enables the PCI matching to be used for detecting CSG cells on intra/inter-frequency. So we propose:

Proposal 1: PCI matching is mandatory implemented in CSG cell detection.

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00235

3. Conclusion

To avoid unnecessary measurement and useless SI reading, we propose that

Proposal 1: PCI matching is mandatory implemented in CSG cell detection.

By means of this proposal, UE would perform measurement only when it detects allowed CSG cell (whether it is allowed or not is determined based on stored information) in the vicinity of where macro finger print has matched.

Reference

IPR2024-00608
Petitioners' Ex. 1008
Ex.1008.00236

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