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Technical Specification

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Performance Management (PM);
Performance measurements Evolved Universal
Terrestrial Radio Access Network (E-UTRAN)
(3GPP TS 32.425 version 8.5.0 Release 8)**



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Foreword

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

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Introduction

The present document is part of a TS-family covering the 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; as identified below:

32.401	Performance Management (PM); Concept and requirements
52.402	Performance Management (PM); Performance measurements – GSM
32.404	Performance Management (PM); Performance measurements - Definitions and template
32.405	Performance Management (PM); Performance measurements Universal Terrestrial Radio Access Network (UTRAN)
32.406	Performance Management (PM); Performance measurements Core Network (CN) Packet Switched (PS) domain
32.407	Performance Management (PM); Performance measurements Core Network (CN) Circuit Switched (CS) domain
32.408	Performance Management (PM); Performance measurements Teleservice
32.409	Performance Management (PM); Performance measurements IP Multimedia Subsystem (IMS)
32.425	Performance Management (PM); Evolved Performance measurements Universal Terrestrial Radio Access Network (E-UTRAN)
32.426	Performance Management (PM); Evolved Packet Core (EPC)

The present document is part of a set of specifications, which describe the requirements and information model necessary for the standardised Operation, Administration and Maintenance (OA&M) of a multi-vendor E-UTRAN and EPC system.

During the lifetime of an E-UTRAN, its logical and physical configuration will undergo changes of varying degrees and frequencies in order to optimise the utilisation of the network resources. These changes will be executed through network configuration management activities and/or network engineering, see TS 32.600 [3].

Many of the activities involved in the daily operation and future network planning of an E-UTRAN require data on which to base decisions. This data refers to the load carried by the network and the grade of service offered. In order to produce this data performance measurements are executed in the NEs, which comprise the network. The data can then be transferred to an external system, e.g. an Operations System (OS) in TMN terminology, for further evaluation. The purpose of the present document is to describe the mechanisms involved in the collection of the data and the definition of the data itself.

Annex B of TS 32.404 helps in the definition of new performance measurements that can be submitted to 3GPP for potential adoption and inclusion in the present document. Annex B of TS 32.404 discusses a top-down performance measurement definition methodology that focuses on how the end-user of performance measurements can use the measurements.

1 Scope

The present document describes the measurements for E-UTRAN.

TS 32.401 [5] describes Performance Management concepts and requirements.

The present document is valid for all measurement types provided by an implementation of an E-UTRAN.

Only measurement types that are specific to E-UTRAN are defined within the present documents. Vendor specific measurement types used in E-UTRAN are not covered. Instead, these could be applied according to manufacturer's documentation.

Measurements related to "external" technologies (such as ATM or IP) as described by "external" standards bodies (e.g. ITU-T or IETF) shall only be referenced within this specification, wherever there is a need identified for the existence of such a reference.

The definition of the standard measurements is intended to result in comparability of measurement data produced in a multi-vendor network, for those measurement types that can be standardised across all vendors' implementations.

The structure of the present document is as follows:

- Header 1: Network Element (e.g. measurements related to eNodeB);
- Header 2: Measurement function (e.g. RRC connection setup related measurements);
- Header 3: Measurements.

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 and/or edition number or version number) 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 TS 32.101: "Telecommunication management; Principles and high level requirements".
- [2] 3GPP TS 32.102: "Telecommunication management; Architecture".
- [3] 3GPP TS 32.600: "Telecommunication management; Configuration Management (CM); Concept and high-level requirements".
- [4] Void.
- [5] 3GPP TS 32.401: "Telecommunication management; Performance Management (PM); Concept and requirements".
- [6] 3GPP TS 32.404: "Performance Management (PM); Performance measurements - Definitions and template".
- [7] 3GPP TS 32.762: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)".
- [8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

- [9] 3GPP TS 36.413: "Evolved Universal Terrestrial Access Network (E-UTRAN); S1 Application Protocol (S1AP)".
- [10] 3GPP TS 36.423: "Evolved Universal Terrestrial Radio Access Network (EUTRAN); X2 application protocol (X2AP)".
- [11] TS 36.314, 'Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2 – Measurements (Release 8)'
- [12] TS 36.300, 'Evolved Universal Terrestrial Radio Access (E-UTRA); and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)'
- [13] 3GPP TS 32.450 Telecommunication management; Key Performance Indicators (KPI) for E-UTRAN: Definitions (Release 8)
- [14] 3GPP TS 36.304, 'Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode'

3 Measurement family and abbreviations

3.1 Measurement family

The measurement names defined in the present document are all beginning with a prefix containing the measurement family name (e.g. RRC.AttConnEstab.Cause). This family name identifies all measurements which relate to a given functionality and it may be used for measurement administration (see TS 32.401 [5]).

The list of families currently used in the present document is as follows:

- DRB (measurements related to Data Radio Bearer)
- RRC (measurements related to Radio Resource Control)
- RRU (measurements related to Radio Resource Utilization)
- ERAB (measurements related to E-RAB)
- HO (measurements related to Handover)
- S1SIG (measurements related to S1 Signalling)
- SRB (measurements related to Signalling Radio Bearer)
- PAG (measurements related to Paging)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	3 rd Generation
3GPP	3G Partnership Project
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
E-UTRAN	Evolved UTRAN
HO	Handover
QoS	Quality of Service
UTRAN	Universal Terrestrial Radio Access Network

You can find below a list of abbreviations used within the measurement types for field E of the measurement template (see 3GPP TS 32.404 [6]).

Alloc	Allocation
Att	Attempt(s,ed)
Conn	Connection
Ded	Dedicated
DL	Downlink
ENB	eNodeB
Estab	Establish (ed,ment)
Fail	Fail(ed, ure)
Freq	Frequency
Inc	Incoming
Out	Outgoing
Pkt	Packet(s)
Prep	Prepare(/Preparation)
Late	Latency
Mod	Modify(/Modification)
Nbr	Number
Rel	Release(s,d)
Res	Resource
Succ	Success(es,ful)
UL	Uplink

4 Measurements related to eNodeB

4.1 RRC connection related measurements

4.1.1 RRC connection establishment

The three measurement types defined in the subclause 4.1.1.n are subject to the "2 out of 3 approach".

4.1.1.1 Attempted RRC connection establishments

- a) This measurement provides the number of RRC connection establishment attempts for each establishment cause.
- b) CC
- c) Receipt of a RRCConnectionRequest message by the eNodeB from the UE. Each RRCConnectionRequest message received is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of RRCConnectionRequest. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnEstabAtt.*Cause* where *Cause* identifies the establishment cause.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.1.1.2 Successful RRC connection establishments

- a) This measurement provides the number of successful RRC establishments for each establishment cause.
- b) CC
- c) Receipt by the eNodeB of a RRCConnectionSetupComplete message following a RRC connection establishment request. Each RRCConnectionSetupComplete message received is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of successful RRC Connection Establishments. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnEstabSucc.*Cause* where *Cause* identifies the establishment cause.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.1.1.3 Failed RRC connection establishments

- a) This measurement provides the number of RRC establishment failures for each establishment cause.
- b) CC
- c) Transmission of an RRCConnectionReject message by the eNodeB to the UE or an expected RRCConnectionSetupComplete message not received by the eNodeB. Each failed RRC connection establishment is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8].
The sum of all supported per cause measurements shall equal the total number of RRC connection establishment failures. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnEstabFail.*Cause* where *Cause* identifies the establishment cause.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.1.2 RRC connection re-establishment

The three measurement types defined in the subclause 4.1.2.n are subject to the "2 out of 3 approach".

4.1.2.1 Attempted RRC connection re-establishments

- a) This measurement provides the number of RRC connection re-establishment attempts for each re-establishment cause.
- b) CC.
- c) Receipt of a RRCConnectionReestablishmentRequest message by the eNodeB from the UE. Each RRCConnectionReestablishmentRequest received is added to the relevant per reestablishment cause

measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of RRC connection re-establishment attempts. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnReEstabAtt.*Cause* where *Cause* identifies the reestablishment cause.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switching.
- h) EPS

4.1.2.2 Successful RRC connection re-establishments

- a) This measurement provides the number of successful RRC connection re-establishments for each re-establishment cause.
- b) CC.
- c) Receipt by the eNodeB of a RRCConnectionReestablishmentComplete message following a RRC connection reestablishment request. Each RRCConnectionReestablishmentComplete message received is added to the relevant per reestablishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of successful RRC connection re-establishments. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnReEstabSucc.*Cause* where *Cause* identifies the establishment cause.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switching.
- h) EPS

4.1.2.3 Failed RRC connection re-establishments

- a) This measurement provides the number of RRC re-establishment failures for each re-establishment cause.
- b) CC.
- c) Transmission of an RRCConnectionReestablishmentReject message by the eNodeB to the UE or an expected RRCConnectionReestablishmentComplete message not received by the eNodeB. Each failed RRC connection re-establishment is added to the relevant per re-establishment.cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of RRC connection re-establishment failures. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRC.ConnReEstabFail.*Cause* where *Cause* identifies the re-establishment.cause.

- f) EUTRAN Cell FDD
EUTRAN Cell TDD
- g) Valid for packet switching.
- h) EPS

4.1.3 RRC connection number

4.1.3.1 Mean number of RRC Connections

- a) This measurement provides the mean number of RRC Connections during each granularity period.
- b) SI.
- c) This measurement is obtained by sampling at a pre-defined interval, the number of RRC connections for each E-UTRAN Cell and then taking the arithmetic mean
- d) A single integer value.
- e) RRC.ConnMean
- f) EUTRAN Cell FDD
EUTRAN Cell TDD
- g) Valid for packet switching.
- h) EPS

4.1.3.2 Maximum number of RRC Connections

- a) This measurement provides the maximum number of RRC Connections during each granularity period.
- b) SI.
- c) This measurement is obtained by sampling at a pre-defined interval, the number of RRC connections for each E-UTRAN cell and then taking the maximum.
- d) A single integer value.
- e) RRC.ConnMax
- f) EUTRAN Cell FDD
EUTRAN Cell TDD
- g) Valid for packet switching.
- h) EPS

4.1.4 RRC connection setup time

4.1.4.1 Mean RRC connection setup time

- a) This measurement provides the mean time per establishment cause it takes to establish an RRC connection.
- b) DER (n=1).
- c) This measurement is obtained by accumulating the time intervals for every successful RRC connection establishment between the receipt of a `RRConnectionRequest` and the corresponding `RRConnectionSetupComplete` message by the eNodeB over the granularity period. The end value of this time will then be divided by the number of successful RRC connections observed in the granularity period to give the

arithmetic mean. The accumulator shall be reinitialised at the beginning of each granularity period. The measurement is split into subcounters per establishment cause, and the possible causes are included in TS 36.331 [8].

- d) Each measurement is an integer value (in milliseconds).
- e) The measurement name has the form RRC.ConnEstabTimeMean.*Cause* where *Cause* identifies the establishment cause
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switching.
- h) EPS

4.1.4.2 Maximum RRC connection setup time

- a) This measurement provides the maximum time per establishment cause it takes to establish an RRC connection.
- b) GAUGE.
- c) This measurement is obtained by monitoring the time intervals for each successful RRC connection establishment between the receipt of a RRCConnectionRequest and the corresponding RRCConnectionSetupComplete message by the eNodeB over the granularity period. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period. The measurement is split into subcounters per establishment cause, and the possible causes are included in TS 36.331 [8].
- d) Each measurement is an integer value (in milliseconds).
- e) The measurement name has the form RRC.ConnEstabTimeMax.*Cause* where *Cause* identifies the establishment cause
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switching.
- h) EPS

4.2 E-RAB related measurements

4.2.1 E-RAB setup

4.2.1.1 Number of initial E-RABs attempted to setup

- a) This measurement provides the number of initial E-RABs attempted to setup. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On receipt by the eNodeB of an INITIAL CONTEXT SETUP REQUEST message, each requested E-RAB in the message is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to setup. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

- e) The measurement name has the form ERAB.EstabInitAttNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.1.2 Number of initial E-RABs successfully established

- a) This measurement provides the number of initial E-RABs successfully established. The measurement is split into subcounters per E-RABs QoS level (*QCI*).
- b) CC
- c) On transmission by the eNodeB of an INITIAL CONTEXT SETUP RESPONSE message, each E-RAB successfully established is added to the relevant measurement per *QCI*, the possible *QCIs* are included in TS 36.413 [9]. The sum of all supported per *QCI* measurements shall equal the total number of E-RABs successfully setup. In case only a subset of per *QCI* measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of *QCIs* plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.EstabInitSuccNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.1.3 Number of initial E-RABs failed to setup

- a) This measurement provides the number of initial E-RABs failed to setup. The measurement is split into subcounters per failure cause.
- b) CC
- c) On transmission by the eNodeB of an INITIAL CONTEXT SETUP RESPONSE, or INITIAL CONTEXT SETUP FAILURE message, each E-RAB failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RAB s failed to setup. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.EstabInitFailNbr.*Cause* where *Cause* identifies the cause resulting in the initial E-RAB setup failure.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.1.4 Number of additional E-RABs attempted to setup

- a) This measurement provides the number of additional E-RABs attempted to setup. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On receipt by the eNodeB of an E-RAB SETUP REQUEST message, each requested E-RAB in the message is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of additional E-RABs attempted to setup. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.EstabAddAttNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Accessibility KPI 'E-RAB Accessibility' defined in [13].

4.2.1.5 Number of additional E-RABs successfully established

- a) This measurement provides the number of additional E-RAB s successfully established. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On transmission by the eNodeB of an E-RAB SETUP RESPONSE message, each E-RAB successfully established is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of additional E-RABs successfully setup. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.EstabAddSuccNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Accessibility KPI 'E-RAB Accessibility' defined [13].

4.2.1.6 Number of additional E-RABs failed to setup

- a) This measurement provides the number of additional E-RABs failed to setup. The measurement is split into subcounters per failure cause.
- b) CC
- c) On transmission by the eNodeB of an E-RAB SETUP RESPONSE message, each E-RAB failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of additional E-RABs failed to setup. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.EstabAddFailNbr.*Cause* where *Cause* identifies the cause resulting in the additional E-RAB setup failure.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.1.7 Mean E-RAB Setup time

- a) This measurement provides the mean time per QCI it takes to establish an E-RAB.
- b) DER (n=1)
- c) This measurement is obtained by accumulating the time intervals for every successfully established E-RAB between the receipt of an E-RAB SETUP REQUEST or INITIAL CONTEXT SETUP REQUEST message and the transmission of the corresponding E-RAB SETUP RESPONSE or INITIAL CONTEXT SETUP RESPONSE message by the eNodeB over the granularity period. The end value of this time will then be divided by the number of successfully established E-RABs in the granularity period to give the arithmetic mean. The accumulator shall be reinitialised at the beginning of each granularity period. The measurement is split into subcounters per QCI, and the possible QCIs are included in TS 36.413 [9].
- d) Each measurement is an integer value (in milliseconds).
- e) The measurement name has the form ERAB.EstabTimeMean.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switching.
- h) EPS

4.2.1.8 Maximum E-RAB Setup time

- a) This measurement provides the maximum time per QCI it takes to establish an E-RAB.
- b) GAUGE
- c) This measurement is obtained by monitoring the time intervals for every successfully established E-RAB between the receipt of an E-RAB SETUP REQUEST or INITIAL CONTEXT SETUP REQUEST message and the transmission of the corresponding E-RAB SETUP RESPONSE or INITIAL CONTEXT SETUP RESPONSE message by the eNodeB over the granularity period. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period.. The measurement is split into subcounters per QCI, and the possible QCIs are included in TS 36.413 [9].
- d) Each measurement is an integer value (in milliseconds).
- e) The measurement name has the form ERAB.EstabTimeMax.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switching.
- h) EPS

4.2.2 E-RAB release

4.2.2.1 Number of E-RABs requested to release initiated by eNodeB per QCI

- a) This measurement provides the number of E-RABs requested to release initiated by eNodeB. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On transmission by the eNodeB of an E-RAB RELEASE INDICATION or a UE CONTEXT RELEASE REQUEST or a RESET message to MME, each corresponding E-RAB requested to release is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs requested to release initiated by eNodeB. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.RelEnbNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.2.2 Number of E-RABs requested to release initiated by eNodeB per cause

- a) This measurement provides the number of E-RABs requested to release initiated by eNodeB. The measurement is split into subcounters per cause.
- b) CC
- c) On transmission by the eNodeB of an E-RAB RELEASE INDICATION or a UE CONTEXT RELEASE REQUEST or a RESET message to MME, each corresponding E-RAB requested to release is added to the relevant measurement per cause. Possible causes are included in TS 36.413 [9].
- d) Each measurement is an integer value. The number of measurements is equal to the number of supported causes.
- e) The measurement names have the form ERAB.RelEnbNbr.*cause* where *cause* identifies the reason for the E-RABs release request initiated by eNodeB.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.2.3 Number of E-RABs attempted to release

- a) This measurement provides the number of E-RABs attempted to release. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On receipt by the eNodeB of an E-RAB RELEASE COMMAND or UE CONTEXT RELEASE COMMAND or a UE CONTEXT RELEASE or a RESET message from MME, or transmission by the eNodeB of a RESET message to MME, each corresponding E-RAB to release is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to release. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.

- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.RelAttNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.2.4 Number of E-RABs successfully released

- a) This measurement provides the number of E-RABs successfully released. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE or UE CONTEXT RELEASE COMPLETE message, or the E-RAB released successfully by source eNB after receiving UE CONTEXT RELEASE, or a RESET ACKNOWLEDGE message to MME, or receipt of a RESET ACKNOWLEDGE message from MME, each corresponding E-RAB successfully released is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs successfully released. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.RelSuccNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.2.5 Number of E-RABs failed to release

- a) This measurement provides the number of E-RABs failed to release. The measurement is split into subcounters per failure cause.
- b) CC
- c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE message, each E-RAB failed to release is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RABs failed to release. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.RelFailNbr.*Cause* where *Cause* identifies the cause resulting in the E-RAB release failure.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic

h) EPS

4.2.2.6 Number of released active E-RABs

- a) This measurement provides the number of released E-RABs that were active at the time of release (i.e. when there was user data in the queue in any of the directions). The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE or UE CONTEXT RELEASE COMPLETE message with the exception of those succeeding the message UE CONTEXT RELEASE COMMAND with 'Cause' indicating that the release was performed due to a successful Mobility activity, or a RESET ACKNOWLEDGE to MME, or receipt of a RESET ACKNOWLEDGE message from MME, if any of the UL or DL are considered active (according to the definition used for "Number of active UEs in TS 36.314 when there is still data in the DL or UL buffer, each corresponding E-RAB to release is added to the relevant measurement per QCI. The possible QCIs are described in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to release with data in the DL or UL buffer. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.RelActNbr.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Retainability KPI 'E-RAB Retainability' defined in [13]

4.2.3 E-RAB modification

4.2.3.1 Number of E-RABs attempted to modify the QoS parameter

- a) This measurement provides the number of E-RABs attempted to modify the QoS parameter. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On receipt by the eNodeB of an E-RAB MODIFY REQUEST message, each E-RAB attempted to modify the QoS parameter is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to modify the QoS parameter. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.ModQoSAttNbr.*QCI* where *QCI* identifies the target E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.3.2 Number of E-RABs successfully modified the QoS parameter

- a) This measurement provides the number of E-RABs successfully modified the QoS parameter. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) On transmission by the eNodeB of an E-RAB MODIFY RESPONSE message, each E-RAB successfully modified the QoS parameter is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs successfully modified the QoS parameter. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.ModQoS SuccNbr.*QCI* where *QCI* identifies the target E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.3.3 Number of E-RABs failed to modify the QoS parameter

- a) This measurement provides the number of E-RABs failed to be modified the QoS parameter. The measurement is split into subcounters per failure cause.
- b) CC
- c) On transmission by the eNodeB of an E-RAB MODIFY RESPONSE message, each E-RAB failed to modify the QoS parameter is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RABs failed to modify the QoS parameter. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.ModQoS FailNbr.*Cause* where *Cause* identifies the cause resulting in the E-RAB Modify failure.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.2.4 E-RAB activity

4.2.4.1 In-session activity time for UE

- a) This measurement provides the aggregated active session time for UEs in a cell.
- b) CC
- c) Number of session seconds aggregated for UEs in a cell. A UE is said to be 'in session' if any E-RAB data on a Data Radio Bearer (UL or DL) has been transferred during the last 100 ms.

- d) Each measurement is an integer value.
- e) ERAB.SessionTimeUE
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Retainability KPI 'E-RAB Retainability' defined in [13].

4.2.4.2 In-session activity time for E-RABs

- a) This measurement provides the aggregated active session time for E-RABs in a cell. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) Number of session seconds aggregated for E-RABs with a certain QCI. The E-RABs for a UE is said to be 'in session' if any E-RAB data on any Data Radio Bearer (UL or DL) has been transferred during the last 100 ms for that QCI. The possible QCIs are described in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total session seconds. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form ERAB.SessionTimeQCI.QCI
where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Retainability KPI 'E-RAB Retainability' defined in [13].

4.3 Handover related measurements

4.3.1 Intra-RAT Handovers

4.3.1.1 Intra-eNB Handover related measurements

4.3.1.1.1 Attempted outgoing intra-eNB handovers per handover cause

- a) This measurement provides the number of attempted outgoing intra-eNB handovers per handover cause.
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to the UE triggering the intra-eNB handover (see TS 36.331 [8]). The sum of all supported per cause measurements shall equal the total number of outgoing intra-eNB handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the *.sum* suffix.

- e) HO.IntraEnbOutAtt.*Cause*
where *Cause* identifies the cause for handover.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.1.2 Successful outgoing intra-eNB handovers per handover cause

- a) This measurement provides the number of successful outgoing intra-eNB handovers per handover cause.
- b) CC.
- c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB handover with specific cause (see TS 36.331 [8]).
The sum of all supported per cause measurements shall equal the total number of outgoing intra-eNB handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the .sum suffix
- e) HO.IntraEnbOutSucc.*Cause*
where *Cause* identifies the cause for handover.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.2 Inter-eNB Handover related measurements

4.3.1.2.1 Attempted outgoing inter-eNB handover preparations

- a) This measurement provides the number of attempted outgoing inter-eNB handover preparations.
- b) CC.
- c) Transmission of the X2AP message HANOVER REQUEST from the source eNB to the target eNB (see TS 36.423[10]), indicating the attempt of an outgoing inter-eNB handover preparation or on transmission of S1AP message HANOVER REQUIRED to the MME (see TS 36.413 [9]).
- d) A single integer value.
- e) HO.InterEnbOutPrepAtt
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.2.2 Attempted outgoing inter-eNB handover executions per handover cause

- a) This measurement provides the number of attempted outgoing inter-eNB handovers per handover cause.
- b) CC.
- c) Transmission of the *RRC ConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).

The sum of all supported per cause measurements shall equal the total number of outgoing inter-eNB handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the .sum suffix.
- e) HO.InterEnbOutAtt.*Cause*
where *Cause* identifies the cause for handover
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.2.3 Successful outgoing inter-eNB handover executions per handover cause

- a) This measurement provides the number of successful outgoing inter-eNB handovers per handover cause.
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. The sum of all supported per cause measurements shall equal the total number of outgoing inter-eNB handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the .sum suffix.
- e) HO.InterEnbOutSucc.*Cause*
where *Cause* identifies the cause for handover.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.3 Handover measurements on neighbour cell basis

4.3.1.3.1 Attempted outgoing handovers per handover cause

- a) This measurement provides the number of attempted outgoing handovers per handover cause and LTE target cell specific.
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).
The sum of all supported per cause measurements shall equal the total number of outgoing inter-eNB handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the .sum suffix.
- e) HO.OutAttTarget.*Cause*
where *Cause* identifies the cause for handover
- f) EUTRANRelation
- g) Valid for packet switched traffic

h) EPS

4.3.1.3.2 Successful outgoing handovers per handover cause

- a) This measurement provides the number of successful outgoing handovers per handover cause and LTE target cell specific.
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation., - or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. The sum of all supported per cause measurements shall equal the total number of outgoing intra-RAT handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the .sum suffix.
- e) HO.OutSuccTarget.Cause
where *Cause* identifies the cause for handover.
- f) EUTRANRelation
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4 Intra- / Inter-frequency Handover related measurements

4.3.1.4.1 Attempted outgoing intra-frequency handovers

- a) This measurement provides the number of attempted outgoing intra-frequency handovers.
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing intra-frequency handover (see TS 36.331 [8]).
- d) A single integer value.
- e) HO.IntraFreqOutAtt.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4.2 Successful outgoing intra-frequency handovers

- a) This measurement provides the number of successful outgoing intra-frequency handovers.
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. Additional trigger points are FFS.
- d) A single integer value.
- e) HO.IntraFreqOutSucc

- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4.3 Attempted outgoing inter-frequency handovers – gap-assisted measurement

- a) This measurement provides the number of attempted outgoing inter-frequency handovers, when measurement gaps are used [12].
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).
- d) A single integer value.
- e) HO.InterFreqMeasGapOutAtt
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4.4 Successful outgoing inter-frequency handovers – gap-assisted measurement

- a) This measurement provides the number of successful outgoing inter-frequency handovers, when measurement gaps are used [12].
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. Additional trigger points are FFS.
- d) A single integer value.
- e) HO.InterFreqMeasGapOutSucc
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4.5 Attempted outgoing inter-frequency handovers – non gap-assisted measurement

- a) This measurement provides the number of attempted outgoing inter-frequency handovers, when measurement gaps are not used [12].
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).
- d) A single integer value.
- e) HO.InterFreqNoMeasGapOutAtt

- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.4.6 Successful outgoing inter-frequency handovers – non gap-assisted measurement

- a) This measurement provides the number of successful outgoing inter-frequency handovers, when measurement gaps are not used [12].
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. Additional trigger points are FFS.
- d) A single integer value.
- e) HO.InterFreqNoMeasGapOutSucc
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.5 Handover related measurements for DRX / non-DRX

4.3.1.5.1 Attempted outgoing handovers with DRX

- a) This measurement provides the number of attempted outgoing handovers, when DRX is used (for DRX see [12]).
- b) CC.
- c) Transmission of the *RRConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).
- d) A single integer value.
- e) HO.DrxOutAtt
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.5.2 Successful outgoing handovers with DRX

- a) This measurement provides the number of successful outgoing handovers, when DRX is used (for DRX see [12]).
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. Additional trigger points are FFS.

- d) A single integer value.
- e) HO.DrxOutSucc
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.5.3 Attempted outgoing handovers non-DRX

- a) This measurement provides the number of attempted outgoing handovers, when DRX is not used (for DRX see [12]).
- b) CC.
- c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]).
- d) A single integer value.
- e) HO.NoDrxOutAtt.
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.1.5.4 Successful outgoing handovers non-DRX

- a) This measurement provides the number of successful outgoing handovers, when DRX is not used (for DRX see [12]).
- b) CC.
- c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover preparation., - or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover preparation. Additional triggerpoints are FFS.
- d) A single integer value.
- e) HO.NoDrxOutSucc
- f) EUTranCellFDD
EUTranCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.3.2 Inter-RAT Handovers

4.3.2.1 Measurements related to inter-RAT Handovers – target cell of 3GPP and non-3GPP network technology

4.3.2.1.1 Attempted outgoing inter-RAT handovers per handover cause

- a) This measurement provides the number of attempted outgoing inter-RAT handovers per cause and target cell specific.

- b) CC.
- c) Transmission of the *MobilityFromEUTRACommand* message or the *HandoverFromEUTRAPreparationRequest* message from the serving eNB to the UE indicating the attempt of an outgoing handover from EUTRAN to UTRAN or to GERAN or to CDMA2000 with a specific cause (see TS 36.331 [8]). The sum of all supported per cause measurements shall equal the total number of outgoing inter-RAT handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first. All IRAT handovers to the neighbouring cells in non-eUTRAN networks are measured.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the *.sum* suffix.
- e) *HO.IartOutAtt.Cause*
where *Cause* identifies the cause for handover
- f) EUTranCellFDD
EUTranCellTDD
GSMRelation
UTRANRelation
CDMA2000Relation
- g) Valid for packet switched traffic
- h) EPS

4.3.2.1.2 Successful outgoing inter-RAT handovers per handover cause

- a) This measurement provides the number of successful outgoing inter-RAT handovers per cause target cell specific.
- b) CC.
- c) Receipt of a S1AP message UE CONTEXT RELEASE COMMAND sent from the MME to the source eNB, indicating a successful IRAT handover initiated due to a specific cause (see TS 36.413 [9]). The sum of all supported per cause measurements shall equal the total number of outgoing inter-RAT handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first. All IRAT handovers to the neighbouring cells in non-eUTRAN are measured.
- d) Each measurement is an integer value. The number of measurements is equal to the number of causes supported plus a possible sum value identified by the *.sum* suffix.
- e) *HO.IartOutSucc.Cause*
where *Cause* indicating the cause for handover.
- f) EUTranCellFDD
EUTranCellTDD
GSMRelation
UTRANRelation
CDMA2000Relation
- g) Valid for packet switched traffic
- h) EPS

4.4 Cell level radio bearer QoS related measurements

4.4.1 Cell PDCP SDU bit-rate

4.4.1.1 Average DL cell PDCP SDU bit-rate

- a) This measurement provides the average cell bit-rate of PDCP SDUs on the downlink. This represents the ingress rate of user plane traffic to the eNodeB (via X2 or S1). The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) This measurement is obtained by accumulating the number of bits entering the eNodeB, and then dividing the sum by the measurement period. The measurement is performed at the PDCP SDU level. PDCP SDUs that are forwarded over the X2/S1 to another eNodeB during handover shall be deducted from the bit count – if this results in a negative bit count the bit count shall be set to zero. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total DL cell PDCP SDU bit-rate. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value representing the bit-rate measured in kb/s. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduBitrateDL.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.1.2 Average UL cell PDCP SDU bit-rate

- a) This measurement provides the average cell bit-rate of PDCP SDUs on the uplink. This represents successful transmissions of user plane traffic; control signalling and retransmissions are excluded from this measure. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) CC
- c) This measurement is obtained by accumulating the number of bits leaving the eNodeB on the X2 or S1 interface, and then dividing the sum by the measurement period. The measurement is performed at the PDCP SDU level. PDCP SDUs that were not received over the air interface in the cell (but were forwarded from another eNodeB during handover) are excluded from the count. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total UL cell PDCP SDU bit-rate. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value representing the bit-rate measured in kb/s. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduBitrateUL.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.1.3 Maximum DL cell PDCP SDU bit-rate

- a) This measurement provides the maximum cell bit-rate of PDCP SDUs on the downlink. This represents the maximum ingress rate of user plane traffic to the eNodeB (via X2 or S1). This is a sum counter measured across all QCIs.
- b) SI
- c) This measurement is obtained by sampling at pre-defined intervals the DL cell PDCP SDU bit-rate summed across all QCIs (see clause 4.4.1.1), and then taking the arithmetic maximum of these samples.
- d) A single integer value representing the maximum bit-rate measured in kb/s.
- e) DRB.PdcpSduBitrateDlMax
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.1.4 Maximum UL cell PDCP SDU bit-rate

- a) This measurement provides the maximum cell bit-rate of PDCP SDUs measured on the uplink. This represents successful transmissions of user plane traffic; control signalling and retransmissions are excluded from this measure. This is a sum counter measured across all QCIs.
- b) SI
- c) The measurement is obtained by sampling at pre-defined intervals the UL cell PDCP SDU bit-rate summed across all QCIs (see clause 4.4.1.2), and then taking the arithmetic maximum of these samples.
- d) A single integer value representing the maximum bit-rate measured in kb/s.
- e) DRB.PdcpSduBitrateUlMax
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.1.5 Average DL cell control plane PDCP SDU bit-rate

- a) This measurement provides the average cell bit-rate of control plane PDCP SDUs on the downlink.
- b) CC.
- c) This measurement is obtained by accumulating the number of received control plane PDCP SDU bits by the eNodeB, including the control plane PDCP SDU bits received from S1 and RRC SAP, and then dividing the sum by the measurement period.
- d) An single integer value in kb/s.
- e) SRB.PdcpSduBitrateDl
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switching.
- h) EPS

4.4.1.6 Average UL cell control plane PDCP SDU bit-rate

- a) This measurement provides the average cell bit-rate of control plane PDCP SDUs on the uplink. This represents successful transmissions of control plane traffic;
- b) CC.
- c) This measurement is obtained by accumulating the number of transmitted uplink control plane PDCP SDU bits by the eNodeB, and then dividing the sum by the measurement period.
- d) An single integer value in kb/s.
- e) SRB.PdcpSduBitrateUl
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switching.
- h) EPS

4.4.2 Active UEs

4.4.2.1 Average number of active UEs on the DL

- a) This measurement provides the average number of UEs that have DTCH data queued on the downlink. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.UEActiveDL.QCI where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.2.2 Average number of active UEs on the UL

- a) This measurement provides the average number of UEs that have DTCH data queued on the uplink. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.
- d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.UEActiveUL.QCI where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD

- g) Valid for packet switched traffic
- h) EPS

4.4.3 Packet Delay and Drop Rate

4.4.3.1 Average DL PDCP SDU delay

- a) This measurement provides the average (arithmetic mean) PDCP SDU delay on the downlink. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) DER (n=1)
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11].
- d) Each measurement is an integer value representing the mean delay in ms. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduDelayDL.*QCI* where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.3.2 DL PDCP SDU drop rate

- a) This measurement provides the fraction of IP packets (PDCP SDUs) which are dropped on the downlink. Only user-plane traffic (DTCH) is considered. A dropped packet is one whose context is removed from the eNodeB without any part of it having been transmitted on the air interface. Packets discarded during handover are excluded from the count. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a drop rate subcounter calculated across all QCIs will be provided first.
- d) Each measurement is an integer value representing the drop rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduDropRateDL.*QCI* where *QCI* identifies the target E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.4 Packet loss rate

4.4.4.1 DL PDCP SDU air interface loss rate

- a) This measurement provides the fraction of IP packets (PDCP SDUs) which are lost (not successfully transmitted) on the downlink air interface. Only user-plane traffic (DTCH) is considered. A lost packet is one whose context is removed from the eNodeB after an attempt has been made to transmit part or all of the packet on the air interface but the whole packet has not been successfully transmitted. The measurement is split into subcounters per E-RAB QoS level (QCI).

- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a loss rate subcounter calculated across all QCIs will be provided first.
- d) Each measurement is an integer value representing the air interface loss rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduAirLossRateDL.QCI where QCI identifies the target E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.4.2 UL PDCP SDU loss rate

- a) This measurement provides the fraction of IP packets (PDCP SDUs) which are lost (not successfully received) on the uplink. Only user-plane traffic (DTCH) and only PDCP SDUs that have entered PDCP (and given a PDCP sequence number) are considered. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a loss rate subcounter calculated across all QCIs will be provided first.
- d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form DRB.PdcpSduLossRateUL.QCI where QCI identifies the target E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.4.5 IP Latency measurements

4.4.5.1 IP Latency in DL, E-RAB level

- a) This measurement provides IP Latency in DL on E-RAB level.
- b) Gauge
- c) This measurement is obtained by the following formula for E-RABs

$$\frac{\text{LatTime}}{\text{LatSample}}$$

LatTime is obtained by accumulating the time T for E-RABs

$$T = t_{\text{first part of data volume transmitted}} - t_{\text{data received}} \quad [ms]$$

The sample of 'T' is made for the new arrived IP data block (PDCP SDU) when there is no other prior data to be transmitted to the same UE in the eNodeB .

LatSample is obtained by accumulating the number of Latency samples taken on the E-RAB level

The measurement is split into subcounters per E-RAB QoS level (QCI).

- d) Each measurement is an integer value representing the time in ms. The number of measurements is equal to the number of QCIs.
- e) The measurement name has the form DRB.IpLateDI.*QCI*
where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Integrity KPI 'E-UTRAN IP Latency' defined in [13]

4.5 Radio resource utilization related measurements

4.5.1 DL PRB Usage for traffic

- a) This measurement provides the usage (in percentage) of physical resource blocks (PRBs) on the downlink for DTCH traffic. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total PRB usage for DTCH. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value from 0 to 100. The usage (in percentage) of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRU.PrbDI.*QCI*
where *QCI* identifies the E-RAB level quality of service class.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.5.2 UL PRB Usage for traffic

- a) This measurement provides the usage (in percentage) of physical resource blocks (PRBs) on the uplink for DTCH traffic. The measurement is split into subcounters per E-RAB QoS level (QCI).
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total PRB usage for DTCH. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value from 0 to 100. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRU.PrbUI.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.5.3 DL Total PRB Usage

- a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) on the downlink for any purpose.
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11].
- d) A single integer value from 0 to 100.
- e) RRU.PrbTotDL
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.5.4 UL Total PRB Usage

- a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) on the uplink for any purpose.
- b) SI
- c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11].
- d) A single integer value from 0 to 100.
- e) RRU.PrbTotUL
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.5.5 RACH Usage

- a) This measurement provides the mean number of RACH preambles received in a cell in one second. Separate counts are provided for dedicated preambles, randomly chosen preambles in group A (aka 'low range') and randomly chosen preambles in group B (aka 'high range').
- b) CC
- c) This measurement is obtained according to the definition in 36.314 [11].
- d) Each measurement is an integer value.
- e) RRU.RachPreambleDedMean
RRU.RachPreambleAMean
RRU.RachPreambleBMean

- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS

4.5.6 Cell Unavailable Time

- a) This measurement provides the length of time the cell has been unavailable for each cause.
- b) DER (n=1)
- c) This measurement is obtained by accumulating the time periods when the cell is unavailable per cause. The possible cause could be 'manual intervention' and 'fault'. The sum of all supported per cause measurements shall equal the total time periods of cell unavailability. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
- d) Each measurement is an integer value (in seconds). The number of measurements is equal to the number of supported causes plus a possible sum value identified by the *.sum* suffix.
- e) The measurement name has the form RRU.CellUnavailableTime.cause.

Where *cause* identifies the cause resulting in cell unavailable.
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support KPI 'E-UTRAN Cell Availability' defined in [13].

4.6 UE-associated logical S1-connection related measurements

4.6.1 UE-associated logical S1-connection establishment

4.6.1.1 Attempted UE-associated logical S1-connection establishment from eNB to MME

- a) This measurement provides the number of attempted UE-associated logical S1-connection establishments from eNB to MME.
- b) CC
- c) Transmission of an INITIAL UE MESSAGE by the eNodeB to the MME (See 36.413 [9]).
- d) A single integer value.
- e) S1SIG.ConnEstabAtt
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Accessibility KPI 'E-RAB Accessibility' defined in [13].

4.6.1.2 Successful UE-associated logical S1-connection establishment from eNB to MME

- a) This measurement provides the number of successful UE-associated logical S1-connection establishments from eNB to MME.
- b) CC
- c) On receipt by the eNB of first message from MME which succeeds INITIAL UE MESSAGE message on an UE-associated logical S1-connection (See 36.413 [9]).
- d) A single integer value.
- e) S1SIG.ConnEstabSucc
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic
- h) EPS
- i) This measurement is to support the Accessibility KPI 'E-RAB Accessibility' defined in [13]

4.7 Paging related measurements

4.7.1 Paging Performance

4.7.1.1. Number of paging records discarded at the eNodeB.

- a) This measurement provides the number of paging records that are discarded at the eNB for paging occasions in each cell.
- b) CC
- c) Reception of a S1AP PAGING message from MME, see TS 36.413[9], with UE identity which satisfies the following formulae from TS 36.304 [14].

$$X = (T \text{ div } N) * (\text{UE_ID mod } N)$$

$$Y = \text{floor}(\text{UE_ID}/N) \text{ mod } N_s$$

AND the maximum number of paging records that can be queued for each paging occasion has been reached.
- d) A single integer value.
- e) PAG. DiscardedNbr
- f) EUTRANCellFDD
EUTRANCellTDD
- g) Valid for packet switched traffic.
- h) EPS

Annex A (informative): Use cases for performance measurements definition

This annex provides the concrete use cases for the E-UTRAN performance measurements defined in clause 4.

A.1 Monitor of call(/session) setup performance

Call(/session) setup is one of most important step to start delivering services by the networks to users.

The success or failure of a call(/session) setup directly impacts the quality level for delivering the service by the networks, and also the feeling of the end user. So the success or failure of call(/session) setup needs be monitored, this can be achieved by the calculation of call setup success rate which gives a direct view to evaluate the call setup performance, and the analysis of the specific reason causing the failure to find out the problem and ascertain the solutions.

In addition, the time duration of the call(/session) setup need to be monitored as it impacts the end user experience, and by comparison with operator"s benchmark requirements, the optimization may be required according the performance.

And due to different priority and tolerance for different service type with different OoS level in the networks, the monitor needs to be opened on each service type and OoS level.

To complete the call(/session) setup procedure, E-UTRAN is mainly responsible for the establishment of radio and S1 signaling connection and service bearer by the RRC connection establishment (See 3GPP TS 36.331[8]), RRC connection reestablishment after RRC connection dropped due to some reasons like radio link failure or handover failure etc (See 3GPP TS 36.331[8]) E-RAB setup (See 3GPP TS 36.413[9]) and Initial UE Context Setup (See 3GPP TS 36.413[9]) procedure.

To support the monitor of success or failure of the call(/session) setup, the performance measurements related to RRC connection establishment (See 3GPP TS 36.331[8]), RRC connection reestablishment (See 3GPP TS 36.331[8]) procedure, and the performance measurements related to E-RAB setup (See 3GPP TS 36.413[9]) and Initial UE Context Setup (See 3GPP TS 36.413[9]) procedure for each QoS level are required To support the monitor of time duration of setup call(/session) setup, the performance measurements related to RRC connection setup time and E-RAB setup time are required.

A.2 Monitor of E-RAB release

E-RAB is the key and limited resource for E-UTRAN to deliver services. The release of the E-RAB needs to be monitored as:

- an abnormal release of the E-RAB will cause the call(/session) drop, which directly impacts the QoS delivered by the networks, and the satisfaction degree of the end user;
- a successfully released E-RAB can be used to setup other requested calls(/sessions). The E-RAB failed to be released will still occupy the limited resource and hence it can not be used to admit other requested calls(/sessions).

The specific reason causing the abnormal and failed release of the E-RAB is required in order to find out the problem and ascertain the solutions. And due to different priority and tolerance for different service type with different OoS level in the networks, the monitor needs to be opened on each service type with OoS level.

The E-RAB can be released by E-RAB Release (See 3GPP TS 36.413[9]) and UE Context Release (See 3GPP TS 36.413[9] and 3GPP TS 36.423[10]) procedure, either initiated by eNodeB or MME.

So performance measurements related to E-RAB Release (See 3GPP TS 36.413[9]) and UE Context Release (See 3GPP TS 36.413[9]) procedure for each service type with QoS level are necessary to support the monitor of E-RAB release.

A.3 Monitor of E-RAB level QoS modification

When an E-RAB has been established, the QoS it experiences in the E-UTRAN is dependent upon the E-RAB level QoS parameters established for the bearer, together with settings of other bearers established in the same cell. If the QoS experienced by a bearer does not meet the expected performance, or the resource need be reassigned for other bearers, the E-RAB level QoS may be adjusted (typically with a knock-on effect onto other bearers).

So the modification of E-RAB level QoS parameters needs to be monitored, and due to different priority and tolerance for different service type with different OoS level in the networks, the monitor needs to be opened on each target service type with OoS level.

The E-RAB level QoS can be modified by E-RAB Modify procedure (see 3GPP TS 36.413[9]), in which the MME entity instructs the eNodeB to change one or more QoS parameters on an E-RAB using the E-RAB MODIFY REQUEST message. The eNodeB typically makes the adjustments as instructed (and adjusts the RRM applied to the bearer appropriately) but in some circumstances the bearer modification can fail. The eNodeB returns an E-RAB MODIFY RESPONSE message that tells the MME whether the modification was successful or not – for an unsuccessful modification a cause value is included. It is important for OAM to measure the failure rate of the bearer modifications, this information can be used, for example, to make adjustments to OAM CM settings.

A.4 Overview handover related Use Cases

Use Case	PM KPI / elementary object
<p>Continuous Network Supervision: Supervision of overall handover performance. It is essential in network operations to follow the success rate of various handover. Low handover success rate will impact user experience, therefore it is important to define measurements to follow handover success rate.</p>	<ul style="list-style-type: none"> - outgoing Intra RAT HO Success Rate (cell) *1 - outgoing Inter RAT HO Success Rate (cell) *1 - outgoing Inter System HO Success Rate (cell) *1 *3 - outgoing Intra Frequency HO Success Rate (cell) *1 - outgoing Inter Frequency HO Success Rate (cell) *1 - outgoing Intra eNB HO Success Rate (cell) *2 - outgoing Inter eNB HO Success Rate (cell) *2 <p>*1: It is expected that the HO success rate may vary depending on the respective scenarios : intra-RAT, inter-RAT, inter System, intra frequency, inter frequency</p> <p>*2: it is expected that the HO success rate may vary depending on the used external interfaces</p> <p>*3: inter system : LTE- non 3GPP HO</p>
<p>Troubleshooting: Detection of bad handover relation. The first use case provides the overall performance of handover success rate on E-UTRAN cell level, but it is essential to get a knowledge between which cell pairs the handover success rate is low. Therefore it is important to know the success rate on neighbor cell relation basis.</p>	<ul style="list-style-type: none"> - HO Success Rate (neighbourcell)

Use Case	PM KPI / elementary object
<p>Troubleshooting: Reason for started handover</p> <p>To go for further analysis of handover failures, it is essential to know what causes the handovers. For this we need to know the success rate of handovers per HO reason.</p>	<p>- outgoing HO Success Rate per HO reason (neighbor cell) *4</p> <p>*4 different results expected e.g. emergency or normal HO</p>
<p>Troubleshooting: Reason for failed handover. To go for further detailed analysis for handover failure it is important to know what the reason for handover failure was, or whether the handover was assisted by measurement gaps or was with DRX.</p> <p>It is also important to know if measurement gaps and DRX are helping in handover procedure or not. (i.e. what is the handover failure rate if measurement gaps are switched on. Measurement gaps and DRX can cause more load and battery consumption to the UE, therefore if these are not causing any changes in handover failure rate, operators may not use them)</p>	<p>- outgoing HO Failure Distribution Rate (cell+neighbourcell) - HO Path Switching Failure Distribution Rate (cell or Interface) - HO Failure Rate DRX / Non DRX (cell) *5 - Inter frequency HO Failure Rate Meas gap assisted / not assisted (cell) *5</p> <p>*5: measurement only on cell basis and not per neighbourcell due to amount of counters as mentioned above.</p>
<p>Network Planning: Traffic flow analysis or Network Planning: Handover traffic optimization</p>	<p>- outgoing Intra RAT HO Success Rate (neighbour cell) - outgoing Inter RAT HO Success Rate (cell) - outgoing Inter System HO Success Rate (cell)</p>

A.5 Monitor of cell level QoS and radio resource utilisation

In an E-UTRAN cell the quality of service achieved is directly influenced by a number of factors, including:

- Loading of users on the cell
- Traffic loading and characteristics
- UE locations and mobility
- RRM policies
 - Scheduling
 - congestion control
 - admission control
 - layer 2 protocol configuration
- Mapping of traffic to QCI
- Setting of QoS parameters other than the QCI.

It is very important to be able to monitor the QoS to determine whether the combined effect of these policies, algorithms and external factors is satisfactory. Unsatisfactory QoS may be rectified by adjusting policies and RRM settings, for instance.

Cell bit-rate

A fundamental measure of QoS is the throughput (data rate) of the cell. The total cell throughput measured across all radio bearers gives an indication of the loading and activity in the cell. Adding a per QCI counter allows the loading on the different QCIs to be measured. For example, if QCI 1 is used exclusively for VoIP then the loading of conversational speech can be directly determined. Finally, the maximum throughput can indicate to the operator whether there is enough capacity in the network; for example, is the backhaul sufficient. Separate counters should be configured on the downlink and uplink. Complexity may be reduced by performing the counters at layer 3, giving the ingress bit-rate to the eNB on the downlink and the egress bit-rate from the eNB on the uplink.

Cell throughput includes both User Plane data and Control Plane data. To support the User Plane data, necessary Control Plane data also need to be transmitted. This Control Plane data although required, will not be perceived (felt) by the User. The total cell throughput helps to evaluate the usage of bandwidth and radio resource.

Operators ideally want to see the Control Plane data as small as possible when compared to the User Plane data without compromising on the service.

Hence it is important to monitor the total cell throughput as well as how much is occupied by Control Plane Data.

Number of actives UEs

It is also of interest to determine how many users are enjoying the throughput numbers determined for each QCI. Therefore, we may count the number of users that are active for each QCI – here active users have data queued pending transmission. A simple division of the throughput (data rate) of a QCI by the number of active users on the QCI indicates the throughput per user on the QCI. For example, taking QCI 1 this metric could indicate the typical codec rate being employed in the cell. Alternatively, for QCI 9 supporting low priority TCP-based traffic it can indicate the typical bandwidth pipe size for a user when he has data to send / receive.

DL packet delay

Latency is of prime concern for some services, particularly conversational services like speech and instant messaging. A counter is added to measure the mean delay for IP packets incurred within the eNodeB. Separate counters are provided per QCI which are particularly useful when the QCI is used by very few services and the packet sizes vary little. It is only practical to measure packet delays on the downlink.

DL packet drop rate

When a cell is heavily loaded congestion can take place. When congestion is not severe the impact is typically the incurrance of additional delay for non-GBR radio bearers. However, when congestion is severe the eNodeB may be forced to discard packets. It is important for the operator to have visibility of packet discard so that corrective action can be instigated (for example, by adjusting admission control settings in the network). It is only practical to measure packet discards on the downlink. Packet discards on handover should not be included in the count.

PRB Usage

The resource utilisation, measured in terms of physical resource blocks (PRBs), is a useful measure of whether a cell is lightly loaded or not. Loading is a key input to network capacity planning and load balancing. Furthermore, when resource utilisation per QCI is reported the distribution of resources between different services can be estimated.

Downlink Air interface packet loss rate

The downlink air interface packet loss can be directly compared with the PELR value of a QCI to see if the packet loss (over the air interface) aspect of quality of service is being met within the cell (see [12] for more details on PELR). On the downlink this measurement can be added to the congestion losses (see DL packet drop rate) to determine the total packet loss rate at the eNodeB. Consequently, the downlink useful bit-rate can be estimated by scaling the measurement of the downlink PDCP ingress bit-rate by $(1 - \text{DL packet drop rate}) (1 - \text{air interface packet loss rate})$.

Uplink packet loss rate

The uplink air interface packet loss rate (per QCI) can be compared directly with the PELR defined for that QCI. An estimate of the uplink air interface packet loss may be provided by the 'Uplink PDCP SDU loss rate'. This uplink measurement is based on PDCP sequence numbers and cannot precisely measure the air interface losses. Any packets

discarded by the UE within the protocol stack (i.e. at layer 2) are also counted since they will have been given a PDCP sequence number. Discards at layer 3 are not counted.

RACH Usage

The RACH plays a vital role in the following procedures:

- Initial access from RRC_IDLE;
- Initial access after radio link failure;
- Handover requiring random access procedure;
- DL data arrival during RRC_CONNECTED requiring random access procedure;
- UL data arrival during RRC_CONNECTED requiring random access procedure;

Furthermore, the random access procedure takes two distinct forms:

- Contention based using a randomly selected preamble (applicable to all five events);
- Non-contention based using a dedicated preamble (applicable to only handover and DL data arrival).

In the use-case of RACH configuration optimization, received Random Access Preambles are signaled across an OAM interface.

Monitoring of the preamble usage in a cell allows the operator to determine if the resources allocated to the RACH by the eNodeB are appropriate for the number of random access attempts. If the resources are underutilised then the operator may reconfigure the eNodeB (via CM) to allocate less resource to RACH thereby freeing up resource for other uplink transmissions. Alternatively, if the resources are heavily utilised then this is indicative of RACH congestion leading to increased latency for the procedures listed above.

The eNodeB can partition the RACH resource between dedicated preambles, randomly selected preambles in group A and randomly selected preambles in group B. This partitioning can be evaluated when usage measurements are made on each set separately.

A.6 Monitor of the number of connected users

The number of the connected users in each cell is valuable information for operators to know how many users are connecting to E-UTRAN per cell basis. This kind of information can help operator to tune the admission control parameters for the cell and to do load balancing between cells to ensure that the target percentage or number of users admitted achieve the target QoS.

A.7 Monitoring of interference situation

In the LTE radio technology interference has to be coordinated on the basis uplink and downlink i.e. in a coordinated usage of the UL resources (Physical Resource Blocks, PRBs) and DL Transmitted Power, which lead to improve SIR and corresponding throughput. These are achieved by means of mechanisms employing channel quality indicators in support of scheduling/radio resource allocation functions.

These RRM functions in the eNB require the setting of frequency / power restrictions and preferences for the resource usage in the different cells. Setting and updating these parameters is the task of a network optimisation (done by operator or automatically by SON).

Use cases for the related interference measurements are e.g. optimisation of ICIC related RRM functionality, the detection of long distance interferer and the interference due to spurious emissions of neighbour cells. The later case is assumed only in high load scenarios or insufficient ICIC functionality due to the fact that ICIC functionality would minimise interference autonomously if sufficient bandwidth is available.

The necessary measurements to identify and analyse the interference situation as input for optimisation tasks has to be defined.

A.8 Monitor of ARQ and HARQ performance

Reliable Packet Delivery is one of the important Performance factor for a better User experience. HARQ retransmissions at the MAC layer ensure reliable packet delivery

In addition, RLC can be configured to operate in acknowledged mode for those applications that need very low packet drops and can tolerate a slightly higher delay from RLC retransmissions.

If a MAC PDU is not delivered, HARQ takes care of retransmitting (upto a maximum configurable number). If all the retransmissions fail at MAC layer, and if RLC is configured to operate in acknowledged mode, RLC's ARQ mechanism will take care of any residual packet errors.

It is important to

- a) maintain the block error rate or packet error rate within tolerable limits
- b) ensure that HARQ retransmissions take care of most packet errors, instead of relying on RLC layer retransmissions (which would increase the delay).

So, it is important to monitor the performance of these schemes.

ARQ Performance if viewed at QCI level can help in monitoring the distribution for each of the services.

HARQ Performance if viewed at MCS (Modulation Coded Scheme) can help in monitoring the MCS Performance also.

A.9 Monitor of RF performance

RF Performance reflects the cell loading levels and abnormal conditions.

In the Downlink, Power Resources are managed by the EUTRAN Cell(RAN).

More Power Resources may help in increasing the Capacity of the System. Hence, there the power resources could be effectively used to optimize the Capacity of the System.

Hence there is a need to keep monitoring the Power Resource Utilization in % and also in absolute terms.

A.10 Monitor of paging performance

In EUTRAN, Paging is under the control of the MME. When the MME wants to page a UE it has to page it in all cells that belong to the TA(s) to which the UE is registered.

The paging load per cell is an important measure for the operator as it allows the operator to properly dimension the resources for paging in the E-UTRAN Cell .

At an E-UTRAN Cell it makes sense to measure the number of discarded paging messages if this is due to some problem in the eNodeB, such as paging occasion overflow. In that scenario the periodicity of paging occasions can be reconfigured in order to ensure that all paging messages are transmitted by the eNodeB in the first available paging occasion, thereby avoiding paging delays and extended call setup delay.

Operators need to know when such an event occurs, in order to identify if the problem is at the E-UTRAN cell level or not.

Annex B (informative): Change history

Change history								
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Cat	Old	New
Mar 2009	SP-43	SP-090143	--	--	Presentation to SA for information and approval	--	1.0.0	8.0.0
Jun 2009	SP-44	SP-090408	002	--	Add missing E-UTRAN measurement for paging discards at the eNodeB - Align with 36.304 and 32.426	F	8.0.0	8.1.0
Sep 2009	SP-45	SP-090534	003	--	Correction on the IP latency and additional SAE Bearers setup measurements	F	8.1.0	8.2.0
Sep 2009	SP-45	SP-090534	005	--	Alignment of PRB usage related measurements with 36.314	F	8.1.0	8.2.0
Jun 2010	SP-48	SP-100259	020	--	Correct L3 messages in measurement definitions	F	8.2.0	8.3.0
Dec 2010	SP-50	SP-100878	028	1	Correcting L3 messages and cleanup	F	8.3.0	8.4.0
Mar 2011	SP-51	SP-110093	041	-	Add missing S1 reset to E-RAB release	F	8.4.0	8.5.0
Mar 2011	SP-51	SP-110093	046	-	Change counter for RACH usage from 'Cumulative Counter' to 'Gauge'	F	8.4.0	8.5.0

History

Document history		
V8.0.0	April 2009	Publication
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V8.3.0	July 2010	Publication
V8.4.0	January 2011	Publication
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