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Contents

Foreword

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1 Scope

The present document contains the description and definition of the measurements performed by E-UTRAN or the UE that are transferred over the standardised interfaces in order to support E-UTRA radio link operations, radio resource management (RRM), network operations and maintenance (OAM), minimization of drive tests (MDT) and self-organising networks (SON).

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

[2] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification ".

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

3 Definitions, symbols 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].

3.2 Symbols

For the purposes of the present document, symbols apply locally in the subclause where they are defined.

3.3 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].

DRB	Data Radio bearer
DCCH	Dedicated Control Channel
DTCH	Dedicated Traffic Channel
HARQ	Hybrid Automatic Repeat Request

PRB	Physical Resource Block
QCI	Quality of service Class Identifier
RN	Relay Node
SRB	Signalling Radio Bearer
TTI	Transmission Time Interval

4 Layer 2 measurements

4.1 E-UTRAN measurements performed by the eNB

4.1.1 PRB usage

The objective of the PRB usage measurements is to measure usage of time and frequency resources. A use case is cell load balancing, where PRB usage is used for information signalled across the X2 interface. Another use-case is OAM performance observability.

If there is one or more RNs served in a cell, for that cell the eNB performs PRB usage measurements separately for all traffic (including transmissions to/from RNs and UEs directly connected to the eNB) and for RN traffic.

4.1.1.1 Total PRB usage

Protocol Layer: MAC

Definition	Total PRB usage is calculated in the time-frequency domain only. The reference point is the Service Access Point between MAC and L1. The measurement is done separately for: - DL - UL Detailed Definitions: $M(T) = \left\lfloor \frac{M1(T)}{P(T)} * 100 \right\rfloor$, where explanations can be found in the table 4.1.1.1-1 below.

Table 4.1.1.1-1

$M(T)$	Total PRB usage. Percentage of PRBs used, averaged during time period T . Value range: 0-100%
$M1(T)$	A count of full physical resource blocks. For the DL, all PRBs used for transmission shall be included. For the UL, all PRBs allocated for transmission shall be included.
$P(T)$	Total number of PRBs available during time period T . For an eNB serving one or more RNs, all PRBs regardless of RN subframe configurations shall be counted. (NOTE)
T	The time period during which the measurement is performed.

NOTE: It is up to the eNB implementation how to calculate *P(T)* with respect to PRBs that may be considered not available, e.g. MBSFN subframes and subframes subject to restrictions due to TDM ICIC.

4.1.1.2 PRB usage per traffic class

Protocol Layer: MAC

Definition	PRB usage per traffic class. This measurement is an aggregate for all UEs in a cell, and is applicable to Dedicated Traffic Channels (DTCH). The reference point is the Service Access Point between MAC and L1. The measurement is done separately for: - DL DTCH, for each QCI. - UL DTCH, for each QCI Detailed Definitions: $M1(qci,T) = \sum_{\forall t} \sum_{\forall p \in S(t)} \frac{1}{W(p)} * X(t) * \frac{B(t,qci)}{B(t)}$, where explanations can be found in the table 4.1.1.2-1 below. $M(qci) = \left\lfloor \frac{M1(qci,T)}{P(T)} * 100 \right\rfloor$, where explanations can be found in the table 4.1.1.2-2 below.

Table 4.1.1.2-1

$M1(qci,T)$	Absolute PRB usage per traffic class. A count of full or partial physical resource blocks.
T	The time period during which the measurement is performed (in TTIs)
t	A transport block in time period T that contain DTCH data. Initial transmissions and HARQ retransmissions shall be counted.
$S(t)$	The set of physical resource blocks used for transmission of transport block t .
$W(p)$	The number of transport blocks that are currently sharing PRB p .
$B(t,qci)$	The total number of DTCH bits for DTCHs with QCI = qci , carried in transport block t
$B(t)$	The total number of DTCH and DCCH bits carried in transport block t .
$X(t)$	If multiplexing is taken into account: $X(t)=1$ always. If multiplexing is not taken into account: $X(t)=1$ if transport block t carries data corresponding to only one QCI and: $X(t)=0$ otherwise. It is up to implementation if to take multiplexing into account or not.

Table 4.1.1.2-2

$M(qci)$	PRB usage per traffic class. Percentage of PRBs used for a certain qci, averaged during time period T . Value range: 0-100%
$P(T)$	Total number of PRBs available during time period T . In an eNB serving one or more RNs, all PRBs regardless of RN subframe configurations shall be counted. (NOTE)

NOTE: It is up to the eNB implementation how to calculate $P(T)$ with respect to PRBs that may be considered not available, e.g. MBSFN subframes and subframes subject to restrictions due to TDM ICIC.

4.1.1.3 Void

4.1.1.4 Void

4.1.1.5 Void

4.1.2 Received Random Access Preambles

A use case for this measurement is RACH configuration optimization, where Received Random Access Preambles is signaled across an OAM interface.

Protocol Layer: MAC

Definition	Received Random Access Preambles. This measurement is applicable to PRACH. The reference point is the Service Access Point between MAC and L1. The measured quantity is the number of received Random Access preambles during a time period over all PRACHs configured in a cell. The measurement is done separately for: - Dedicated preambles - Randomly selected preambles in the low range - Randomly selected preambles in the high range. The unit of the measured value is [/s].

4.1.3 Number of active UEs

The objective of the measurement is to measure number of active UEs per QCI for OAM performance observability. It is intended to be part of a calculation to determine the bitrate UEs achieve when they are active, i.e. when applications are transmitting and receiving data.

For an eNB serving one or more RNs, the measurement refers to the number of active UEs connected directly to the eNB, excluding RNs.

4.1.3.1 Number of Active UEs in the DL per QCI

Protocol Layer: MAC, RLC, PDCP

Definition	Number of Active UEs in the DL per QCI. This measurement refers to UEs for which there is buffered data for the DL for DRBs. The measurement is done separately per QCI. Detailed Definition: $M(T,qci,p) = \left\lfloor \frac{\sum_{\forall i} N(i,qci)}{I(T,p)} \right\rfloor$,where explanations can be found in the table 4.1.3.1-1 below.

Table 4.1.3.1-1

$M(T,qci,p)$	Number of Active UEs in the DL per QCI, averaged during time period T . Unit: Integer.
$N(i,qci)$	Number of UEs for which there is buffered data for the DL in MAC, RLC or PDCP protocol layers for a Data Radio Bearer of traffic class with QCI = qci at sampling occasion i . In RLC and PDCP layers, buffered data corresponds to *data available for transmission* according to the definitions in TS 36.322 and TS 36.323. Buffered data includes data for which HARQ transmission has not yet terminated.
i	Sampling occasion during time period T . A sampling occasion shall occur once every p seconds.
p	Sampling period length. Unit: second. The sampling period shall be at most 0.1 s.
$I(T,p)$	Total number of sampling occasions during time period T .
T	Time Period during which the measurement is performed, Unit: second.

4.1.3.2 Number of Active UEs in the UL per QCI

Protocol Layer: MAC

Definition	Number of Active UEs in the UL per QCI. This measurement refers to UEs for which there is buffered data for the UL for DRBs. The measurement is done separately per QCI. Detailed Definition: $M(T,qci,p) = \left\lfloor \frac{\sum_{\forall i} N(i,qci)}{I(T,p)} \right\rfloor$ where explanations can be found in the table 4.1.3.2-1 below.

NOTE: For this measurement, the expected accuracy is dependent on application scenario, cell load UE configuration and how DRBs are distributed over logical channel groups.

Table 4.1.3.2-1

$M(T,qci,p)$	Number of Active UEs in the UL per QCI, averaged during time period T. Unit: Integer.
$N(i,qci)$	Number of UEs for which there is buffered data for the UL in MAC, RLC or PDCP protocol layers for a Data Radio Bearer of traffic class with QCI = qci at sampling occasion. i This is a eNB estimation that is expected to be based on Buffer Status Reporting, provided semi-persistent grants and progress of ongoing HARQ transmissions (by including buffered data for which HARQ transmission has not yet terminated in buffered data). In addition, the eNB can use the analysis of received data in the estimation. In such case, when QCI cannot be determined at the time of the sampling occasion, eNB can determine QCI after successful reception of data.
i	Sampling occasion during time period T. A sampling occasion shall occur once every p seconds.
p	Sampling period length. Unit: second. The sampling period shall be at most 0.1 s.
$I(T,p)$	Total number of sampling occasions during time period T.
T	Time Period during which the measurement is performed, Unit: second.

4.1.4 Packet Delay

4.1.4.1 Packet Delay in the DL per QCI

The objective of this measurement is to measure L2 Packet Delay for OAM performance observability or for QoS verification of MDT.

If there is one or more RNs served in a cell, for that cell the eNB performs each measurement separately for packets transmitted between the eNB and UEs and for packets transmitted between the eNB and RNs.

Protocol Layer: MAC, RLC, PDCP

Definition	Packet Delay in the DL per QCI. This measurement refers to packet delay for DRBs. For arrival of packets the reference point is PDCP upper SAP. For successful reception the reference point is MAC lower SAP. The measurement is done separately per QCI. Detailed Definition: $M(T,qci) = \left\lfloor \frac{\sum_{\forall i} tAck(i) - tArriv(i)}{I(T)} \right\rfloor$,where explanations can be found in the table 4.1.4.1-1 below.

Table 4.1.4.1-1

$M(T,qci)$	Packet Delay in the DL per QCI, averaged during time period T . Unit: Integer ms.
$tArriv(i)$	The point in time when PDCP SDU i arrives.
$tAck(i)$	The point in time when the last piece of PDCP SDU *i* was received by the UE according to received HARQ feedback information.
i	A PDCP SDU that arrives at the PDCP upper SAP during time period T . PDCP SDU for which HARQ acknowledgement is not received for all parts shall not be included in the calculation.
$I(T)$	Total number of PDCP SDUs i .
T	Time Period during which the measurement is performed

4.1.5 Data Loss

4.1.5.1 Packet Discard Rate in the DL per QCI

The objective of this measurement is to measure packets that are dropped due to congestion, traffic management etc, for OAM performance observability or QoS verification of MDT.

For an eNB serving one or more RNs, packets transmitted between the eNB and RNs are excluded, i.e., only packets transmitted between the eNB and UEs are counted.

Protocol Layer: MAC, RLC, PDCP

Definition	Packet Discard Rate in the DL per QCI. This measurement refers to discard for DRBs. One packet corresponds to one PDCP SDU. The reference point is PDCP upper SAP. The measurement is done separately per QCI. Detailed Definition: $M(T,qci) = \left\lfloor \frac{Ddisc(T,qci)*1000000}{N(T,qci)} \right\rfloor$,where explanations can be found in the table 4.1.5.1-1 below.

NOTE 1: Packet loss is expected to be small or very small The statistical accuracy of an individual discard rate measurement result is dependent on how many packets has been received, and thus the time for the measurement.

NOTE 2: In case the measurement is used with small time periods, e.g. fraction of minute for MDT, it is not expected that the result will reflect PELR.

Table 4.1.5.1-1

$M(T,qci)$	Packet Discard Rate in the DL per QCI, averaged during time period T . Unit: number of discarded packets per received packets * 10^6, Integer.
$Ddisc(T,qci)$	Number of DL packets, for which no part has been transmitted over the air, of a data radio bearer with QCI = qci , that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over.
$N(T,qci)$	Number of DL packets of bearer with QCI = qci that has entered PDCP upper SAP during time period T (NOTE).
T	Time Period during which the measurement is performed, Unit: minutes (NOTE 1, NOTE 2).

4.1.5.2 Packet Uu Loss Rate in the DL per QCI

The objective of this measurement is to measure packets that are lost at Uu transmission, for OAM performance observability.

.If there is one or more RNs served in a cell, for that cell the eNB performs each measurement separately for packets transmitted between the eNB and UE and for packets transmitted between the eNB and RNs.

Protocol Layer: MAC, RLC, PDCP

Definition	Packet Uu Loss Rate in the DL per QCI. This measurement refers to packet loss for DRBs. One packet corresponds to one PDCP SDU. The measurement is done separately per QCI. Detailed Definition: $M(T,qci) = \left\lfloor \frac{Dloss(T,qci) * 1000000}{N(T,qci) + Dloss(T,qci)} \right\rfloor$, where explanations can be found in the table 4.1.5.2-1 below.

NOTE: Packet loss is expected to be upper bounded by the PELR of the QCI which takes values between 10^{-6} and 10^{-2}. The statistical accuracy of an individual packet loss rate measurement result is dependent on how many packets have been received, and thus the time for the measurement.

Table 4.1.5.2-1

$M(T,qci)$	Packet Uu Loss Rate in the DL per QCI. Unit: number of lost packets per transmitted packets * 10^6, Integer.
$Dloss(T,qci)$	Number of DL packets, of a data radio bearer with QCI = qci, for which at least a part has been transmitted over the air but not positively acknowledged, and it was decided during time period T that no more transmission attempts will be done. If transmission of a packet might continue in another cell, it shall not be included in this count.
$N(T,qci)$	Number of DL packets, of a data radio bearer with QCI = qci, which has been transmitted over the air and positively acknowledged during time period T.
T	Time Period during which the measurement is performed, Unit: minutes (NOTE).

4.1.5.3 Packet Loss Rate in the UL per QCI

The objective of this measurement is to measure packets that are lost in the UL, for OAM performance observability or QoS verification of MDT.

If there is one or more RNs served in a cell, for that cell the eNB performs each measurement separately for packets transmitted between the eNB and UE and for packets transmitted between the eNB and RNs.

Protocol Layer: PDCP

Definition	Packet Loss Rate in the UL per QCI. This measurement refers to packet loss for DRBs. One packet corresponds to one PDCP SDU. Reference point is the PDCP upper SAP. The measurement is done separately per QCI. Detailed Definition: $M(T,qci) = \left\lfloor \frac{Dloss(T,qci)*1000000}{N(T,qci)} \right\rfloor$, where explanations can be found in the table 4.1.5.3-1 below.

NOTE 1: Packet loss is expected to be upper bounded by the PELR of the QCI which takes values between 10^{-6} and 10^{-2}. The statistical accuracy of an individual packet loss rate measurement result is dependent on how many packets have been received, and thus the time for the measurement.

NOTE 2: In case the measurement is used with small time periods, e.g. fraction of minute for MDT, it is not expected that the result will reflect PELR.

Table 4.1.5.3-1

$M(T,qci)$	Packet Loss Rate in the UL per QCI. Unit: number of lost packets per transmitted packets * 10^6, Integer.
$Dloss(T,qci)$	Number of missing UL PDCP sequence numbers, representing packets that are not delivered to higher layers, of a data radio bearer with QCI = qci during time period T. If transmission of a packet might continue in another cell, it shall not be included in this count.
$N(T,qci)$	Total number of UL PDCP sequence numbers (also including missing sequence numbers) of a bearer with QCI = qci, starting from the sequence number of the first packet delivered by PDCP upper SAP to higher layers until the sequence number of the last packet during time period T.
T	Time Period during which the measurement is performed, Unit: minutes (NOTE 1, NOTE 2).

4.1.6 Scheduled IP Throughput

The objective of this measurement is to measure over Uu the IP throughput independent of traffic patterns and packet size. This measurement is mainly intended for data bursts that are large enough to require transmissions to be split across multiple TTIs. The measurement is performed per QCI per UE. Initial buffering time in UE or eNB is excluded.

For an eNB serving one or more RNs, packets transmitted between the eNB and RNs are excluded, i.e., only packets transmitted between the eNB and UEs are counted.

4.1.6.1 Scheduled IP Throughput in DL

Protocol Layer: PDCP, RLC, MAC

Definition	Scheduled IP Throughput in DL. Throughput of PDCP SDU bits in downlink for packet sizes or data bursts that are large enough to require transmissions to be split across several TTIs, by excluding transmission of the last piece of data in a data burst. Only data transmission time is considered, i.e. when data transmission over Uu has begun but not yet finished. Each measurement is a real value representing the throughput in kbits/s. The measurement is performed per QCI per UE. For successful reception, the reference point is MAC upper SAP. This measurement is obtained by the following formula for a measurement period: $\text{If} \sum \text{ThpTimeDl} > 0, \ \frac{\sum \text{ThpVolDl}}{\sum \text{ThpTimeDl}} \text{x}1000 [\text{kbits/s}]$, where $\text{If} \sum \text{ThpTimeDl} = 0, \ 0 \ [\text{kbits/s}]$ For small data bursts, where all buffered data is included in one initial HARQ transmission, $ThpTimeDl = 0$, otherwise $ThpTimeDl = T1 - T2 \ [ms]$ Explanations of the parameters can be found in the table 4.1.6.1-1 below.

Table 4.1.6.1-1

$ThpTimeDl$	The time to transmit a data burst excluding the last piece of data transmitted in the TTI when the buffer is emptied. A sample of "ThpTimeDl" for each time the DL buffer for one E-RAB is emptied.
$T1$	The point in time after T2 when data up until the second last piece of data in the transmitted data burst which emptied the PDCP SDU available for transmission for the particular E-RAB was successfully transmitted, as acknowledged by the UE.
$T2$	The point in time when the first transmission begins after a PDCP SDU becomes available for transmission, where previously no PDCP SDUs were available for transmission for the particular E-RAB.
$ThpVolDl$	The volume of a data burst, excluding the data transmitted in the TTI when the buffer is emptied. A sample for ThpVolDl is the data volume, counted on PDCP SDU level, in kbits successfully transmitted (acknowledged by UE) in DL for one E-RAB during a sample of ThpTimeDl. It shall exclude the volume of the last piece of data emptying the buffer.

4.1.6.2 Scheduled IP Throughput in UL

Protocol Layer: PDCP, RLC, MAC

Definition	Scheduled IP Throughput in UL. eNB estimate of the throughput of PDCP SDU bits in uplink for packet sizes or data bursts (where a UL data burst is the collective data received while the eNB estimate of the UE buffer size is continuously above zero) that are large enough to require transmissions to be split across several TTIs, by excluding transmission of the last piece of data. Only data transmission time is considered, i.e. when data transmission over Uu has begun but not yet finished. Each measurement is a real value representing the throughput in kbits/s. The measurement is performed per QCI per UE. For successful reception, the reference point is MAC upper SAP. This measurement is obtained by the following formula for a measurement period: $\text{If} \sum \text{ThpTimeUl} > 0, \ \frac{\sum \text{ThpVolUl}}{\sum \text{ThpTimeUl}} \text{x}1000 [\text{kbits/s}]$, where $\text{If} \sum \text{ThpTimeUl} = 0, \ 0 \ [\text{kbits/s}]$ For small data bursts, where all buffered data is included in one initial HARQ transmission $ThpTimeUl = 0$ otherwise : $ThpTimeUl = T1 - T2 \ [ms]$ Explanations of the parameters can be found in the table 4.1.6.2-1 below.

Table 4.1.6.2-1

$ThpTimeUl$	The time to transmit a data burst excluding the data transmitted in the TTI when the buffer is emptied. A sample of "ThpTimeUl" for each time the UL buffer for one E-RAB is emptied.
$T1$	The point in time when the data up until the second last piece of data in data burst has been successfully received for a particular E-RAB
$T2$	The point in time when transmission is started for the the first data in data burst for a particular E-RAB.
$ThpVolUl$	The volume of a data burst, excluding the data transmitted in the TTI when the buffer is emptied. A sample for ThpVolUl is the data volume counted on PDCP SDU level in kbits received in UL for one E-RAB during a sample of ThpTimeUl, (It shall exclude the volume of the last piece of data emptying the buffer).

4.1.7 Scheduled IP Throughput for MDT

This measurement is mainly intended for measuring the throughput for MDT when the radio interface is the bottleneck.The objective of this measurement is to measure over Uu the IP throughput independent of traffic patterns and packet size.

For a data burst that spans measurement periods, the eNB splits the data burst at the measurement period boundary.

4.1.7.1 Scheduled IP Throughput for MDT in DL

Protocol Layer: PDCP, RLC, MAC

Definition	Scheduled IP Throughput for MDT in DL. Throughput of PDCP SDU bits in downlink for data bursts that are large enough to require transmissions to be split across several TTIs, by excluding the data transmitted in the last TTI of the data burst. Only data transmission time is considered, i.e. when data transmission over Uu has begun but not yet finished. The measurement is performed per RAB per UE, and also per UE. For successful reception, the reference point is MAC upper SAP. A data burst begins at the point in time when the first transmission begins after a PDCP SDU becomes available for transmission, where previously no PDCP SDUs were available for transmission for the E-RAB (in per E-RAB per UE case) or for any E-RABs of the UE (in per UE case). The data burst ends at the point in time when transmissions are successfully completed and there is no portion of a PDCP SDU pending transmission for the E-RAB (in per E-RAB per UE case) or for any E-RABs of the UE (in per UE case). This measurement is obtained by the following formula for a measurement period: $\text{If} \sum \text{ThpTimeDl} > 0, \ \frac{\sum \text{ThpVolDl}}{\sum \text{ThpTimeDl}} \text{x}1000 \ [kbits/s]$, where $\text{If} \sum \text{ThpTimeDl} = 0, \ 0 \ [kbits/s]$ Explanations of the parameters can be found in the table 4.1.7.1-1 below.

Table 4.1.7.1-1

ThpTimeDl	If the data burst is small enough to be transmitted in one TTI, then *ThpTimeDl* = 0. Otherwise, *ThpTimeDl* = *T*1 – *T*2 [ms].
*T*1	If transmission of a data burst is ongoing at the end of the measurement period, then T1 is the point in time when the measurement period ends. Otherwise, T1 is the point in time when the last TTI used for transmission of the data burst begins.
*T*2	If transmission of a data burst is ongoing at the start of the measurement period, then T2 is the point in time when the measurement period begins. Otherwise, T2 is the point in time when the first TTI used for transmission of the data burst begins.
ThpVolDl	The data volume, counted on PDCP SDU level, in kbits successfully transmitted (acknowledged by UE) in DL for the data burst excluding the data volume transmitted in the last TTI.

4.1.7.2 Scheduled IP Throughput for MDT in UL

Protocol Layer: PDCP, RLC, MAC

Definition	Scheduled IP Throughput for MDT in UL. eNB estimate of the throughput of PDCP SDU bits in uplink for data bursts that are large enough to require transmissions to be split across several TTIs, by excluding the data transmitted in the last TTI of the data burst. Only data transmission time is considered, i.e. when data transmission over Uu has begun but not yet finished. The measurement is performed per UE. For successful reception, the reference point is MAC upper SAP. A data burst begins at the point in time when the first transmission begins after the eNB estimate of the UE buffer size becomes greater than zero for at least one E-RAB of the UE, where previously the estimate was zero for all E-RABs of the UE. The data burst ends at the point in time when transmissions are successfully completed and the eNB estimate of the UE buffer size becomes zero for all E-RABs of the UE, where previously the estimate was greater than zero for at least one E-RAB of the UE. This measurement is obtained by the following formula for a measurement period: $\text{If} \sum \text{ThpTimeUl} > 0, \quad \frac{\sum \text{ThpVolUl}}{\sum \text{ThpTimeUl}} \text{x}1000\ [kbits/s]$, where $\text{If} \sum \text{ThpTimeUl} = 0, \quad 0\ \ [kbits/s]$ Explanations of the parameters can be found in the table 4.1.7.2-1 below.

Table 4.1.7.2-1

$ThpTimeUl$	If the data burst is small enough to be transmitted in one TTI, then *ThpTimeUl* = 0. Otherwise, *ThpTimeUl* = *T*1 – *T*2 [ms].
$T1$	If transmission of a data burst is ongoing at the end of the measurement period, then T1 is the point in time when the measurement period ends. Otherwise, T1 is the point in time when the last TTI used for transmission of the data burst begins.
$T2$	If transmission of a data burst is ongoing at the start of the measurement period, then T2 is the point in time when the measurement period begins. Otherwise, T2 is the point in time when the first TTI used for transmission of the data burst begins.
$ThpVolUl$	The data volume counted on PDCP SDU level in kbits received in UL for the data burst excluding the data volume received in the last TTI used for transmission of the data burst.

4.1.8 Data Volume

The objective of this measurement is to measure the data volume transmitted or received by the eNB in a configured measurement period for MDT. The measurement is performed per QCI per UE.

4.1.8.1 Data volume in DL

Protocol Layer: PDCP

Definition	Data Volume for MDT in DL. Amount of PDCP SDU bits in downlink delivered from PDCP layer to RLC layer in a measurement period. The measurement is performed per QCI per UE. The unit is kbit.

4.1.8.2 Data Volume in UL

Protocol Layer: PDCP

Definition	Data Volume for MDT in UL. Amount of PDCP SDU bits successfully received by the eNB in uplink in a measurement period. The measurement is performed per QCI per UE. The unit is kbit.

4.1.9 Data Volume for Shared Networks

The objective of this measurement is to measure the data volume transmitted or received by the eNB in a configured measurement period, for the different PLMN identities in a shared network. The measurement is performed per configured PLMN ID per configured QoS profile criteria.

The QoS profile criteria may include one or more of the following criteria: one QCI indicator, one GBR Indicator, one ARP Indicator, where

- a QCI Indicator identifies one specific QCI value. QCI values range from 1 to 256. If the indicator is not set then all QCI values should be taken into account.
- a GBR Indicator identifies one GBR range value defined by OAM. If the indicator is not set then all GBR ranges should be taken into account.
- an ARP Indicator identifies one ARP priority value. ARP values range from 1 to 15. If the indicator is not set then all ARP priority values should be taken into account.

The QoS profile criteria are satisfied when all the configured indicators are matched. It is possible that none of the QoS parameters are configured in which case the measurement is collected per configured PLMN ID.

4.1.9.1 Data volume for shared networks in DL

Protocol Layer: PDCP

Definition	Data Volume for shared networks in DL. Amount of PDCP SDU bits in downlink delivered from PDCP layer to RLC layer in a measurement period. The measurement is performed per configured PLMN ID per configured DL QoS profile criteria. The unit is Mbit.

4.1.9.2 Data Volume for shared networks in UL

Protocol Layer: PDCP

Definition	Data Volume for shared networks in UL. Amount of PDCP SDU bits successfully received by the eNB in uplink in a measurement period. The measurement is performed per configured PLMN ID per configured UL QoS profile criteria. The unit is Mbit.

4.2 E-UTRAN measurements performed by the UE

4.2.1 Packet Delay

4.2.1.1 UL PDCP Packet Delay per QCI

The objective of this measurement performed by UE is to measure Excess Packet Delay Ratio in Layer PDCP for QoS verification of MDT.

Protocol Layer: RLC, PDCP

Definition	PDCP Packet Delay in the UL per QCI. This measurement refers to packet delay for DRBs, which captures the delay from packet arrival at PDCP upper SAP until the packet starts to be delivered to RLC. The measurement is done separately per QCI. Detailed Definition: $M(T,qci) = \frac{nExcess(T,qci)}{nTotal(T,qci)}$,where $tULdelay(i,qci) = tDeliv(i,qci) - tArrival(i,qci)$ explanations can be found in the table 4.2.1.1-1 below.

Table 4.2.1.1-1

$M(T,qci)$	Ratio of packets in UL per QCI exceeding the configured delay threshold among the UL PDCP SDUs transmitted.
$nExcess(T,qci)$	Number of PDCP SDUs of a data radio bearer with QCI = qci ,for which ULdelay $tULdelay(i,qci)$ exceeded the configured *delayThreshold* as defined in TS 36.331 [5] during the time period T.
$nTotal(T,qci)$	Number of PDCP SDUs of a data radio bearer with QCI = qci , for which at least a part of SDU was transmitted during the time period T.
$tULdelay(i,qci)$	Queuing delay observed at the UE PDCP layer from packet arrival at PDCP upper SAP until the packet starts to be delivered to RLC, the packet belongs to a data radio bearer with QCI = qci .
$tDeliv(i,qci)$	The point in time when the PDCP SDU *i* of a data radio bearer with QCI = qci was delivered to lower layers.
$tArrival(i,qci)$	The point in the time when the PDCP SDU i of a data radio bearer with QCI = qci arrives at PDCP upper SAP.
i	Index of PDCP SDU that arrives at the PDCP upper SAP during time period T .
T	Time period during which the measurement is performed.

4.2.1.1.1 Measurement report mapping for PDCP SDU queuing delay

UL PDCP SDU queuing delay shall be measured according to configuration as defined in TS 36.331 [5].

The UE shall report UL PDCP SDU queuing delay as the ratio of SDUs exceeding the configured delay threshold and the total number of SDUs received by the UE during the measurement period.

The reported excess PDCP queuing delay ratio is mapped to 32 levels with the quantities in the range of 0 < nExcess ≤ 100% with uniform quantization in the log domain.

The mapping of measured quantity is defined in Table 4.2.1.1.1-1.

Table 4.2.1.1.1-1: EXCESS DELAY RATIO measurement report mapping (5 –bit value)

Reported value	Measured quantity value	Unit
EXCESS DELAY RATIO_00	0 < EXCESS DELAY RATIO ≤ 0,079	%
EXCESS DELAY RATIO_01	0,079 < EXCESS DELAY RATIO ≤ 0,100	%
EXCESS DELAY RATIO_02	0,100 < EXCESS DELAY RATIO ≤0,126	%
EXCESS DELAY RATIO_03	0,126 < EXCESS DELAY RATIO ≤ 0,158	%
EXCESS DELAY RATIO_04	0,158 < EXCESS DELAY RATIO ≤ 0,199	%
EXCESS DELAY RATIO_05	0,199 < EXCESS DELAY RATIO ≤ 0,251	%
EXCESS DELAY RATIO_06	0,251 < EXCESS DELAY RATIO ≤ 0,316	%
EXCESS DELAY RATIO_07	0,316 < EXCESS DELAY RATIO ≤ 0,398	%
EXCESS DELAY RATIO_08	0,398 < EXCESS DELAY RATIO ≤ 0,501	%
EXCESS DELAY RATIO_09	0,501 < EXCESS DELAY RATIO ≤ 0,631	%
EXCESS DELAY RATIO_10	0,631 < EXCESS DELAY RATIO ≤ 0,794	%
EXCESS DELAY RATIO_11	0,794 < EXCESS DELAY RATIO ≤ 1,000	%
EXCESS DELAY RATIO_12	1,000 < EXCESS DELAY RATIO ≤ 1,259	%
EXCESS DELAY RATIO_13	1,259 < EXCESS DELAY RATIO ≤ 1,585	%
EXCESS DELAY RATIO_14	1,585 < EXCESS DELAY RATIO ≤ 1,995	%
EXCESS DELAY RATIO_15	1,995 < EXCESS DELAY RATIO ≤ 2,511	%
EXCESS DELAY RATIO_16	2,511 < EXCESS DELAY RATIO ≤ 3,161	%
EXCESS DELAY RATIO_17	3,161 < EXCESS DELAY RATIO ≤ 3,980	%
EXCESS DELAY RATIO_18	3,980 < EXCESS DELAY RATIO ≤ 5,011	%
EXCESS DELAY RATIO_19	5,011 < EXCESS DELAY RATIO ≤ 6,309	%
EXCESS DELAY RATIO_20	6,309 < EXCESS DELAY RATIO ≤ 7,943	%
EXCESS DELAY RATIO_21	7,943 < EXCESS DELAY RATIO ≤ 10,00	%
EXCESS DELAY RATIO_22	10,00 < EXCESS DELAY RATIO ≤ 12,589	%
EXCESS DELAY RATIO_23	12,589 < EXCESS DELAY RATIO ≤ 15,849	%
EXCESS DELAY RATIO_24	15,849 < EXCESS DELAY RATIO ≤ 19,953	%
EXCESS DELAY RATIO_25	19,953 < EXCESS DELAY RATIO ≤ 25,119	%
EXCESS DELAY RATIO_26	25,119 < EXCESS DELAY RATIO ≤ 31,623	%
EXCESS DELAY RATIO_27	31,623 < EXCESS DELAY RATIO ≤ 39,811	%
EXCESS DELAY RATIO_28	39,811 < EXCESS DELAY RATIO ≤ 50,119	%
EXCESS DELAY RATIO_29	50,119 < EXCESS DELAY RATIO ≤ 63,096	%

EXCESS DELAY RATIO_30	63,096 < EXCESS DELAY RATIO ≤ 79,433	%
EXCESS DELAY RATIO_31	79,433 < EXCESS DELAY RATIO ≤ 100	%

Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Cat	Subject/Comment	New version
2008-12	RP-42	RP-081034	-	-		v1.0.0 was approved as v8.0.0 and put under CR control	8.0.0
2009-01						Keywords added, white space trimmed, file properties set	8.0.1
2009-03	RP-43	RP-090127	0001	-		Packet Loss Rate Measurements	8.1.0
	RP-43	RP-090127	0002	1		36.314 Rapporteur Updates	8.1.0
	RP-43	RP-090127	0003	1		Correction to the definition of the Number of active UEs per QCI	8.1.0
	RP-43	RP-090127	0004	-		Correction to the sampling of number of active Ues	8.1.0
	RP-43	RP-090127	0005	-		Inclusion of SRB0 for PRB usage for SRB	8.1.0
	RP-43	RP-090127	0007	-		Total PRB Usage Detail Definition	8.1.0
2009-06	RP-44	RP-090512	0009	-		Removal of measurements not reflected in interface specifications	8.2.0
	RP-44	RP-090512	0010	-		Correction to the minimum measurement time for data loss measurements	8.2.0
	RP-44	RP-090512	0011	-		Correction to the definition of PDCP SDU Delay measurement	8.2.0
2009-12	RP-46	RP-091314	0019	-		CR on the PRB usage per traffic class taking multiple antenna transmission into account	8.3.0
2009-12	RP-46	-	-	-		Upgrade to the Release 9 - no technical change	9.0.0
2010-06	RP-48	RP-100556	0020	-		Throughput Measurement	9.1.0
2010-12	RP-50	-	-	-		Upgrade to Release 10 - no technical change	10.0.0
2011-06	RP-52	RP-110849	0021	-		L2 measurements in an eNB serving RNs	10.1.0
	RP-52	RP-110830	0022	1		L2 measurements in an eNB with MBSFN, ABS subframes	10.1.0
2011-09	RP-53	RP-111288	0023	-		Addition of L2 measurements for Data Loss for RNs	10.2.0
2012-09	RP-57	RP-121370	0027	1		Introduction of MDT measurements	11.0.0
2012-12	RP-58	RP-121946	0028	-		CR to 36.314 on Scheduled IP Throughput for MDT in DL	11.1.0
	RP-58	RP-121946	0029	2		CR to 36.314 on Scheduled IP Throughput for MDT in UL	11.1.0
2014-09	RP-65	RP-141511	0033	-		Corrections for TS36.314	12.0.0
2015-12	RP-70	RP-152082	0034	1		New MDT measurement introduced by feMDT	13.0.0
	RP-70	RP-151955	0035	-		Introduction of data volume measurements in shared E-UTRAN	13.0.0
2016-03	RP-71	RP-160470	0036	-		Reporting of UL PDCP delay measurements for FeMDT	13.1.0
2017-03	RP-75					Upgrade to Release-14 - no technical change	14.0.0

History

Document history		
V14.0.0	April 2017	Publication