ETSI TS 138 314 V17.1.0 (2022-08)

TECHNICAL SPECIFICATION

5G;
NR;
Layer 2 measurements
(3GPP TS 38.314 version 17.1.0 Release 17)

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

If you find a security vulnerability in the present document, please report it through our
Coordinated Vulnerability Disclosure Program:
https://www.etsi.org/standards/coordinated-vulnerability-disclosure

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.
No recommendation as to products and services or vendors is made or should be implied.
No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.
In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

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

1 Scope

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

Only the differences relative to TS 28.552 v16.2.0 [2] are specified in this specification.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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

[2] 3GPP TS 28.552: "5G performance measurements".

[3] 3GPP TS 38.331: "Radio Resource Control (RRC) protocol specification".

[4] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms 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 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].

4 Layer 2 measurements

4.1 General

All the per DRB per cell measurements and per DRB per UE measurements can be aggregated into per QoS level per cell and per PLMN ID per cell by network implementation. All the performance measurements for gNB defined in TS 28.552 [2] 5.1 can be calculated into per PLMN ID level by network implementation. Per QoS level refers to per mapped 5QI for NR SA or per QCI for EN-DC.

4.2 NR measurements performed by the gNB

4.2.1 Measurements valid for all gNB deployment scenarios

4.2.1.1 Received Random Access Preambles

4.2.1.1.1 Received Random Access Preambles per cell

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

Protocol Layer: MAC

Table 4.2.1.1.1-1: Definition for Received Random Access Preambles per cell

Definition	Received Random Access Preambles per cell. 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].

4.2.1.1.1a Received 4-step Random Access Preambles per cell

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

Protocol Layer: MAC

Table 4.2.1.1.1a-1: Definition for Received 4-step Random Access Preambles per cell

Definition	Received 4-step Random Access Preambles per cell. 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 of 4-step RA attempts 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].

4.2.1.1.1b Received 2-step Random Access Preambles per cell

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

Protocol Layer: MAC

Table 4.2.1.1.1b-1: Definition for Received 2-step Random Access Preambles per cell

Definition	Received 2-step Random Access Preambles per cell. 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 of 2-step RA attempts 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].

4.2.1.1.2 Received Random Access Preambles per SSB

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

Protocol Layer: MAC

Table 4.2.1.1.2-1: Definition for Received Random Access Preambles per SSB

Definition	Received Random Access Preambles per SSB. 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 the SSB of the 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].

4.2.1.1.2a Received 4-step Random Access Preambles per SSB

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

Protocol Layer: MAC

Table 4.2.1.1.2a-1: Definition for Received 4-step Random Access Preambles per SSB

Definition	Received 4-step Random Access Preambles per SSB. 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 of 4-step RA attempts during a time period over all PRACHs configured in the SSB of the 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].

4.2.1.1.2b Received 2-step Random Access Preambles per SSB

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

Protocol Layer: MAC

Table 4.2.1.1.2b-1: Definition for Received 2-step Random Access Preambles per SSB

Definition	Received 2-step Random Access Preambles per SSB. 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 of 2-step RA attempts during a time period over all PRACHs configured in the SSB of the 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].

4.2.1.2   Packet delay

4.2.1.2.1   General

Packet delay includes RAN part of delay and CN part of delay.

The RAN part of DL packet delay measurement comprises:

- D1 (DL delay in over-the-air interface), referring to Average delay DL air-interface in TS 28.552 [2] 5.1.1.1.1.

- D2 (DL delay on gNB-DU), referring to Average delay in RLC sublayer of gNB-DU in TS 28.552 [2] 5.1.3.3.3.

- D3 (DL delay on F1-U), referring to Average delay on F1-U in TS 28.552 [2] 5.1.3.3.2.

- D4 (DL delay in CU-UP), referring to Average delay DL in CU-UP in TS 28.552 [2] 5.1.3.3.1.

The DL packet delay measurements, i.e. D1 (the DL delay in over-the-air interface), D2 (the DL delay in gNB-DU), D3 (the DL delay on F1-U) and D4 (the DL delay in CU-UP), should be measured per DRB per UE.

     NOTE: The delay measurements D1, D2 and D4 are also applicable for EUTRA in case of EN-DC related DL delay measurements on the MN side.

The RAN part (including UE) of UL packet delay measurement comprises:

- D1 (UL PDCP packet average delay, as defined in clause 4.3.1.1).

- D2.1 (average over-the-air interface packet delay, as defined in 4.2.1.2.2).

- D2.2 (average RLC packet delay, as defined in 4.2.1.2.3).

- D2.3 (average delay UL on F1-U, it is measured using the same metric as the average delay DL on F1-U defined in TS 28.552 [2] clause 5.1.3.3.2).

- D2.4 (average PDCP re-ordering delay, as defined in 4.2.1.2.4).

The UL packet delay measurements, i.e. D1(UL PDCP packet average delay), D2.1(average over-the-air interface packet delay), D2.2(average RLC packet delay), D2.3(average delay UL on F1-U) and D2.4(average PDCP re-ordering delay), should be measured per DRB per UE. The unit of D1, D2.1, D2.2, D2.3 and D2.4 is 0.1ms.

     NOTE: The delay measurements D1, D2.1, D2.2 and D2.4 are also applicable for EUTRA in case of EN-DC related UL delay measurements on the MN side.

For non CU-UP and DU split case, RAN part of packet delay excludes the delay at FI-U interface, i.e. D2.3 and D3.

If network disables the PDCP re-ordering function, the value of Average PDCP re-ordering delay i.e. D2.4 should be set to 0.

For the QoS monitoring in TS 23.501 [4], RAN informs the RAN part of UL packet delay measurement, or the RAN part of DL packet delay measurement, or both to the CN.

4.2.1.2.2 Average over-the-air interface packet delay in the UL per DRB per UE

The objective of this measurement is to measure air interface UL packet delay for OAM performance observability or for QoS verification of MDT or for the QoS monitoring as defined in TS 23.501 [4].

Protocol Layer: MAC

Table 4.2.1.2.2-1: Definition for Average over-the-air packet delay in the UL per DRB per UE

Definition	Average over-the-air packet delay in the UL per DRB per UE. This measurement is applicable for EN-DC and SA. This measurement refers to packet delay for DRBs. This measurement provides the average (arithmetic mean) time it takes to successfully receive a transport block from the time of UL transmission indicated in scheduling grant. Detailed Definition: $M(T, drbid) = \left\lfloor \frac{\sum_{\forall i} tSucc(i,drbid) - tSched(i,drbid)}{I(T)} \right\rfloor$, where explanations can be found in the table 4.2.1.2.2-2 below.

Table 4.2.1.2.2-2: Parameter description for Average over-the-air packet delay in the UL per DRB per UE

$M(T, drbid)$	Over-the-air packet delay in the UL per DRB per UE, averaged during time period T. Unit: 0.1 ms.
$tSched(i, drbid)$	The point in time when the UL MAC SDU i is scheduled in MAC layer as per the scheduling grant provided.
$tSucc(i, drbid)$	The point in time when the UL MAC SDU i is successfully sent to RLC.
i	A UL MAC SDU that arrives at the MAC during time period T.
$I(T)$	Total number of UL MAC SDUs i.
T	Time Period during which the measurement is performed
$drbid$	The identity of the measured DRB.

4.2.1.2.3 Average RLC packet delay in the UL per DRB per UE

The objective of this measurement is to measure RLC delay in the UL for OAM performance observability or for QoS verification of MDT or for the QoS monitoring as defined in TS 23.501 [4].

Protocol Layer: RLC

Table 4.2.1.2.3-1: Definition for Average RLC packet delay in the UL per DRB per UE

Definition	Average RLC delay in the UL per DRB per UE. This measurement is applicable for EN-DC and SA. This measurement refers to packet delay for DRBs. For CU-UP and DU split scenario or DC scenario, this measurement refers to the RLC delay on each DU or RAN node. This measurement provides the average (arithmetic mean) time it takes from the RLC PDU including the first part of an RLC SDU is received to the RLC SDU is sent to PDCP or CU-UP for split gNB. Detailed Definition: $M(T, drbid) = \left\lfloor \frac{\sum_{\forall i} tSent(i,drbid) - tReceiv(i,drbid)}{I(T)} \right\rfloor$, where explanations can be found in the table 4.2.1.2.3-2 below.

Table 4.2.1.2.3-2: Parameter description for Average RLC packet delay in the UL per DRB per UE

$M(T, drbid)$	RLC delay in the UL per DRB per UE, averaged during time period T. Unit: 0.1 ms.
$tReceiv(i, drbid)$	The point in time when the UL RLC PDU including the first part of the UL RLC SDU i is received.
$tSent(i, drbid)$	The point in time when the UL RLC SDU i is sent to PDCP or CU-UP for split gNB.
i	A UL RLC SDU that is received by the RLC during time period T.
$I(T)$	Total number of UL RLC SDUs i.
T	Time Period during which the measurement is performed
$drbid$	The identity of the measured DRB.

4.2.1.2.4　　　　Average PDCP re-ordering delay in the UL per DRB per UE

The objective of this measurement is to measure PDCP re-ordering delay in the UL for OAM performance observability or for QoS verification of MDT or for the QoS monitoring as defined in TS 23.501 [4].

Protocol Layer: PDCP

Table 4.2.1.2.4-1: Definition for Average PDCP re-ordering delay in the UL per DRB per UE

Definition	Average PDCP re-ordering delay in the UL per DRB per UE. This measurement is applicable for EN-DC and SA. This measurement refers to packet delay for DRBs. This measurement provides the average (arithmetic mean) time it takes from the point a PDCP PDU is received to the PDCP SDU is sent to upper SAP. Detailed Definition: $M(T, drbid) = \left\lfloor \frac{\sum_{\forall i} tSent(i, drbid) - tReceiv(i, drbid)}{I(T)} \right\rfloor$, where explanations can be found in the table 4.1.1.2.4-2 below.

Table 4.2.1.2.4-2: Parameter description for Average PDCP re-ordering delay in the UL per DRB per UE

$M(T, drbid)$	PDCP re-ordering delay in the UL per DRB per UE, averaged during time period T. Unit: 0.1 ms.
$tReceiv(i, drbid)$	The point in time when the UL PDCP PDU including the UL PDCP SDU i is received.
$tSent(i, drbid)$	The point in time when the UL PDCP SDU i is sent to upper SAP.
i	A UL PDCP SDU that is received by the PDCP during time period T.
$I(T)$	Total number of UL PDCP SDUs received during time period T.
T	Time Period during which the measurement is performed
$drbid$	The identity of the measured DRB.

4.2.1.3　　　　Number of active UEs in RRC_CONNECTED

4.2.1.3.1　　　　General

The objective of the measurement is to measure the number of active UEs per QoS level for OAM performance observability or for SON functions e.g., mobility load balancing. 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. The measurements are applicable for both non-split gNB and split gNB deployment scenario.

4.2.1.3.2　　　　Mean number of Active UEs in the DL per DRB per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.2-1: Definition for Mean number of Active UEs in the DL per DRB per cell

Definition	Mean number of Active UEs in the DL per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the DL for DRBs. Detailed Definition: $M(T, drbid, p) = \dfrac{\left\lfloor \frac{\sum_{\forall i} N(i, drbid)}{I(T,p)} * 10 \right\rfloor}{10}$, where explanations can be found in the table 4.2.1.3.2-2 below.

Table 4.2.1.3.2-2: Parameter description for Mean number of Active UEs in the DL per DRB per cell

$M(T, drbid, p)$	Mean number of Active UEs in the DL per DRB per cell, averaged during time period T. Unit: 0.1.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the DL in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i. Data available for transmission 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.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.3.3   Max number of Active UEs in the DL per DRB per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.3-1: Definition for Max number of Active UEs in the DL per DRB per cell

Definition	Maximum number of Active UEs in the DL per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the DL for DRBs. Detailed Definition: $M(T, drbid, p) = \max_T \big(N(i, drbid) \big)$, where explanations can be found in the table 4.2.1.3.3-2 below.

Table 4.2.1.3.3-2: Parameter description for Max number of Active UEs in the DL per DRB per cell

$M(T, drbid, p)$	Maximum number of Active UEs in the DL per DRB per cell, averaged during time period T. Unit: Integer.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the DL in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i. Data available for transmission 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.
T	Time Period during which the measurement is performed, Unit: second.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.3.4 Mean number of Active UEs in the UL per DRB per cell

Protocol Layer: MAC

Table 4.2.1.3.4-1: Definition for Mean number of Active UEs in the UL per DRB per cell

Definition	Mean number of Active UEs in the UL per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs. Detailed Definition: $M(T, drbid, p) = \dfrac{\left\lceil \frac{\sum_{\forall i} N(i, drbid)}{I(T, p)} * 10 \right\rceil}{10}$, where explanations can be found in the table 4.2.1.3.4-2 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 4.2.1.3.4-2: Parameter description for Mean number of Active UEs in the UL per DRB per cell

$M(T, drbid, p)$	Mean number of Active UEs in the UL per DRB per cell, averaged during time period T. Unit: 0.1.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the UL in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i This is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation. In such case, when DRB cannot be determined at the time of the sampling occasion, gNB can determine DRB 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.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.3.5 Max number of Active UEs in the UL per DRB per cell

Protocol Layer: MAC

Table 4.2.1.3.5-1: Definition for Max number of Active UEs in the UL per DRB per cell

Definition	Maximum number of Active UEs in the UL per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs. Detailed Definition: $M(T, drbid, p) = \max_T \big(N(i, drbid) \big)$, where explanations can be found in the table 4.2.1.3.5-2 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 4.2.1.3.5-2: Parameter description for Max number of Active UEs in the UL per DRB per cell

$M(T, drbid, p)$	Maximum number of Active UEs in the UL per DRB per cell, averaged during time period T. Unit: Integer.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the UL in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i This is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation. In such case, when DRB cannot be determined at the time of the sampling occasion, gNB can determine DRB 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.
T	Time Period during which the measurement is performed, Unit: second.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.3.6 Mean number of Active UEs per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.6-1: Definition for Mean number of Active UEs per cell

Definition	Mean number of Active UEs per cell. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs, or there is data available for transmission for the DL for DRBs, or both. Detailed Definition: $M(T,p) = \dfrac{\left\lfloor \frac{\sum_{\forall i} N(i)}{I(T,p)} * 10 \right\rfloor}{10}$, where explanations can be found in the table 4.2.1.3.6-2 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 4.2.1.3.6-2: Parameter description for Mean number of Active UEs per cell

$M(T, p)$	Mean number of Active UEs per cell, averaged during time period T. Unit: 0.1.
$N(i)$	Number of UEs for which there is data available for transmission for the UL or for the DL or for both in MAC or RLC protocol layers at sampling occasion i For UL, this is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation.
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.

4.2.1.3.7 Max number of Active UEs per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.7-1: Definition for Max number of Active UEs per cell

Definition	Maximum number of Active UEs per cell. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs, or there is data available for transmission for the DL for DRBs, or both. Detailed Definition: $M(T, p) = \max_{T}\big(N(i)\big)$, where explanations can be found in the table 4.2.1.3.7-2 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 4.2.1.3.7-2: Parameter description for Max number of Active UEs per cell

$M(T, p)$	Maximum number of Active UEs per cell, averaged during time period T. Unit: Integer.
$N(i)$	Number of UEs for which there is data available for transmission for the UL or for the DL or for both in MAC or RLC protocol layers at sampling occasion i For UL, this is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation.
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.
T	Time Period during which the measurement is performed, Unit: second.

4.2.1.3.8 Mean number of Active UEs per DRB per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.8-1: Definition for Mean number of Active UEs per DRB per cell

Definition	Mean number of Active UEs per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs, or there is data available for transmission for the DL for DRBs, or both. Detailed Definition: $M(T, drbid, p) = \dfrac{\left\lceil \frac{\sum_{\forall i} N(i, drbid)}{I(T,p)} * 10 \right\rceil}{10}$, where explanations can be found in the table 4.2.1.3.8-2 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 4.2.1.3.8-2: Parameter description for Mean number of Active UEs per DRB per cell

$M(T, drbid, p)$	Mean number of Active UEs per DRB per cell, averaged during time period T. Unit: 0.1.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the UL or for the DL or for both in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i For UL, this is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation. In such case, when DRB cannot be determined at the time of the sampling occasion, gNB can determine DRB 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.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.3.9　Max number of Active UEs per DRB per cell

Protocol Layer: MAC, RLC

Table 4.2.1.3.9-1: Definition for Max number of Active UEs per DRB per cell

Definition	Maximum number of Active UEs per DRB per cell. The DRBs are mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC. This measurement refers to UEs for which there is data available for transmission for the UL for DRBs, or there is data available for transmission for the DL for DRBs, or both. Detailed Definition: $M(T, drbid, p) = \max_T\big(N(i, drbid)\big)$, where explanations can be found in the table 4.2.1.3.9-1 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 4.2.1.3.9-2: Parameter description for Max number of Active UEs per DRB per cell

$M(T, drbid, p)$	Maximum number of Active UEs per DRB per cell, averaged during time period T. Unit: Integer.
$N(i, drbid)$	Number of UEs for which there is data available for transmission for the UL or for the DL or for both in MAC or RLC protocol layers for a Data Radio Bearer of traffic class at sampling occasion i For UL, this is a gNB estimation that is expected to be based on Buffer Status Reporting, provided configured grants and progress of ongoing HARQ transmissions (by including data for which HARQ transmission has not yet terminated). In addition, the gNB can use the analysis of received data in the estimation. In such case, when DRB cannot be determined at the time of the sampling occasion, gNB can determine DRB 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.
T	Time Period during which the measurement is performed, Unit: second.
$drbid$	The DRBs mapped with the same 5QI for NR SA or mapped with the same QCI for EN-DC.

4.2.1.4　　Number of stored inactive UE contexts

4.2.1.4.1　　General

The objective of the measurement is to measure number of stored inactive UE contexts for OAM performance observability. It is intended to be part of indication about the memory consumption in a RAN node.

The measurement is obtained by sampling at a pre-defined interval, the number of inactive UE contexts for each gNB and then taking the arithmetic mean or maximum value over pre-defined time duration.

4.2.1.4.2　　Mean number of stored inactive UE contexts

Protocol Layer: RRC

Table 4.2.1.4.2-1: Definition for Mean number of stored inactive UE contexts

Definition	Mean number of stored inactive UE contexts. Detailed Definition: $M(T, p) = \left\lfloor \frac{\sum_{\forall i} N(i)}{I(T, p)} \right\rfloor$, where explanations can be found in the table 4.2.1.4.2-2 below.

Table 4.2.1.4.2-2: Parameter description for Mean number of stored inactive UE contexts

$M(T, p)$	Mean number of stored Inactive UE contexts, averaged during time period T. Unit: Integer.
$N(i)$	Number of inactive UE contexts stored in the gNB at sampling occasion i.
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.

4.2.1.4.3   Max number of stored inactive UE contexts

Protocol Layer: RRC

Table 4.2.1.4.3-1: Definition for Max number of stored inactive UE contexts

Definition	Maximum number of stored inactive UE contexts.
	Detailed Definition: $M(T,p) = \max_{T}\big(N(i)\big)$, where explanations can be found in the table 4.2.1.4.3-2 below.

Table 4.2.1.4.3-2: Parameter description for Max number of stored inactive UE contexts

$M(T,p)$	Maximum number of stored Inactive UE contexts sampled during time period T. Unit: Integer.
$N(i)$	Number of inactive UE contexts stored in the gNB at sampling occasion i.
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.
T	Time Period during which the measurement is performed, Unit: second.

4.2.1.5   Packet Loss Rate

4.2.1.5.1   Packet Uu Loss Rate in the DL per DRB per UE

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

Protocol Layer: RLC

Table 4.2.1.5.1-1: Definition for Packet Uu Loss Rate in the DL per DRB per UE

Definition	Uu Packet Loss Rate in the DL per DRB per UE. One packet corresponds to one RLC SDU. The measurement is done separately per DRB. Detailed Definition: $M(T,drbid) = \left\lfloor \frac{Dloss(T,drbid)*1000000}{N(T,drbid)+Dloss(T,drbid)} \right\rfloor$, where explanations can be found in the table 4.2.1.5.1-2 below.

NOTE 1: Packet loss is expected to be upper bounded by the PER (packet error rate, as defined in TS 23.501 [4]) of the DRB 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: The granularity for Packet loss rate measurement is per DRB per UE, as defined in TS 28.552 [2].

Table 4.2.1.5.1-2: Parameter description for Packet Uu Loss Rate in the DL per DRB per UE

$M(T, drbid)$	Packet Loss Rate in the DL per DRB per UE. Unit: number of lost packets per transmitted packets per DRB * 10^6, Integer.
$Dloss(T, drbid)$	Number of DL packets, of a data radio bearer with DRB Identity = $drbid$, 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.
$N(T, drbid)$	Number of DL packets, of a data radio bearer with DRB Identity = $drbid$, 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.
$drbid$	The identity of the measured DRB.

4.2.1.6 Other measurements defined in TS 28.552 [2]

The granularity for PDCP SDU Data Volume measurement defined in TS 28.552 [2] is per DRB per UE.

The granularity for Average UE throughput measurement defined in TS 28.552 [2] is per UE and per DRB per UE.

PRB usage measurements are defined in TS 28.552 [2], i.e. DL/UL Total PRB Usage, Distribution of DL/UL Total PRB Usage. M(T), M1(T), P(T) are measured per cell. P(T) is the total available PRBs for this cell. M1(T) is the PRBs used for traffic transmission in this cell. Counting unit for PRB usage measurement is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier).

4.2.1.7 PRB Usage for MIMO

4.2.1.7.1 PDSCH PRB Usage for MIMO in the DL per cell

This measurement provides the total usage (in percentage) of PDSCH physical resource blocks (PRBs) for MIMO in the downlink per cell. The objective of the measurement is to measure usage of time and frequency resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.1-1: Definition for PDSCH PRB Usage for MIMO in the DL per cell

Definition	PDSCH PRB Usage for MIMO in the DL per cell is calculated in the time-frequency domain.
	Detailed Definition: $M(T) = \left\lfloor \frac{\sum_{\forall i}\sum_{\forall j}\{M1_{ij}(T) * L_{ij}(T)\}}{\sum_{\forall j}\{P_j(T)\} * \text{Alpha}} * 100 \right\rfloor$, where explanations can be found in the table 4.2.1.7.1-2 below.

Table 4.2.1.7.1-2: Parameter description for PDSCH PRB Usage for MIMO in the DL per cell

$M(T)$	Total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T with integer value range: 0-100
$M1_{ij}(T)$	A count of PDSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE i that is scheduled during time period T.
j	Sampling occasion during time period T. A sampling occasion is 1 symbol.
$P_j(T)$	Total number of PDSCH PRBs available for sampling occasion j on single MIMO layer per cell.
T	Time Period during which the measurement is performed.
Alpha	Constant value configured by OAM with float value range: 1.00-100.00. With this parameter, $M(T)$ should not be larger than 100.

4.2.1.7.2 PUSCH PRB Usage for MIMO in the UL per cell

This measurement provides the total usage (in percentage) of PUSCH physical resource blocks (PRBs) for MIMO in the uplink per cell. The objective of the measurement is to measure usage of time and frequency resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.2-1: Definition for PUSCH PRB Usage for MIMO in the UL per cell

Definition	PUSCH PRB Usage for MIMO in the UL per cell is calculated in the time-frequency domain. Detailed Definition: $M(T) = \left\lfloor \frac{\sum_{\forall i} \sum_{\forall j} \{M1_{ij}(T) * L_{ij}(T)\}}{\sum_{\forall j} \{P_j(T)\} * \text{Alpha}} * 100 \right\rfloor$, where explanations can be found in the table 4.2.1.7.2-2 below.

Table 4.2.1.7.2-2: Parameter description for PUSCH PRB Usage for MIMO in the UL per cell

$M(T)$	Total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T with integer value range: 0-100
$M1_{ij}(T)$	A count of PUSCH PRBs scheduled for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE that is scheduled during time period T.
j	Sampling occasion during time period T. A sampling occasion is 1 symbol.
$P_j(T)$	Total number of PUSCH PRBs available for sampling occasion j on single MIMO layer per cell.
T	Time Period during which the measurement is performed.
Alpha	Constant value configured by OAM with float value range: 1.00-100.00. With this parameter, $M(T)$ should not be larger than 100.

4.2.1.7.3 PDSCH PRB Usage based on statistical MIMO layer in the DL per cell

This measurement provides the total usage (in percentage) of PDSCH physical resource blocks (PRBs) for statistical MIMO layer per cell. The objective of the measurement is to measure usage of time and frequency resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.3-1: Definition for PDSCH PRB Usage based on statistical MIMO layer in the DL per cell

Definition	PDSCH PRB Usage based on statistical MIMO layer in the DL per cell is calculated in the time-frequency domain.
	Detailed Definition: $$M(T1) = \left\lceil \frac{\sum_{\forall i} \sum_{\forall j} \{M1_{ij}(T1) * L_{ij}(T1)\}}{\sum_{\forall j}\{P_j(T1)\} * \beta} * 100 \right\rceil$$ $$\beta = \max_{T2} LaveDL(T)$$ explanations can be found in the table 4.2.1.7.3-2 below.

Table 4.2.1.7.3-2: Parameter description for PDSCH PRB Usage based on statistical MIMO layer in the DL per cell

$M(T1)$	Total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period $T1$ with integer value.
$M1_{ij}(T1)$	A count of PDSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T1)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE i that is scheduled during time period $T1$.
j	Sampling occasion during time period T1. A sampling occasion is 1 symbol.
$P_j(T1)$	Total number of PDSCH PRBs available for sampling occasion j on single MIMO layer per cell.
$T1$	Time period during which the measurement is performed to calculate $M(T1)$, e.g., 15min, 1 hour, etc.
β	A variable factor for MIMO layer assigned with the maximum $LaveDL$ during time period T2 with float value 1.00-100.00.
$LaveDL(T)$	Average value of scheduled MIMO layers per PRB on the DL during time perior T with float value 1.00-100.00, as defined in TS 28.552 [2].
T	Time period during which the measurement is performed to calculate $LaveDL(T)$, as defined in TS 28.552 [2].
$T2$	Time period during which the measurement is performed to calculate β, e.g., 1 week, etc.

NOTE: For this measurement, same β value is used for the entire duration of T1.

4.2.1.7.4 PUSCH PRB Usage based on statistical MIMO layer in the UL per cell

This measurement provides the total usage (in percentage) of PUSCH physical resource blocks (PRBs) for statistical MIMO layer in the uplink per cell. The objective of the measurement is to measure usage of time and frequency resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.4-1: Definition for PUSCH PRB Usage based on statistical MIMO layer in the UL per cell

Definition	PUSCH PRB Usage based on statistical MIMO layer in the UL per cell is calculated in the time-frequency domain. Detailed Definition: $$M(T1) = \left\lceil \frac{\sum_{\forall i} \sum_{\forall j} \{M1_{ij}(T1) * L_{ij}(T1)\}}{\sum_{\forall j} \{P_j(T1)\} * \beta} * 100 \right\rceil$$ $$\beta = \max_{T2} LaveUL(T)$$ explanations can be found in the table 4.2.1.7.4-2 below.

Table 4.2.1.7.4-2: Parameter description for PUSCH PRB Usage based on statistical MIMO layer in the UL per cell

$M(T1)$	Total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period $T1$ with integer value.
$M1_{ij}(T1)$	A count of PUSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T1)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE i that is scheduled during time period $T1$.
j	Sampling occasion during time period T1. A sampling occasion is 1 symbol.
$P_j(T1)$	Total number of PUSCH PRBs available for sampling occasion j on single MIMO layer per cell.
$T1$	Time period during which the measurement is performed to calculate M(T1), e.g., 15min, 1 hour, etc.
β	A variable factor for MIMO layer assigned with the maximum $LaveUL$ during time period T2 with float value 1.00-100.00.
$LaveUL(T)$	Average value of scheduled MIMO layers per PRB on the UL during time perior T with float value 1.00-100.00, as defined in TS 28.552 [2].
T	Time period during which the measurement is performed to calculate $LaveUL(T)$, as defined in TS 28.552 [2].
$T2$	Time period during which the measurement is performed to calculate β, e.g., 1 week, etc.

NOTE: For this measurement, same β value is used for the entire duration of T1.

4.2.1.7.5   Enhanced PDSCH PRB Usage for MIMO in the DL per cell

This measurement provides the total usage (in percentage) of PDSCH physical resource blocks (PRBs) for MIMO in the downlink per cell. The objective of the measurement is to measure usage of time, frequency and spatial resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.5-1: Definition for enhanced PDSCH PRB Usage for MIMO in the DL per cell

Definition	PDSCH PRB Usage for MIMO in the DL per cell is calculated in the time-frequency and spatial domain.
	Detailed Definition: $$M(T) = \begin{cases} \left\lfloor \frac{\sum_{\forall i}\sum_{\forall j}\{M1_{ij}(T)*L_{ij}(T)\}}{\sum_{\forall j}\{P_j(T)\}*LM(T)} * 100 \right\rfloor \text{ and } LM(T) = \frac{\sum_j Lmax_j(T)}{K(T)}; \text{if } K(T) \neq 0 \\ 0; \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\text{Otherwise} \end{cases}, \text{ where}$$ $$K(T) = \sum_{j, Lmax_{j(T)} \neq 0} 1$$ explanations can be found in the table 4.2.1.7.5-2 below.

Table 4.2.1.7.5-2: Parameter description for enhanced PDSCH PRB Usage for MIMO in the DL per cell

$M(T)$	Total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T with integer value range: 0-100
$M1_{ij}(T)$	A count of PDSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE i that is scheduled during time period T.
j	Sampling occasion during time period T. A sampling occasion is 1 symbol.
T	Time period during which the measurement is performed.
$P_j(T)$	Total number of PDSCH PRBs available for sampling occasion j on single MIMO layer per cell.
$LM(T)$	PDSCH Time-domain average of the Maximum Scheduled Layer Number of the cell for MIMO scenario during time period T, defined in TS 28.552 [2].
$Lmax_j(T)$	The maximum number of scheduling layer of PDSCH at sampling occasion j;
$K(T)$	The number of sampling occasions at which $Lmax_j(T)$ is not 0.

4.2.1.7.6   Enhanced PUSCH PRB Usage for MIMO in the UL per cell

This measurement provides the total usage (in percentage) of PUSCH physical resource blocks (PRBs) for MIMO in the uplink per cell. The objective of the measurement is to measure usage of time, frequency and spatial resources. A use-case is OAM performance observability.

Protocol Layer: MAC, PHY

Table 4.2.1.7.6-1: Definition for enhanced PUSCH PRB Usage for MIMO in the UL per cell

Definition	PUSCH PRB Usage for MIMO in the UL per cell is calculated in the time-frequency and spatial domain.
	Detailed Definition: $$M(T) = \begin{cases} \left\lfloor \frac{\sum_{\forall i}\sum_{\forall j}\{M1_{ij}(T)*L_{ij}(T)\}}{\sum_{\forall j}\{P_j(T)\}*LM(T)} * 100 \right\rfloor \text{ and } LM(T) = \frac{\sum_j Lmax_j(T)}{K(T)}; \text{if } K(T) \neq 0 \\ 0; \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\text{Otherwise} \end{cases}, \text{ where}$$ $$K(T) = \sum_{j, Lmax_{j(T)} \neq 0} 1$$ explanations can be found in the table 4.2.1.7.6-2 below.

Table 4.2.1.7.6-2: Parameter description for enhanced PUSCH PRB Usage for MIMO in the UL per cell

$M(T)$	Total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T with integer value range: 0-100
$M1_{ij}(T)$	A count of PUSCH PRBs scheduled for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carrier)
$L_{ij}(T)$	The number of MIMO layers scheduled for UE i at sampling occasion j.
i	A UE that is scheduled during time period T.
j	Sampling occasion during time period T. A sampling occasion is 1 symbol.
T	Time period during which the measurement is performed.
$P_j(T)$	Total number of PUSCH PRBs available for sampling occasion j on single MIMO layer per cell.
$LM(T)$	PUSCH Time-domain average of the Maximum Scheduled Layer Number of the cell for MIMO scenario during time period T, defined in TS 28.552 [2].
$Lmax_j(T)$	The maximum number of scheduling layer of PUSCH at sampling occasion j;
$K(T)$	The number of sampling occasions at which $Lmax_j(T)$ is not 0.

4.2.1.8 Number of PDCP Packets in Split-DRB Scenario

4.2.1.8.1 Number of PDCP Non-duplicated Packets per cell group per Split-DRB per UE

The objective of this measurement is to calculate number of PDCP non-duplicated packets sent per cell group per UE per split DRB, for QoS verification of MDT.

Protocol layer: PDCP

Table 4.2.1.8.1-1: Definition for total number of PDCP non-duplicated packets per CG per Split-DRB per UE

Definition	Total number of PDCP non-duplicated packet sent over per cell groups per DRB per UE. This measurement is applicable for EN-DC and SA. This measurement provides the total number of PDCP non-duplicated packets sent over per cell groups. Detailed Definition: $I(T, drbid) = \mid P(T, drbid)\mid$, where explanations can be found in the table 4.2.1.8.1-2 below.

Table 4.2.1.8.1-2: Parameter description for total number of PDCP non-duplicated packets per CG per Split-DRB per UE

$I(T, drbid)$	Total number of PDCP non-duplicated packets sent per CG per DRB per UE during the time period T.
$P(T, drbid)$	A set of PDCP non duplicated packets sent per CG per UE per split DRB during the time period T.
$\mid P(T, drbid)\mid$	Cardinality of the set P.

4.2.1.8.2 Number of PDCP duplicated Packets per Split-DRB per UE

The objective of this measurement is to calculate number of PDCP duplicated packets per cell group per UE per split DRB, for QoS verification of MDT.

Protocol layer: PDCP

Table 4.2.1.8.2-1: Definition for total number of PDCP duplicated packets per Split-DRB per UE

Definition	Total number of PDCP duplicated packet sent per Split-DRB per UE. This measurement is applicable for EN-DC and SA. This measurement provides the total number of PDCP duplicated packets sent over per DRB. Detailed Definition: $I(T, drbid) = \|P(T, drbid)\|$, where explanations can be found in the table 4.2.1.8.1-2 below.

Table 4.2.1.8.2-2: Parameter description for total number of PDCP duplicated packets per Split-DRB per UE

$I(T, drbid)$	Total number of PDCP duplicated packets sent per Split-DRB per UE during the time period T.
$P(T, drbid)$	A set of PDCP duplicated packets sent per split DRB per UE during the time period *T*.
$\|P(T, drbid)\|$	Cardinality of the set P.

4.3 NR measurements performed by the UE

4.3.1 Packet delay

4.3.1.1 UL PDCP Packet Average Delay per DRB per UE

The objective of this measurement performed by UE is to measure Packet Delay in Layer PDCP for QoS verification of MDT or for the QoS monitoring as defined in TS 23.501 [4].

Protocol Layer: PDCP

Table 4.3.1.1-1: Definition for UL PDCP Packet Average Delay per DRB per UE

Definition	PDCP Packet Delay in the UL per DRB. This measurement refers to PDCP queuing delay for DRBs in the UE, which captures the delay from packet arrival at PDCP upper SAP until the UL grant to transmit the packet is available, which has included the delay the UE gets resources granted (from sending SR/RACH to get the first grant). The measurement is done separately per DRB. Detailed Definition: $M(T, drbid) = \left\lfloor \frac{\sum_{\forall i} tDeliv(i,drbid) - tArrival(i,drbid)}{I(T)} \right\rfloor$, where explanations can be found in the table 4.3.1.1-2 below.

NOTE: UE measures UL PDCP queueing delay at DRB level. It is up to gNB to convert DRB level delay to QoS level delay with the assumption that all QoS flows mapped to the same DRB get the same QoS treatment, and it is up to gNB to calculate QoS level delay if multiple DRBs mapped with the same QoS.

Table 4.3.1.1-2: Parameter description for UL PDCP Packet Average Delay per DRB per UE

$M(T, drbid)$	PDCP average delay in the UL per DRB, averaged during time period T. Unit: 0.1 ms. PDCP average delay in the UL per DRB is 1s if the actual value is larger than 1s.
$tArrival(i)$	The point in time when the UL PDCP SDU i arrivals at PDCP upper SAP.
$tDeliv(i)$	The point in time when the UL MAC PDU k including the first part of UL PDCP SDU i is scheduled for transmission.
i	A UL PDCP SDU that is received by the PDCP during time period T.
$I(T)$	Total number of UL PDCP SDUs received during time period T.
T	Time Period during which the measurement is performed
$drbid$	The identity of the measured DRB.

4.3.1.2 UL PDCP Excess Packet Delay per DRB

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

Protocol Layer: PDCP

Table 4.3.1.2-1: Definition for UL PDCP Excess Packet Delay per DRB

Definition	PDCP Excess Packet Delay in the UL per DRB. It represents the ratio of packets in UL per DRB exceeding the configured delay threshold among the UL PDCP SDUs received. The delay for each packet is calculated from packet arrival at PDCP upper SAP until the UL grant to transmit the packet is available, which has included the delay the UE gets resources granted (from sending SR/RACH to get the first grant). The measurement is done separately per DRB. Detailed Definition: $$M(T, drbid) = \frac{nExcess(T, drbid)}{nTotal(T, drbid)}$$ $tULdelay(i, drbid) = tDeliv(i, drbid) - tArrival(i, drbid)$, where explanations can be found in the table 4.3.1.2-1 below.

Table 4.3.1.2-2

$M(T, drbid)$	Ratio of packets in UL per DRB exceeding the configured delay threshold among the UL PDCP SDUs for which the UL MAC PDU including the first part of UL PDCP SDU is scheduled for transmission during the time period T.
$nExcess(T, drbid)$	Number of PDCP SDUs of a data radio bearer with DRB Identity = $drbid$, for which ULdelay $tULdelay(i, drbid)$ exceeded the configured *delayThreshold* as defined in TS 38.331 [3] during the time period T.
$nTotal(T, drbid)$	Number of PDCP SDUs of a data radio bearer with DRB Identity = $drbid$, for which the UL MAC PDU including the first part of UL PDCP SDU is scheduled for transmission during the time period T.
$tULdelay(i, drbid)$	Queuing delay observed at the UE PDCP layer from the UL PDCP SDU i belonging to a data radio bearer with DRB Identity = $drbid$ arrival at PDCP upper SAP until the UL MAC PDU k including the first part of UL PDCP SDU i is scheduled for transmission during the time period T.
$tDeliv(i, drbid)$	The point in time when the UL MAC PDU k including the first part of UL PDCP SDU i is scheduled for transmission.
$tArrival(i, drbid)$	The point in time when the UL PDCP SDU i 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.

4.3.1.2.1 Measurement report mapping for PDCP Excess Packet Delay

UL PDCP excess packet delay shall be measured according to configuration as defined in TS 38.331 [3].

The UE shall report UL PDCP excess packet 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 PDCP excess packet delay ratio is mapped to 32 levels with the quantities in the range of $0 < nExcess \leq 100\%$ with uniform quantization in the log domain.

The mapping of measured quantity is defined in Table 4.3.1.2.1-1.

Table 4.3.1.2.1-1: EXCESS DELAY 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	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2019-08	RAN2#107	R2-1909426	-	-	-	Draft skeleton	0.0.1
2019-10	RAN2#107bis	R2-1912957	-	-	-	Agreements from RAN2#107 on: - including the general reference to SA2 spec	0.0.2
2019-11	RAN2#108	R2-1915203	-	-	-	Capture agreements from RAN2#107bis on received random access preambles, UL over-the-air transmission delay and number of UEs.	0.0.3
2020-02	RAN2#109e	R2-2000908	-	-	-	Capture agreements from RAN2#108 on received random access preamble per SSB, delay measurements, packet loss rate.	0.0.4
2020-03	RAN2#109e	R2-2002000	-	-	-	Capture agreements from RAN2#109-e.	0.0.5
2020-04	RAN2#109bis-e	R2-2003487	-	-	-	Re-submission after RANP#87-e.	0.1.0
2020-05	RAN2#109bis-e	R2-2003874	-	-	-	Capture agreements from RAN2#109bis-e	0.2.0
2020-05	RAN2#110-e	R2-2005434	-	-	-	Update after email discussion [Post109bis-e][910][MDTSON] CR to 38.314	0.3.0
2020-06	RAN2#110-e	R2-2006195	-	-	-	Capture agreements from RAN2#110-e, including changes to 4.1.1.	0.4.0
2020-06	RAN2#110-e	RP-200785				Submitted to RAN#88-e for approval	1.0.0
2020-07	RAN#88					Approved and upgraded to Release 16	16.0.0
2020-09	RP-89	RP-201931	0003	-	F	Correction for L2M to capture agreements from [AT111-e][802] offline discussion	16.1.0
2020-12	RP-90	RP-202776	0012	-	F	Capture agreements and miscellaneous corrections for layer 2 measurement	16.2.0
2021-03	RP-91	RP-210693	0013	1	F	Miscellaneous corrections to TS 38.314	16.3.0
2021-09	RP-93	RP-212443	0017	1	F	On corrections to packet loss rate measurements	16.4.0
2022-03	RP-95	RP-220492	0020	-	B	Running 38.314 CR for R17 layer 2 measurements	17.0.0
2022-06	RP-96	RP-221733	0023	1	F	Corrections on TS 38.314	17.1.0

History

Document history		
V17.0.0	May 2022	Publication
V17.1.0	August 2022	Publication