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TECHNICAL SPECIFICATION

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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).

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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:

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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.

In drafting the TS/TR, pay particular attention to the use of modal auxiliary verbs! TRs shall not contain any normative provisions.

In the present document, modal verbs have the following meanings:

    shall   indicates a mandatory requirement to do something

    shall not   indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

    should   indicates a recommendation to do something

    should not   indicates a recommendation not to do something

    may   indicates permission to do something

    need not   indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

    can   indicates that something is possible

    cannot   indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

    will   indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

    will not   indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document specifies the UE level measurements for 5G system, and the corresponding collection and reporting mechanisms.

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 23.501: "System Architecture for the 5G System".

[3]   3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[4]   3GPP TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2".

[5]   3GPP TS 38.415: "NG-RAN; PDU session user plane protocol".

[6]   3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[7]   3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[8]   3GPP TS 38.314: "NR; Layer 2 Measurements".

[9]   3GPP TS 37.320: "Universal Terrestrial Radio Access (UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRA); Radio measurement collection for Minimization of Drive Tests (MDT);Overall description; Stage 2".

[10]   3GPP TS 28.532: "Management and orchestration; Generic management services".

[11]   3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[12]   3GPP TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".

[13]   3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace: Trace control and configuration management".

[14]   3GPP TS 32.423: "Telecommunication management; Subscriber and equipment trace: Trace data definition and management".

[15]   3GPP TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)"

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in 3GPP 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 3GPP TR 21.905 [1].

3.2 Symbols

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

Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

4 Overview

The UE level measurements, i.e., the measurements per UE, in addition to the traditional performance measurements which are aggregated for the UEs to a measured object (e.g., a cell), are required to support AI/ML for NG-RAN, and NWDAF analytics.

The UE level measurement is produced by 5GC Network Function or NG-RAN node for a particular UE, and provided by the MnS producer to the authorized consumer(s).

5 UE level measurements collection and reporting

The UE level measurements are collected by the MnS consumer from MnS producer via the Provisioning MnS (see TS 28.532 [10]) through managing the MOI of TraceJob (see TS 28.622 [11], and TS 28.623 [12]) with the specific job type(s).

In 5G system, the 5GC UE level measurements collection and reporting are supported by extending the Trace mechanisms for both signalling and management based activation; the NG-RAN UE level measurements collection and reporting is supported by MDT mechanisms for both signalling and management based activation. The Trace Session activation/deactivation, Trace Recording Session start/stop, and 5GC UE level measurements specific configuration parameters, and MDT specific configuration parameters, and 5GC UE level measurements and MDT measurements reporting are specified in TS 32.422 [13]. The Trace Record content, and Trace Report file and streaming format for 5GC UE level measurements and MDT measurements are specified in TS 32.423 [14].

6 UE level measurements definitions

6.1 General

The UE level measurements defined in clause may be collected by management based activation and signalling based activation of Trace job with the extended job type(s), as described in clause 5.

For the management based activation, when the MnS consumer does not specify the specific UE to measure, it is up to the NFs or NG-RAN node to decide the number of UEs and select the UEs to measure.

6.2 UE level measurements definitions for 5GC

6.2.1 General

This clause defines the UE level measurements for 5GC NFs, including UPF.

6.2.2 UE level measurements definitions for UPF

6.2.2.1 Packet delay

6.2.2.1.1 Average DL packet delay between PSA UPF and UE for a QoS flow

a) This measurement provides the average DL packet delay between PSA UPF and UE for a QoS flow. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs the per QoS Flow per UE QoS monitoring according to the QoS monitoring request received from SMF during PDU Session Establishment or Modification procedure (see TS 23.501 [2]). The QoS monitoring can be initiated on SMF by management system via `QFQoSMonitoringControl` MOI (see TS 28.541 [3]), or by PCF via QoS Monitoring policy included in the PCC rule provisioning (see TS 23.503 [4]). PSA UPF creates and sends the monitoring packets to the RAN according to QoS monitoring request received from the SMF.

For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information included in the GTP-U header (see TS 23.501 [2] and TS 38.415 [5]):

- T1 indicating the local time the DL GTP PDU monitoring packet was sent by the PSA UPF;

- T2 indicating the local time that the DL GTP PDU monitoring packet was received by NG-RAN;

- The DL Delay Result from NG-RAN to UE indicating the downlink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see TS 38.415 [5],and the DL Delay Result is denoted by $DRdl$ in the present document);

The PSA UPF counts the number (N) of GTP PDU monitoring response packets for the S-NSSAI and the QoS flow received in the granularity period, and takes the following calculation:

$$\frac{\sum_{i=1}^{N}(T2_i - T1_i + DRdl_i)}{N}$$

d) Each measurement is a real representing the average delay in 0.1ms.

e) GTP.DelayDlPsaUpfUeMean.*SNSSAI.QFI*.

Where *SNSSAI* identifies the S-NSSAI, and *QFI* identifies the QoS flow.

f) UPFFunction.

g) N4 Session Identifier.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.2.2.1.2 Average UL packet delay between PSA UPF and UE for a QoS flow (excluding D1)

a) This measurement provides the average UL packet delay between PSA UPF and UE for a QoS flow, excluding the D1 UL PDCP delay occurred in the UE. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs the per QoS Flow per UE QoS monitoring according to the QoS monitoring request received from SMF during PDU Session Establishment or Modification procedure (see TS 23.501 [2]). The QoS monitoring can be initiated on SMF by management system via `QFQoSMonitoringControl` MOI (see TS 28.541 [3]), or by PCF via QoS Monitoring policy included in the PCC rule provisioning (see TS 23.503 [4]). PSA UPF creates and sends the monitoring packets to the RAN according to QoS monitoring request received from the SMF.

For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see TS 23.501 [2] and TS 38.415 [5]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The UL Delay Result from UE to NG-RAN indicating the uplink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (excluding the D1 UL PDCP delay occurred in the UE) (see TS 38.415 [5]. The UL Delay Result is denoted by $DRul$ in the present document);

The PSA UPF counts the number (N) of GTP PDU monitoring response packets for the S-NSSAI and QoS flow received in the granularity period, and takes the following calculation:

$$\frac{\sum_{i=1}^{N}(T4_i - T3_i + DRul_i)}{N}$$

d) Each measurement is a real representing the average delay in 0.1 ms.

e) GTP.DelayUlPsaUpfUeMeanExcD1.*SNSSAI.QFI*.

Where *SNSSAI* identifies the S-NSSAI, and *QFI* identifies the QoS flow.

f) UPFFunction.

g) N4 Session Identifier.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.2.2.1.3 Average UL packet delay between PSA UPF and UE for a QoS flow (including D1)

a) This measurement provides the average UL packet delay between PSA UPF and UE for a QoS flow, including the D1 UL PDCP delay occurred in the UE. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs the per QoS Flow per UE QoS monitoring according to the QoS monitoring request received from SMF during PDU Session Establishment or Modification procedure (see TS 23.501 [2]). The QoS monitoring can be initiated on SMF by management system via `QFQoSMonitoringControl` MOI (see TS 28.541 [3]), or by PCF via QoS Monitoring policy included in the PCC rule provisioning (see TS 23.503 [4]).

PSA UPF creates and sends the monitoring packets to the RAN according to QoS monitoring request received from the SMF.

For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see TS 23.501 [2] and TS 38.415 [5]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The UL Delay Result from UE to NG-RAN indicating the uplink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU), the delay over Uu interface, and the D1 UL PDCP delay occurred in the UE (see TS 38.415 [5]. The UL Delay Result is denoted by $DRul$ in the present document);

The PSA UPF counts the number (N) of GTP PDU monitoring response packets for the S-NSSAI and the QoS flow received in the granularity period, and takes the following calculation:

$$\frac{\sum_{i=1}^{N}(T4_i - T3_i + DRul_i)}{N}$$

d) Each measurement is a real representing the average delay in 0.1 ms.

e) GTP.DelayDlPsaUpfUeMeanIncD1.*SNSSAI.QFI*.

   Where *SNSSAI* identifies the S-NSSAI, and *QFI* identifies the QoS flow.

f) UPFFunction.

g) N4 Session Identifier.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.2.2.1.4 Average UL packet delay between PSA UPF and NG-RAN for a QoS flow

a) This measurement provides the average UL packet delay between PSA UPF and NG-RAN for a QoS flow. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs the per QoS Flow per UE QoS monitoring according to the QoS monitoring request received from SMF during PDU Session Establishment or Modification procedure (see TS 23.501 [2]). The QoS monitoring can be initiated on SMF by management system via `QFQoSMonitoringControl` MOI (see TS 28.541 [3]), or by PCF via QoS Monitoring policy included in the PCC rule provisioning (see TS 23.503 [4]). PSA UPF creates and sends the monitoring packets to the RAN according to QoS monitoring request received from the SMF.

For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see TS 23.501 [2] and TS 38.415 [5]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF.

The PSA UPF counts the number (N) of GTP PDU monitoring response packets for the S-NSSAI and the QoS flow received in the granularity period, and takes the following calculation:

$$\frac{\sum_{i=1}^{N}(T4_i - T3_i)}{N}$$

d) Each measurement is a real representing the average delay in 0.1ms.

e) GTP.DelayUlPsaUpfNgranMean.*SNSSAI.QFI*.
    Where *SNSSAI* identifies the S-NSSAI, and *QFI* identifies the QoS flow.

f) EP_N3 (contained by UPFFunction);
    EP_N9 (contained by UPFFunction).

g) N4 Session Identifier.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by
    NWDAF (see TS 23.288 [7]).

6.2.2.1.5   Average DL packet delay between PSA UPF and NG-RAN for a QoS flow

a) This measurement provides the average DL packet delay between PSA UPF and NG-RAN for a QoS flow. This
    measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs the per QoS Flow per UE QoS monitoring according to the QoS monitoring request received
from SMF during PDU Session Establishment or Modification procedure (see TS 23.501 [2]). The QoS
monitoring can be initiated on SMF by management system via `QFQoSMonitoringControl` MOI (see TS
28.541 [3]), or by PCF via QoS Monitoring policy included in the PCC rule provisioning (see TS 23.503 [4]).
PSA UPF creates and sends the monitoring packets to the RAN according to QoS monitoring request received
from the SMF.

For each GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the
following time stamps and information (see TS 23.501 [2] and TS 38.415 [5]):

- T1 received in the GTP-U header of the monitoring response packet in the "DL Sending Time Stamp
   Repeated" part of UL PDU Session Information (PDU Type 1) Format as defined in 38.415 [5] indicating the
   local time that the DL GTP PDU was sent by the PSA UPF;

- T2 received in the GTP-U header of the monitoring response packet in the "DL Received Time Stamp" part
   of UL PDU Session Information (PDU Type 1) Format as defined in 38.415 [5] indicating the local time that
   the DL GTP PDU was received by the NG-RAN;

The PSA UPF counts the number (N) of GTP PDU monitoring response packets for the S-NSSAI and the QoS
flow received in the granularity period, and takes the following calculation:

$$\frac{\sum_{i=1}^{N}(T2_i - T1_i)}{N}$$

d) Each measurement is a real representing the average delay in 0.1 ms.

e) GTP.DelayDlPsaUpfNgranMean.*SNSSAI.QFI*.
    Where *SNSSAI* identifies the S-NSSAI, and *QFI* identifies the QoS flow.

f) EP_N3 (contained by UPFFunction);
    EP_N9 (contained by UPFFunction).

g) N4 Session Identifier.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by
    NWDAF (see TS 23.288 [7]).

6.3　　UE level measurements definitions for NG-RAN

6.3.1　　UE level measurements definitions for gNB

6.3.1.1　　Packet delay

6.3.1.1.1　　Average delay DL air-interface

a) This measurement provides the average (arithmetic mean) time it takes for packet transmission over the air-interface in the downlink direction. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D1 (see TS 38.314 [8]) as part of DL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained as: sum of (point in time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of HARQ ACK from UE for UM mode or point in time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of RLC ACK for AM mode, minus time when corresponding RLC SDU part arriving at MAC layer) divided by total number of RLC SDUs transmitted to UE successfully. The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

   [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.AirIfDelayDlUe.*Filter*,
   Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.2　　Average delay DL in gNB-DU

a) This measurement provides the average (arithmetic mean) RLC SDU delay on the downlink within the gNB-DU, for initial transmission of all RLC packets. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D2 (see TS 38.314 [8]) as part of DL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained as: sum of (time when the last part of an RLC SDU was scheduled and sent to the MAC layer for transmission over the air, minus time of arrival of the same packet at the RLC ingress F1-U termination) divided by total number of RLC SDUs arriving at the RLC ingress F1-U termination. If the RLC SDU needs retransmission (for Acknowledged Mode) the delay will still include only one contribution (the original one) to this measurement. The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of S-NSSAIs.
   [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.RlcSduDelayDlUe.*Filter*,
   Where Filter is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

    f) NRCellDU

    g) S-TMSI.

    h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.3   Average delay DL on F1-U

    a) This measurement provides the average (arithmetic mean) GTP packet delay DL on the F1-U interface. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D3 (see TS 38.314 [8]) as part of DL M6 measurement (see TS 37.320 [9]).

    b) DER (n=1)

    c) This measurement is obtained as: the time when receiving a GTP packet from the gNB-DU at the ingress GTP termination of GNBCUUPFunction, minus time when the same packet was sent to gNB-DU from the GTP egress termination of GNBCUUPFunction, minus feedback delay time (including queuing delay) in gNB-DU, obtained result is divided by two. The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.
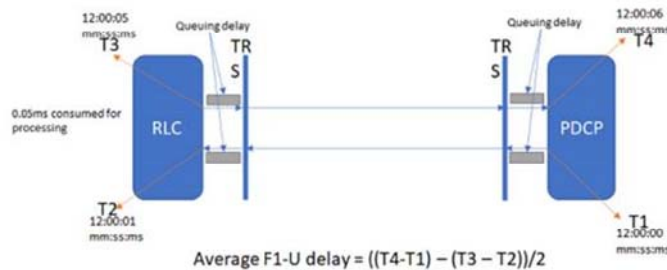

Figure 6.3.1.1.3-1 Average delay DL on F1U

    d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of S-NSSAIs.
      [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) $\leq$ 100.

    e) The measurement name has the form DRB.PdcpF1DelayDlUe.*Filter*,
      Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

    f) GNBCUUPFunction

    g) S-TMSI.

    h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

    NOTE : The NR RAN container (DL USER DATA/ DL DATA DELIVERY STATUS) carried in the GTP-U packet over the F1-U interface is used for the measurement.

6.3.1.1.4   Average delay DL in CU-UP

    a) This measurement provides the average (arithmetic mean) PDCP SDU delay on the downlink within the gNB-CU-UP, for all PDCP packets. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D4 (see TS 38.314 [8]) as part of DL M6 measurement (see TS 37.320 [9]).

    b) DER (n=1)

c) This measurement is obtained as: sum of (time when sending a PDCP SDU to the gNB-DU at the egress PDCP layer on F1-U/Xn-U, minus time of arrival of the same packet at NG-U ingress IP termination) divided by total number of PDCP SDUs arriving at NG-U ingress IP termination. The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduDelayDlUe.*Filter*,
Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.5 UL PDCP packet average delay

a) This measurement provides the average (arithmetic mean) UL PDCP packet average delay. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D1 (see TS 38.314 [8]) as part of UL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained according to the definition in clause 4.3.1.1 of TS 38.314 [8], named "UL PDCP Packet Average Delay per DRB per UE". The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpDelayUlUe.*Filter*,
Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.6 Average delay UL on over-the-air interface

a) This measurement provides the average (arithmetic mean) over-the-air packet delay on the uplink. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D2.1 (see TS 38.314 [8]) as part of UL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained according to the definition in clause 4.2.1.2.2 of TS 38.314 [8], named "Average over-the-air interface packet delay in the UL per DRB per UE". The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.AirIfDelayUlUe.*Filter*,
    Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.7   Average RLC packet delay in the UL

a) This measurement provides the average (arithmetic mean) RLC packet delay on the uplink, i.e., the delay within the gNB-DU. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D2.2 (see TS 38.314 [8]) as part of UL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained according to the definition in clause 4.2.1.2.3 of TS 38.314 [8], named "Average RLC packet delay in the UL per DRB per UE". The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in the unit 0.1 milliseconds. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

    [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.RlcDelayUlUe.*Filter*,
    Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.1.8   Average PDCP re-ordering delay in the UL

a) This measurement provides the average (arithmetic mean) PDCP re-ordering delay on the uplink, i.e., the delay within the gNB-CU-UP. The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as D2.4 (see TS 38.314 [8]) as part of UL M6 measurement (see TS 37.320 [9]).

b) DER (n=1)

c) This measurement is obtained according to the definition in clause 4.2.1.2.4 of TS 38.314 [8], named "Average PDCP re-ordering delay in the UL per DRB per UE". The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in the unit 0.1 milliseconds. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

    [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpReordDelayUlUe.*Filter*,
    Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) S-TMSI.

h) One usage of this measurement is to support the end-to-end data volume transfer time analytics conducted by NWDAF (see TS 23.288 [7]).

6.3.1.2   Packet Loss for all gNB deployment scenario

6.3.1.2.1   DL Packet Loss Rate on Uu

a) This measurement provides the DL Packet (i.e., RLC SDU) Loss rate on Uu interface. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. This measurement is also referred to as DL M7 in TS 37.320 [9].

b) CC

c) This measurement is obtained according to the definition in clause 4.2.1.5.1 of TS 38.314 [8], named "Packet Uu Loss Rate in the DL per DRB per UE". The measurement is performed per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels multiplied by the number of supported S-NSSAIs.

e) DRB.PacketLossRateUuDlUe.*Filter*,
Where *Filter* is a combination of QoS level and S-NSSAI, QoS level represents the mapped 5QI or QCI level, and *SNSSAI* represents S-NSSAI.

f) NRCellDU

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

6.3.1.3   Packet loss for split gNB deployment scenario

6.3.1.3.1   UL PDCP SDU Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at gNB-CU-UP. It is a measure of the UL packet loss including any packet losses in the air interface, in the gNB-CU and on the F1-U interface. Only user-plane traffic (DTCH) and only PDCP SDUs that have entered PDCP (and given a PDCP sequence number) are considered. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI. This measurement is also referred to as UL M7 in TS 37.320 [9].

b) SI

c) This measurement is obtained as: 1,000,000* Number of missing UL PDCP sequence numbers, representing packets that are not delivered to higher layers, of a data radio bearer, divided by Total number of UL PDCP sequence numbers (also including missing sequence numbers) of a bearer, starting from the sequence number of the first packet delivered by UE PDCP to gNB-CU-UP until the sequence number of the last packet. If transmission of a packet might continue in another cell, it shall not be included in this count. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurements are performed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.PacketLossRateUlUe, and optionally DRB.PacketLossRateUlUe.*QoS* where *QoS* identifies the target quality of service class, and DRB.PacketLossRateUlUe.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) GNBCUUPFunction;

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

6.3.1.3.2   UL F1-U Packet Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at gNB-CU-UP. It is a measure of the UL packet loss on the F1-U interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI. This measurement is also referred to as UL M7 in TS 37.320 [9].

b) SI

c) This measurement is obtained as: 1,000,000* Number of missing UL GTP sequence numbers (TS 29.281 [15]), representing packets that are not delivered to higher layers, of a data radio bearer, divided by Total number of UL GTP sequence numbers (also including missing sequence numbers) of a bearer, starting from the GTP sequence number of the first packet delivered by gNB-DU to gNB-CU-UP until the GTP sequence number of the last packet. Separate counters are optionally maintained for mapped 5QI (or QCI for option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are performed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.F1UpacketLossRateUlUe, and optionally DRB.F1UPacketLossRateUlUe.*QoS* where *QoS* identifies the target quality of service class, and DRB.F1UPacketLossRateUlUe.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) GNBCUUPFunction

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

6.3.1.3.3   DL F1-U Packet Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at the gNB-DU). It is a measure of the DL packet loss on the F1-U interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI. This measurement is also referred to as DL M7 in TS 37.320 [9].

b) SI

c) This measurement is obtained as: 1,000,000* Number of missing DL GTP sequence numbers (TS 29.281 [15]), representing packets that are not delivered to lower layers, of a data radio bearer, divided by Total number of UL GTP sequence numbers (also including missing sequence numbers) of a bearer, starting from the sequence number of the first packet delivered by gNB-CU-UP to gNB-DU until the GTP sequence number of the last packet. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are performed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.F1UpacketLossRateDlUe, and optionally DRB.F1UPacketLossRateDlUe.*QoS* where *QoS* identifies the target quality of service class, and DRB.F1UPacketLossRateDlUe.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

6.3.1.4 UE throughput

6.3.1.4.1 Average DL UE throughput in gNB

a) This measurement provides the average UE throughput in downlink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless of if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI. This measurement is also referred to as DL M5 in TS 37.320 [9].

b) DER(N=1)

c) This measurement is obtained according to the following formula based on the "ThpVolDl" and "ThpTimeDl" defined below. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.

If $\sum ThpTimeDl > 0$, $\frac{\sum ThpVolDl}{\sum ThpTimeDl} \times 1000$ [kbit/s]

If $\sum ThpTimeDl = 0$, 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission, $ThpTimeDl = 0$, otherwise $ThpTimeDl = T1 - T2 \, [ms]$

ThpTimeDl	The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeDl" for each time the DL buffer for one Data Radio Bearer (DRB) 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 RLC SDU available for transmission for the particular DRB was successfully transmitted, as acknowledged by the UE.
$T2$	The point in time when the first transmission begins after a RLC SDU becomes available for transmission, where previously no RLC SDUs were available for transmission for the particular DRB.
$ThpVolDl$	The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolDl is the data volume, counted on RLC SDU level, in kbit successfully transmitted (acknowledged by UE) in DL for one DRB during a sample of ThpTimeDl. (It shall exclude the volume of the last piece of data emptying the buffer).

d) Each measurement is a real value representing the throughput in kbit per second. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form
DRB.UEThpDl, or optionally
DRB.UEThpDl.*QoS,* where *QoS* identifies the target quality of service class, and
DRB.UEThpDl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

6.3.1.4.2 Average UL UE throughput in gNB

a) This measurement provides the average UE throughput in uplink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless of using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI. This measurement is also referred to as UL M5 in TS 37.320[9].

B) DER(N=1)

c) This measurement is obtained according to the following formula based on the "ThpVolUl" and "ThpTimeUl" defined below. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.

If $\sum ThpTimeUl > 0$, $\frac{\sum ThpVolUl}{\sum ThpTimeUl} \times 1000$ [kbit/s]

If $\sum ThpTimeUl = 0$, 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission $ThpTimeUl = 0$

otherwise $ThpTimeUl = T1 - T2$ [ms]

ThpTimeUl	The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeUl" for each time the UL buffer for one Data Radio Bearer (DRB) 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 DRB
$T2$	The point in time when transmission is started for the first data in data burst for a particular DRB.
$ThpVolUl$	The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolUl is the data volume counted on RLC SDU level in kbit received in UL for one DRB during a sample of ThpTimeUl, (It shall exclude the volume of the last piece of data emptying the buffer).

d) Each measurement is a real value representing the throughput in kbit per second. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form
DRB.UEThpUl, or optionally
DRB.UEThpUl.*QoS,* where *QoS* identifies the target quality of service class, and
DRB.UEThpUl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU

g) S-TMSI

h) One usage of this measurement is to support ML training and performance evaluation.

Annex A (normative): Template for definitions of UE level measurements

Following is the template for defining the UE level measurements for 5G system.

Clause title: descriptive measurement name

This is a descriptive name of the measurement type that is specified as clause X of the present document.

a) Description

This subclause contains an explanation of the measurement.

b) Collection Method

This n contains the form in which this measurement data is obtained:

- **CC** (Cumulative Counter);

- **GAUGE** (dynamic variable), used when data being measured can vary up or down during the period of measurement;

- **DER** (Discrete Event Registration), when data related to a particular event are captured every n^{th} event is registered, where n can be 1 or larger;

- **SI** (Status Inspection);

- **TF** (Transparent Forwarding);

- **OM** (Object Mapping).

c) Condition

This subclause contains the condition which causes the measurement result data to be updated;
This will be defined by identifying protocol related trigger events for starting and stopping measurement processes, or updating the current measurement result value. Where it is not possible to give a precise condition, then the conditional circumstances leading to the update are stated.

If a measurement is related to "external" technologies, this subclause shall give a brief reference to other standard bodies.

d) Measurement Result (measured value(s), Units)

This subclause contains a description of expected result value(s) (e.g. a single integer value). If a measurement is related to "external" technologies, this subclause shall also give a brief reference to other standard bodies.

The definition applies for each measurement result.

e) Measurement Type

This subclause contains a short form of the measurement name specified in the header, which is used to identify the measurement type in the result files.

The measurement names are dotted sequences of items. The sequence of elements identifying a measurement is organised from the general to the particular:

- The first item identifies the measurement family (e.g. RRC, DRB, HO). Note that this family may also be used for measurement administration purpose.

- The second item identifies the name of the measurement itself, for which the following rules shall apply:

    ▪ The second item of the measurement name can be divided into <Operation>, <Reason/Result> and <Direction> (and in that order)

    ▪ Examples of Operation can be Establishment, Release, and Modification

- ▪ Examples of Reason/Result can be Attempt, Failure, Success, Throughput and Volume

- ▪ Examples of Direction can be Incoming, Outgoing, Uplink and Downlink

- Depending on the measurement type, additional items may be present to specify subcounters (failure causes, traffic classes, min, max, avg, G, U, ...). In case of multiple additional items, they are also represented as a dotted sequence of items. When available, the template will describe to which standard it is referring to for these additional items (e.g. cause, traffic class). Otherwise, the additional item semantics need to be described in detail in the present document.

  Standardised causes will be a number. This number shall be derived according to which of the following rules applies:

  - For the standardised causes with numeric values explicitly specified in the reference specification, the subcounter name will be the number assigned to this cause in this reference specification.

  - For the standardised causes without numeric values explicitly specified in the reference specification, but where the causes are identified, the subcounter name shall be a number from 1 to n mapped in an incremental sequence to each of the specified causes following top-down sequence in the order they are identified in the reference specification (e.g. RRC.ConnEstabAtt.1, 1 identifies the establishment cause "emergency", see TS 38.331 [6]).

  - For the standardised causes without numeric values explicitly specified in the reference specification and the causes identified and the causes have been divided into different cause groups, the subcounter should be defined as the form of *'Cause group'.Cause*, where:

    - the subcounter name of *'Cause group'* shall be an incremental number from 1 to n to identify each cause group specified in a top-down sequence following the order they are identified in the reference specification;

    - the subcounter name of *cause* within this cause group shall be an incremental number from 1 to n to identify each cause within the group specified in a top-down sequence following the order they are identified within the cause group in the reference specification;

      the non standardised causes should be a string (e.g. RRC.ConnEstab.NoReply).

f) Measured Object Class

This subclause describes the measured object class (e.g., `NRCellCU`, `NRCellDU`, `GNBCUCPFunction`, `UPFFunction`). The object class used for this purpose shall be in accordance with NRMs defined in any NRM IRPs, such as those defined in 3GPP TS 28.541 [3].

For object classes currently not defined according to the above, the present document defines its own nomenclature.

It is possible to use the same measurement name for a standardized measurement type implemented at a different object class level than the one defined in the Standard. The same measurement type can apply to one or more measurements for which all fields of the measurement template are the same except the item f) "Measurement Object Class". For instance, a measurement which uses the same template as a given measurement type but relates to another or different object classes shall have the same name.

g) Measured UE Identifier

This element indicates what type of the identifiers of the UE needs to be provided. The type of the UE identifier could be IMSI, IMEI, SUPI, N4 Session ID or RAN UE ID, etc., subject to the specific measurement.

h) Purpose

This optional clause aims at providing additional information on the interest of the measurement but is purely indicative.

Annex B (informative):
Use cases for UE level measurements

Annex C (informative):
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Re v**	**Cat**	**Subject/Comment**	**New version**
2023-11	SA5#152	S5-237552	-	-	-	Initial skeleton (v0.0.0)	0.0.0
2023-11	SA5#152	S5-237955	-	-	-	Add structure for new draft TS 28.abc UE level measurements	0.1.0
2023-11	SA5#152	S5-238399	-	-	-	Add template for UE level measurement definition	0.1.0
2023-11	SA5#152	S5-238164	-	-	-	Add per-UE measurement related to DL packet delay between PSA UPF and UE	0.1.0
2023-11	SA5#152	S5-238165	-	-	-	Add per-UE measurement related to UL packet delay between PSA UPF and UE	0.1.0
2024-02	SA5#153	S5-240867	-	-	-	Add per-UE measurement related to average packet loss for all gNB deployment scenario	0.2.0
2024-02	SA5#153	S5-240868	-	-	-	Add per-UE measurement related to average packet loss for split gNB deployment scenario	0.2.0
2024-02	SA5#153	S5-240870	-	-	-	Add per-UE measurement related to UE throughput	0.2.0
2024-02	SA5#153	S5-240871	-	-	-	Add UE level measurement related to DL packet delay between NG-RAN and UE	0.2.0
2024-02	SA5#153	S5-240872	-	-	-	dd UE level measurement related to UL packet delay between NG-RAN and UE	0.2.0
2024-02	SA5#153	S5-240873	-	-	-	Add UE level measurement related to packet delay between PSA UPF and NG-RAN	0.2.0
2024-02	SA5#153	S5-240214	-	-	-	Add scope	0.2.0
2024-02	SA5#153	S5-240215	-	-	-	Add overview	0.2.0
2024-02	SA5#153	S5-240866	-	-	-	Add mechanisms for UE level measurements collection and reporting	0.2.0
2024-03	SA#103	SP-240260				Draft after editHelp review and sent to SA for information and approval	1.0.0
2024-03	SA#103					Upgrade to change control version	18.0.0
2024-06	SA#104	SP-240818	0001	1	F	R18 CR 28.558 overview alignment	18.1.0
2024-06	SA#104	SP-240818	0003	-	F	Rel-18 CR TS 28.558 corrections on the average delay measurement	18.1.0
2024-06	SA#104	SP-240818	0004	-	F	Rel-18 CR TS 28.558 Correct the description of the reference for gNB measurements	18.1.0

History

Document history		
V18.0.0	May 2024	Publication
V18.1.0	July 2024	Publication