

O-RAN Working Group 3 Near-Real-time RAN Intelligent Controller E2 Service Model (E2SM) KPM

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O-RAN Working Group 3 Near-Real-time RAN Intelligent Controller E2 Service Model (E2SM) KPM

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Revision History

Date	Revision	Description
2018.11.25	00.00.0	Applied skeleton 00.01.04 to build KPM Monitor E2SM
2018.12.01	00.00.1	Applied change from E2SM-NI-v000.01.05
2018.12.09	00.00.2	Removed Policy section, specifies detail list of container IE
2018.12.11	00.00.3	Align with E2SM-NI as per comments from A. Urie
2018.12.12	00.00.4	Add E2 Node ID, O-CU-CP/O-CU-UP container as per comments from WG3
2018.12.18	00.00.5	Updated Style Type and Format Type definition aligned with Nokia E2SM-NI v00.01.08
2019.01.14	00.00.6	Change name from KPIMON to KPMMON, additional alignment with Nokia E2SM-NI v00.01.08 and ASN.1 message addition
2019.01.16	00.00.7	ASN.1 update
2019.01.17	00.00.8	Add RIC Style Type in RIC Indication message IE with a corresponding change to the ASN.1 encoding
2019.01.19	00.00.9	Change the name to E2SM-KPM, add Action Definition with RIC style list, made section 7.8 update for additional alignment with E2SM-NI, add Annex A.
2019.01.20	00.00.10	Update Scope, rename Slice ID to S-NSSAI, add Action Definition to each style definition, remove EPC and 5GC style, add CU-CP EPC style, fix the use of 5QI and QCI for E2 indication header, and correctly reference 28.552 for 5GC IEs
2019.01.20	00.00.11	Remove Report Period IE Test Condition and Report Period IE Value from trigger definition and ASN.1. Reference 28.552 for Active UE and PDCP DL/UL data volume
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2021.03.30	02.00.03	Adopt INTEL's CR-0003 for clean-up
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1 Introductory Material

1.1 Scope

This Technical Specification has been produced by the O-RAN Alliance.

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

Release x.y.z

where:

- x the first digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc. (the initial approved document will have x=01).
- y the second digit is incremented when editorial only changes have been incorporated in the document.
- z the third digit included only in working versions of the document indicating incremental changes during the editing process.

The present document specifies the E2 Service Model (E2SM) “Key Performance Measurement” (KPM) for the RAN function handling reporting of the cell-level performance measurements for 5G networks defined in TS 28.552 [4] and for EPC networks defined in TS 32.425 [8], and their possible adaptation of UE-level or QoS flow-level measurements.

2 References

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

- References are either specific (identified by date of publication, 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.

- [1] 3GPP TR 21.905: “Vocabulary for 3GPP Specifications”.
- [2] O-RAN Working Group 3, Near-Real-time RAN Intelligent Controller, Architecture & E2 General Aspects and Principles (E2GAP)
- [3] ORAN WG3, O-RAN Working Group 3, Near-Real-time RAN Intelligent Controller, E2 Application Protocol (E2AP).
- [4] 3GPP TS 28.552: “Management and orchestration 5G performance measurements”.
- [5] ITU-T Recommendation X.680 (2002-07): “Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation”.
- [6] ITU-T Recommendation X.681 (2002-07): “Information technology – Abstract Syntax Notation One (ASN.1): Information object specification”.

- [7] ITU-T Recommendation X.691 (2002-07): "Information technology - ASN.1 encoding rules - Specification of Packed Encoding Rules (PER)".
- [8] 3GPP TS 32.425: "Telecommunication management Performance Management Performance managements".
- [9] IETF RFC 5905 (2010-06): "Network Time Protocol Version 4: Protocol and Algorithms Specification".
- [10] 3GPP TS 32.404: "Telecommunication management; Performance Management (PM); Performance measurements; Definitions and template".
- [11] 3GPP TR 25.921: "Guidelines and principles for protocol description and error handling".
- [12] O-RAN Working Group 3, Near-Real-time RAN Intelligent Controller, E2 Service Model (E2SM)
- [13] 3GPP TS 36.413: "E-UTRAN; S1 Application Protocol (S1AP)"

3 Definitions and Abbreviations

3.1 Definitions

E2 Node: as defined in E2GAP [2].

RAN Function: as defined in E2GAP [2]

E2 Service Model: The description of the Services exposed by a specific RAN function within an E2 Node over the E2 interface towards the Near-RT RIC.

KPM Report: The performance measurements for 4G LTE and 5G NR Network Functions.

3.2 Abbreviations

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

O-CU	O-RAN Central Unit
O-CU-CP	O-RAN Central Unit – Control Plane
O-CU-UP	O-RAN Central Unit – User Plane
O-DU	O-RAN Distributed Unit
Near-RT RIC	Near-real-time RAN Intelligent Controller
Non-RT-RIC	Non-real-time RAN Intelligent Controller
EN-DC	E-UTRA-NR Dual Connectivity
MR-DC	Multi-Radio Dual Connectivity

4 General

4.1 Forwards and Backwards Compatibility

The forwards and backwards compatibility of the protocol is assured by a mechanism where all current and future messages, and IEs or groups of related IEs, include ID and criticality fields that are coded in a standard format that will not be changed in the future. These parts can always be decoded regardless of the standard version.

4.2 Specification Notations

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

Service	When referring to a Service in the specification the SERVICE NAME is written with upper case characters and in bold followed by the word "service", e.g. REPORT service.
Procedure	When referring to an elementary procedure in the specification the Procedure Name is written with the first letters in each word in upper case characters followed by the word "procedure", e.g. Handover Preparation procedure.
Message	When referring to a message in the specification the MESSAGE NAME is written with all letters in upper case characters followed by the word "message", e.g. HANDOVER REQUEST message.
IE	When referring to an information element (IE) in the specification the <i>Information Element Name</i> is written with the first letters in each word in upper case characters and all letters in Italic font followed by the abbreviation "IE", e.g. <i>E-RAB ID</i> IE.
Value of an IE	When referring to the value of an information element (IE) in the specification the "Value" is written as it is specified in the specification enclosed by quotation marks, e.g. "Value".

4.3 Identifiers

For the purposes of the present document, the following identifiers are defined:

Style Type	The identifier used to nominate a specific approach or Style used to exposing a given RIC Service (REPORT, INSERT, CONTROL and POLICY). The same E2SM may support more than one Style for each RIC Service.
Format Type	The identifier used to nominate a specific formatting approach used to encode one of the E2AP IEs defined in this E2SM. The same E2SM may support more than one encoding Formats for each E2AP IE and each E2AP IE message encoding Format may be used by one or more RIC Service Styles.

5 E2SM Services

As defined in E2 General Aspects and Principles [2], a given RAN Function offers a set of services to be exposed over the E2 (REPORT, INSERT, CONTROL and/or POLICY) using E2AP [3] defined procedures. Each of the E2AP Procedures listed in table 5-1 contains specific E2 Node RAN Function dependent Information Elements (IEs).

Table 5-1: Relationship between E2SM services and E2AP Information elements

RAN Function specific E2SM Information Elements	E2AP Information Element reference	Related E2AP Procedures
RIC Event Trigger Definition	E2AP [3] section 9.2.9	RIC SUBSCRIPTION
RIC Action Definition	E2AP [3] section 9.2.12	RIC SUBSCRIPTION
RIC Indication Header	E2AP [3] section 9.2.17	RIC INDICATION
RIC Indication Message	E2AP [3] section 9.2.16	RIC INDICATION
RIC Call Process ID	E2AP [3] section 9.2.18	RIC INDICATION RIC CONTROL
RIC Control Header	E2AP [3] section 9.2.20	RIC CONTROL
RIC Control Message	E2AP [3] section 9.2.19	RIC CONTROL
RAN Function Definition IE	E2AP [3] section 9.2.23	E2 SETUP RIC SERVICE UPDATE

All of these RAN Function specific IEs are defined in E2AP [3] as "OCTET STRING".

1 The purpose of this specification is to define the contents of these fields for the specific RAN Function “KPM
2 Monitor”.

6 RAN Function Service Model Description

6.1 RAN Function Overview

E2 Service Model KPM (E2SM-KPM) supports O-CU-CP, O-CU-UP, and O-DU as part of NG-RAN connected to 5GC or as part of E-UTRAN connected to EPC.

The E2 Node shall host the RAN Function “KPM Monitor” which performs the following functionalities:

- Exposure of available measurements from O-DU, O-CU-CP, and/or O-CU-UP via the RAN Function Definition IE.
- Periodic reporting of measurements subscribed from Near-RT RIC.

This E2SM specification also exposes a set of services described in clause 6.2.

6.2 Supported RIC Services

6.2.1 REPORT

The “KPM Monitor” RAN Function provides the following **REPORT** services:

- E2 Node Measurement
- E2 Node Measurement for a single UE
- Condition-based, UE-level E2 Node Measurement
- Common Condition-based, UE-level E2 Node Measurement
- E2 Node Measurements for multiple UEs

These services may be initiated according to:

- Periodical event.

7 RAN Function Description

7.1 Description

The E2AP [3] procedures, E2 SETUP and RIC SERVICE UPDATE, are used to transport the RAN Function Definition IE.

In this E2SM-KPM, the *RAN Function Definition* IE shall provide the following information:

- RAN Function name along with associated information on E2SM definition
- Event trigger styles list along with the corresponding encoding type for each associated E2AP IE.
- RIC REPORT Service styles list along with the corresponding encoding type for each associated E2AP IE.

7.2 RAN Function Name

RAN Function Short Name “ORAN-E2SM-KPM”

RAN Function Description “KPM Monitor”

RAN Function Instance, required when and if an E2 Node exposes more than one instance of a RAN Function based on this E2SM.

7.3 Supported RIC Event Trigger Styles

7.3.1 Event Trigger Style Types

RIC Style Type	Style Name	Supported RIC Service Style			Style Description
		Report	Insert	Policy	
1	Periodic Report	1	-	-	<i>RIC Event Trigger Definition</i> IE based on reporting period

7.3.2 Event Trigger Style 1: Periodic Report

This Event Trigger style 1 is to set the KPM report period and uses the *RIC Event Trigger Definition* IE Format 1 (8.2.1.1.1)

7.4 Supported RIC REPORT Service Styles

7.4.1 REPORT Service Style Type

RIC Style Type	Style Name	Style Type Description
1	E2 Node Measurement	Used to carry measurement report from a target E2 Node
2	E2 Node Measurement for a single UE	Used to carry measurement report for a single UE of interest from a target E2 Node
3	Condition-based, UE-level E2 Node Measurement	Used to carry UE-level measurement report for a group of UEs per measurement type matching subscribed conditions from a target E2 Node
4	Common Condition-based, UE-level Measurement	Used to carry measurement report for a group of UEs across a set of measurement types satisfying common subscribed conditions from a target E2 Node
5	E2 Node Measurement for multiple UEs	Used to carry measurement report for multiple UE of interest from a target E2 Node

7.4.2 REPORT Service Style 1: E2 Node Measurement

7.4.2.1 REPORT Service Style description

The REPORT Service style 1 provides the performance measurement information collection from an E2 Node.

7.4.2.2 REPORT Service *RIC Action Definition* IE contents

This REPORT Service style aims to subscribe to the measurements defined in TS 28.552 [4] and TS 32.425 [8], and uses the *RIC Action Definition* IE Format 1 (8.2.1.2.1).

The REPORT Service *RIC Action Definition* IE contains measurement types that Near-RT RIC is requesting to subscribe followed by a list of subcounters to be measured for each measurement type, and a granularity period indicating collection interval of those measurements.

For the measurement types that belong to a measurement object class confined in a single cell (e.g. "EUTRANCellFDD" in TS 32.425 [8] or "NRCellIDU" in TS 28.552 [4]), the *Cell Global ID* IE shall be included in the IE to point to a specific

cell for collecting measurements within the E2 Node. The *Cell Global ID* IE may not be included if all the subscribed measurement types are cell agnostic, i.e. belonging to measurement object classes not confined in a single cell (e.g. "GNBCUUPFunction" in TS 28.552 [4]). In case that both single-cell-confined and cell agnostic measurement types are subscribed together, the *Cell Global ID* IE shall be included in the IE and the E2 Node shall ignore the included *Cell Global ID* IE for those cell agnostic measurement types.

A measurement ID can be used for subscription instead of a measurement type if an identifier of a certain measurement type was exposed by an E2 Node via the *RAN Function Definition* IE.

7.4.2.3 REPORT Service *RIC Indication Header* IE contents

This REPORT Service style uses the *RIC Indication Header* IE Format 1 (8.2.1.3.1), which contains a measurement collection start time as UTC format.

The REPORT Service *RIC Indication Header* IE may carry file format version, sender name, sender type, and vendor name as printable strings.

7.4.2.4 REPORT Service *RIC Indication Message* IE contents

This REPORT Service style uses the *RIC Indication Message* IE Format 1 (8.2.1.4.1).

The REPORT Service *RIC Indication Message* IE carries a set of measurement data reported from an E2 Node. The reported data contains a set of measurement records, each collected at every granularity period during the reporting period. In case the E2 Node is not able to provide reliable data for a granularity period during the reporting period, it may include the optional *Incomplete Flag* IE, which indicates that the corresponding measurements record in the reported data is not reliable.

The REPORT Service *RIC Indication Message* IE optionally carry subscription information, i.e. *Measurement Information List* IE that indicates the order of measured values for each measurement record in the reported data, or their granularity period. If not present, the original subscription information shall apply.

7.4.3 REPORT Service Style 2: E2 Node Measurement for a single UE

7.4.3.1 REPORT Service Style description

The REPORT Service style 2 provides the performance measurement information collection for a single UE of interest from an E2 Node.

7.4.3.2 REPORT Service *RIC Action Definition* IE contents

This REPORT Service style uses the *RIC Action Definition* IE Format 2 (8.2.1.2.2), where the included UE ID indicates a specific UE of interest for measurement collection.

The rest of the subscription information follows the same as described in 7.4.2.2.

7.4.3.3 REPORT Service *RIC Indication Header* IE contents

This REPORT Service style uses the *RIC Indication Header* IE Format 1 (8.2.1.3.1) as described in 7.4.2.3.

7.4.3.4 REPORT Service *RIC Indication Message* IE contents

This REPORT Service style uses the *RIC Indication Message* IE Format 1 (8.2.1.4.1) as described in 7.4.2.4, where the measurement data reported is associated only to a specific UE that was subscribed.

7.4.4 REPORT Service Style 3: Condition-based, UE-level E2 Node Measurement

7.4.4.1 REPORT Service Style description

The REPORT Service style 3 provides the UE-level performance measurement information collection for a group of UEs per measurement type matching subscribed conditions from an E2 Node.

7.4.4.2 REPORT Service *RIC Action Definition* IE contents

This REPORT Service style uses the *RIC Action Definition* IE Format 3 (8.2.1.2.3), where, for each requested measurement within the *Measurement Information Condition List* IE, the *Matching Condition* IE serves as a condition to include the matched UEs' measurement values into the reporting. The *Matching Condition* IE can be expressed by a list of subcounters to be measured (i.e. as a list of labels), or by a list of test conditions that need to be passed, or by a combination of both.

The rest of the subscription information follows the same as described in 7.4.2.2.

7.4.4.3 REPORT Service *RIC Indication Header* IE contents

This REPORT Service style uses the *RIC Indication Header* IE Format 1 (8.2.1.3.1) as described in 7.4.2.3.

7.4.4.4 REPORT Service *RIC Indication Message* IE contents

This REPORT Service style uses the *RIC Indication Message* IE Format 2 (8.2.1.4.2).

The REPORT Service *RIC Indication Message* IE carries a set of UE-level measurement data matching subscribed conditions. The included *Measurement Information Condition UE List* IE indicates the order of measured values for each measurement record in the reported data – a list of UE IDs satisfying the subscribed *Matching Condition* IE for each requested measurement.

In every granularity period during which a UE matching a subscribed condition stays in the E2 Node and maintains the RRC_CONNECTED or RRC_INACTIVE state, the E2 Node collects the related data and reports it at the end of the reporting period. In the granularity periods where the UE does not appear in the RRC_CONNECTED or RRC_INACTIVE state (e.g. transitioned to RRC_IDLE or UE identity track is lost), the E2 Node does not collect the related data and NULL is reported for those granularity periods until the end of the Reporting Period. In this case, the E2 Node stops reporting measurements related to this UE in the subsequent reporting periods.

The list of matched UE IDs can be omitted for a certain subscribed measurement type if none of the UEs were matched during the reporting period.

The rest of the information follows the same as described in 7.4.2.4.

7.4.5 REPORT Service Style 4: Common condition-based, UE-level Measurement

7.4.5.1 REPORT Service Style description

The REPORT Service style 4 provides the UE-level performance measurement information collection for a group of UEs across a set of measurement types matching common subscribed conditions from an E2 Node.

7.4.5.2 REPORT Service *RIC Action Definition* IE contents

This REPORT Service style uses the *RIC Action Definition* IE Format 4 (8.2.1.2.4), where a *Matching Condition* IE serves as a condition to include the matched UEs' measurement values into the reporting, common for each requested measurement within the *Measurement Information List* IE. The *Matching Condition* IE is expressed by a list of test conditions to filter matching UEs.

The rest of the subscription information follows the same as described in 7.4.2.2.

7.4.5.3 REPORT Service *RIC Indication Header* IE contents

This REPORT Service style uses the *RIC Indication Header* IE Format 1 (8.2.1.3.1) as described in 7.4.2.3.

7.4.5.4 REPORT Service *RIC Indication Message* IE contents

This REPORT Service style uses the *RIC Indication Message* IE Format 3 (8.2.1.4.3).

The REPORT Service *RIC Indication Message* IE Format 3 carries a list of measurement data for UE(s) matching subscribed conditions.

In every granularity period during which a UE matching a subscribed condition stays in the E2 Node and maintains the RRC_CONNECTED or RRC_INACTIVE state, the E2 Node collects the related data and reports it at the end of the reporting period. In the granularity periods where the UE does not appear in the RRC_CONNECTED or RRC_INACTIVE state (e.g. transitioned to RRC_IDLE or UE identity track is lost), the E2 Node does not collect the related data and NULL is reported for those granularity periods until the end of the Reporting Period. In this case, the E2 Node stops reporting measurements related to this UE in the subsequent reporting periods.

If none of the UEs were matched during the reporting period, then E2 Node does not report measurements for that reporting period.

The rest of the information follows the same as described in 7.4.2.4.

7.4.6 REPORT Service Style 5: E2 Node Measurement for Multiple UEs

7.4.6.1 REPORT Service Style description

The REPORT Service style 5 provides the performance measurement information collection for multiple UEs of interest from an E2 Node.

7.4.6.2 REPORT Service *RIC Action Definition* IE contents

This REPORT Service style uses the *RIC Action Definition* IE Format 5 (8.2.1.2.5), where the included UE Identifiers indicates UEs of interest for measurement collection.

The rest of the subscription information follows the same as described in 7.4.2.2.

7.4.6.3 REPORT Service *RIC Indication Header* IE contents

This REPORT Service style uses the *RIC Indication Header* IE Format 1 (8.2.1.3.1) as described in 7.4.2.3.

7.4.6.4 REPORT Service *RIC Indication Message* IE contents

This REPORT Service style uses the *RIC Indication Message* IE Format 3 (8.2.1.4.3) as described in 7.4.5.4, where the measurement data reported is associated to multiple UEs that was subscribed and available in the system.

7.5 Supported RIC INSERT Service Styles

Note: Not used in this service model

7.6 Supported RIC CONTROL Service Styles

Note: Not used in this service model

7.7 Supported RIC POLICY Service Styles

Note: Not used in this service model

7.8 Supported RIC Styles and E2SM IE Formats

Table 7.8-1 and 7.8-2 provide a summary of the E2SM IE Formats defined to support this E2SM specification.

Table 7.8-1: Summary of the E2SM IE Formats defined to support RIC Event Trigger Styles

RIC Event Trigger Style	Event Trigger Definition Format
Style 1	1

Table 7.8-1: Summary of the E2SM IE Formats defined to support RIC Service Styles

RIC Service Style	Action Definition Format	Indication Header Format	Indication Message Format	Call Process ID Format	Control Header Format	Control Message Format	Control Outcome Format
REPORT							
Style 1	1	1	1				
Style 2	2	1	1				
Style 3	3	1	2				
Style 4	4	1	3				
Style 5	5	1	3				
INSERT							
CONTROL							
POLICY							

7.9 Conversion for UE-level and QoS flow-level measurements derived from 3GPP defined measured values

The conversion of the measurements' definitions provided in TS 28.552 [4], TS 32.425 [8], and O-RAN specific measurement defined in Section 7.10 is performed according to the following rules:

The type of the original measurements	The corresponding per-UE and per-UE-per-slice measurements	The corresponding per-QoS flow and per-slice-per-QoS flow measurements	Notes
Throughput Delay Data volume In-session activity time	Measured per UE	Measured per QoS flow	For the Throughput and Data volume measurements, the formulas specified in 3GPP are used with restriction to the individual UE or individual QoS flow , and also based on Section 7.9.1.
PDCCP drop rate IP latency	Measured per UE	Measured per QoS flow	For the Throughput and Data volume measurements, the formulas specified in

			3GPP are used with restriction to the individual UE or individual QoS flow.
Radio resource utilization	Measured per UE	N/A	The formulas specified in 3GPP are used with restriction to the individual UE.
RRC connections related PDU sessions related DRBs related QoS flows related	Measured per UE	N/A	
Mobility management	Measured per UE	N/A	
CQI related MCS related	Measured per UE	N/A	
PEE related	N/A	N/A	
Distribution of Normally/Abnormally Released Calls	Measured per UE	N/A	

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7.9.1 Changes in the units of measurements while adopting for E2SM-KPM

3

The units of the following measurements in TS 28.552 [4] and TS 32.425 [8] are replaced with newer units, as shown in the table below.

4

Measurement Type	Measurement Name	Data Type	Unit used in 3GPP	Unit used in E2SM-KPM
DL Cell PDCP SDU Data Volume, defined in TS 28.552 [4] clause 5.1.2.1.2.1.	DRB.PdcpSduVolumeDL_Filter	INTEGER	Mbit	Kbit
UL Cell PDCP SDU Data Volume, defined in TS 28.552 [4] clause 5.1.2.1.2.2.	DRB.PdcpSduVolumeUL_Filter	INTEGER	Mbit	Kbit
DL PDCP PDU Data Volume, defined in TS 28.552 [4] clause 5.1.3.6.1.1.	QosFlow.PdcpPduVolumeDL_Filter	INTEGER	Mbit	Kbit
UL PDCP PDU Data Volume, defined in TS 28.552 [4] clause 5.1.3.6.1.2.	QosFlow.PdcpPduVolumeUL_Filter	INTEGER	Mbit	Kbit
DL PDCP SDU Data Volume, defined in TS 28.552 [4] clause 5.1.3.6.2.1.	QosFlow.PdcpSduVolumeDI_Filter	INTEGER	Mbit	Kbit
UL PDCP SDU Data Volume, defined in TS 28.552 [4] clause 5.1.3.6.2.2.	QosFlow.PdcpSduVolumeUI_Filter	INTEGER	Mbit	Kbit
DL Cell PDCP SDU Data Volume on X2 interface, defined in TS 28.552 [4] clause 5.1.2.1.1.2.	DRB.PdcpSduVolumeX2DL_Filter	INTEGER	Mbit	Kbit
UL Cell PDCP SDU Data Volume on X2 interface, defined in TS 28.552 [4] clause 5.1.2.1.2.2.	DRB.PdcpSduVolumeX2UL_Filter	INTEGER	Mbit	Kbit
DL Cell PDCP SDU Data Volume on Xn interface, defined in TS 28.552 [4] clause 5.1.2.1.1.3.	DRB.PdcpSduVolumeXnDL_Filter	INTEGER	Mbit	Kbit
UL Cell PDCP PDU Data Volume on Xn interface, defined in TS 28.552 [4] clause 5.1.2.1.2.3.	DRB.PdcpSduVolumeXnUL_Filter	INTEGER	Mbit	Kbit
DL PDCP SDU Data Volume per interface, defined in TS 28.552 [4] clause 5.1.3.6.2.3.	DRB.F1uPdcpSduVolumeDI.QoS, DRB.X2uPdcpSduVolumeDI.QoS, DRB.XnuPdcpSduVolumeDI.QoS	INTEGER	Mbit	Kbit
UL PDCP SDU Data Volume per interface, defined in TS 28.552 [4] clause 5.1.3.6.2.4.	DRB.F1uPdcpSduVolumeUI.QoS, DRB.X2uPdcpSduVolumeUI.QoS, DRB.XnuPdcpSduVolumeUI.QoS	INTEGER	Mbit	Kbit
DL cell PDCP SDU Data Volume, defined in TS 32.425 [8] clause 4.4.7.1.	DRB.PdcpSduVolumeDI_Filter	INTEGER	Mbit	Kbit
UL cell PDCP SDU Data Volume, defined in TS 32.425 [8] clause 4.4.7.2.	DRB.PdcpSduVolumeUI_Filter	INTEGER	Mbit	Kbit
In-session activity time for UE, defined in TS 28.552 [4] clause 5.1.1.13.2.2.	QF.SessionTimeUE	INTEGER	s	ms
In-session activity time for DRB, defined in TS 28.552 [4] clause 5.1.1.10.4.	DRB.SessionTime.5QI, DRB.SessionTime.SNSSAI	INTEGER	s	ms
In-session activity time for QoS flow, defined in TS 28.552 [4] clause 5.1.1.13.2.1.	QF.SessionTimeQoS.QoS	INTEGER	s	ms
In-session activity time for UE, defined in TS 32.425 [8] clause 4.2.4.1.	ERAB.SessionTimeUE	INTEGER	s	ms
In-session activity time for E-RABs, defined in TS 32.425 [8] clause 4.2.4.2.	ERAB.SessionTimeQCI.QCI	INTEGER	s	ms
IP throughput in UL, defined in TS 32.425 [8] clause 4.4.6.2.	DRB.IPThpUI.QCI	REAL	Kbit	Kbit/s

The changes in the units of the measurements shown in the above table are to prevent the reported values from being reported as 0 caused by rounding off the precision in the decimals to report them as INTEGER, except the last row of “IP throughput in UL”, which is to fix the erroneous unit.

7.10 O-RAN specific Performance Measurement

7.10.1 DL Transmitted Data Volume

Measurement Name	DL Transmitted Data Volume
a) Description	<p>This measurement provides the transmitted data volume in the downlink in a measurement time. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.</p> <p>The unit is kbit.</p>
b) Collection Method	CC
c) Condition	<p>This measurement is obtained by counting the data volume counted on RLC SDU level, in kbit successfully transmitted (acknowledged by UE) in DL for one DRB during measurement time T. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.</p>
d) Measurement Result	<p>Each measurement is an integer value representing the number of bits measured in kbits (1kbits=1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.</p>
e) Measurement Type	<p>The measurement name has the form DRB.RlcSduTransmittedVolumeDL_Filter.</p> <p>Where filter is a combination of PLMN ID and QoS level and S-NSSAI.</p> <p>Where PLMN ID represents the PLMN ID, QoS represents the mapped 5QI or the QCI level, and SNSSAI represents S-NSSAI.</p>
f) Measurement Object Class	NRCelIDU
g) Switching Technology	Valid for packet switched traffic
h) Generation	5GS
i) Purpose	<p>One usage of this measurement is for performance assurance within integrity area (user plane connection quality).</p>

1 7.10.2 UL Transmitted Data Volume

Measurement Name	UL Transmitted Data Volume
a) Description	<p>This measurement provides the transmitted data volume in the uplink in a certain period. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.</p> <p>The unit is kbit.</p>
b) Collection Method	CC
c) Condition	<p>This measurement is obtained by counting the data volume counted on RLC SDU level, in kbit successfully transmitted (acknowledged by E2 Node) in UL for one DRB during measurement time T. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.</p>
d) Measurement Result	<p>Each measurement is an integer value representing the number of bits measured in kbits (1kbits=1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.</p>
e) Measurement Type	<p>The measurement name has the form DRB.RlcSduTransmittedVolumeUL_Filter.</p> <p>Where filter is a combination of PLMN ID and QoS level and S-NSSAI.</p> <p>Where PLMN ID represents the PLMN ID, QoS represents the mapped 5QI or the QCI level, and SNSSAI represents S-NSSAI.</p>
f) Measurement Object Class	NRCelIDU
g) Switching Technology	Valid for packet switched traffic
h) Generation	5GS
i) Purpose	<p>One usage of this measurement is for performance assurance within integrity area (user plane connection quality).</p>

2

7.10.3 Distribution of Percentage of DL Transmitted Data Volume to Incoming Data Volume

Measurement Name	Distribution of Percentage of DL Transmitted Data Volume to Incoming Data Volume
a) Description	This measurement provides the distribution of the percentage of successfully transmitted data volume to incoming data volume in downlink for UEs. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.
b) Collection Method	CC
c) Condition	<p>The Measurement is calculated by $100 \cdot x/y$ for each UE.</p> <p>x is incremented by counting the number of bits counted on RLC SDU level successfully transmitted (acknowledged by UE) in DL for one DRB during measurement time T.</p> <p>y is incremented by counting the number of bits entering the RLC layers in DL for one DRB during measurement time T.</p> <p>For each UE, the bin corresponding to the percentage of transmitted data volume to incoming data volume ($100 \cdot x/y$) experienced by the UE is incremented by one.</p> <p>Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.</p>
d) Measurement Result	A set of integers, each representing the (integer) number of samples with a percentage of DL transmitted data volume to incoming data volume in the range represented by that bin. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.
e) Measurement Type	The measurement name has the form DRB.PerDataVolumeDLDist.Bin where Bin represents the bin, or optionally DRB.PerDataVolumeDLDist.Bin.QOS, where QOS identifies the target quality of service class, and DRB.PerDataVolumeDLDist.Bin.SNSSAI, where SNSSAI identifies the S-NSSAI, and DRB.PerDataVolumeDLDist.Bin.PLMN, where PLMN identifies the PLMN ID.
f) Measurement Object Class	NRCelIDU
g) Switching Technology	Packet Switched
h) Generation	5GS
i) Purpose	Network Operator's Traffic Engineering Community

7.10.4 Distribution of Percentage of UL Transmitted Data Volume to Incoming Data Volume

Measurement Name	Distribution of Percentage of UL Transmitted Data Volume to Incoming Data Volume
a) Description	This measurement provides the distribution of the percentage of successfully transmitted data volume to incoming data volume in uplink for UEs. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.
b) Collection Method	CC
c) Condition	<p>The Measurement is calculated by $100 \cdot x/y$ for each UE.</p> <p>x is incremented by counting the number of bits counted on RLC SDU level successfully transmitted (acknowledged by E2 Node) in UL for one DRB during measurement time T.</p> <p>y is incremented by counting the number of bits entering the RLC layers in UL for one DRB during measurement time T. It is up to implementation how to measure y reliably during T.</p> <p>For each UE, the bin corresponding to the percentage of transmitted data volume to incoming data volume ($100 \cdot x/y$) experienced by the UE is incremented by one.</p> <p>Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.</p>
d) Measurement Result	A set of integers, each representing the (integer) number of samples with a percentage of UL transmitted data volume to incoming data volume in the range represented by that bin. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.
e) Measurement Type	The measurement name has the form DRB.PerDataVolumeULDist.Bin where Bin represents the bin, or optionally DRB.PerDataVolumeULDist.Bin.QOS, where QOS identifies the target quality of service class, and DRB.PerDataVolumeULDist.Bin.SNSSAI, where SNSSAI identifies the S-NSSAI, and DRB.PerDataVolumeULDist.Bin.PLMN, where PLMN identifies the PLMN ID.
f) Measurement Object Class	NRCeIDU
g) Switching Technology	Packet Switched
h) Generation	5GS
i) Purpose	Network Operator's Traffic Engineering Community

1 7.10.5 Distribution of DL Packet Drop Rate

Measurement Name	Distribution of DL Packet Drop Rate
a) Description	This measurement provides the fraction of RLC SDU packets which are dropped on the downlink, due to high traffic load, traffic management etc in the gNB-DU. Only user-plane traffic (DTCH) is considered. A dropped packet is one without any part of it having been transmitted on the air 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.
b) Collection Method	SI
c) Condition	This attribute is created by counting the number of UEs experiencing a certain packet loss rate in each range.
d) Measurement Result	Each measurement is an integer value representing the drop rate multiplied by 1E6 of each UE within the range of the bin. 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) Measurement Type	The measurement name has the form DRB.RlcPacketDropRateDLDist and optionally DRB.RlcPacketDropRateDLDist.QOS where QOS identifies the target quality of service class, and DRB.RlcPacketDropRateDLDist.SNSSAI where SNSSAI identifies the S-NSSAI.
f) Measurement Object Class	NRCelIDU
g) Switching Technology	Valid for packet switched traffic
h) Generation	5GS
i) Purpose	One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

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7.10.6 Distribution of UL Packet Loss Rate

Measurement Name	Distribution of UL Packet Loss Rate
a) Description	This measurement provides the distribution of 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.
b) Collection Method	SI
c) Condition	This attribute is created by counting the number of UEs experiencing a certain packet loss rate in each range.
d) Measurement Result	Each measurement is an integer value representing the loss rate multiplied by 1E6 of each UE within the range of the bin. 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) Measurement Type	The measurement name has the form DRB.PacketLossRateULDIST and optionally DRB.PacketLossRateULDIST.QOS where QOS identifies the target quality of service class, and DRB. PacketLossRateULDIST.SNSSAI where SNSSAI identifies the S-NSSAI.
f) Measurement Object Class	GNBCUUPFunction. NRCellCU.
g) Switching Technology	Valid for packet switched traffic.
h) Generation	5GS.
i) Purpose	One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

8 Elements for E2SM Service Model

8.1 General

Sub-clause 8.2 describes the structure of the information elements as required for E2SM-KPM in tabular format. Sub-clause 8.3 presents individual information elements. Sub-clause 8.4 provides the corresponding ASN.1 definition of each information element.

The following attributes are used for the tabular description of the messages and information elements:

NOTE: The messages have been defined by the guidelines specified in 3GPP TR 25.921 [11].

8.2 Message Functional Definition and Content

8.2.1 Messages for RIC Functional procedures

8.2.1.1 RIC EVENT TRIGGER DEFINITION IE

This information element is part of the RIC SUBSCRIPTION REQUEST message sent by the Near-RT RIC to an E2 Node and is required for event triggers used to initiate REPORT actions.

Direction: NEAR-RT RIC → E2 Node.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE <i>Event Trigger Format</i>				
>E2SM-KPM Event Trigger Definition Format 1	M		8.2.1.1.1	

8.2.1.1.1 E2SM-KPM Event Trigger Definition Format 1

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Reporting Period	M		INTEGER (1..4294967295)	The reporting period is expressed in unit of 1 millisecond.

8.2.1.2 RIC ACTION DEFINITION IE

This information element is part of the RIC SUBSCRIPTION REQUEST message sent by the Near-RT RIC to an E2 Node. In this service model, this information element provides additional information for the nominated Action (Report).

Direction: NEAR-RT RIC → E2 Node.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
RIC Style Type	M		8.3.3	
CHOICE <i>Action Definition Format</i>				
>E2SM-KPM Action Definition Format 1	M		8.2.1.2.1	
>E2SM-KPM Action Definition Format 2	M		8.2.1.2.2	
>E2SM-KPM Action Definition Format 3	M		8.2.1.2.3	
>E2SM-KPM Action Definition Format 4	M		8.2.1.2.4	
>E2SM-KPM Action Definition Format 5	M		8.2.1.2.5	

8.2.1.2.1 E2SM-KPM Action Definition Format 1

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurement Information List		1.. <maxnoofMeasurementInfo>		
>CHOICE <i>Measurement Type</i>				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>List of Labels		1.. <maxnoofLabelInfo>		
>>Label Information	M		8.3.11 Measurement Label	
Granularity Period	M		8.3.8 Granularity Period	Collection interval of measurements
Cell Global ID	O		8.3.20 Cell Global ID	Points to a specific cell for generating measurements subscribed by the <i>Measurement Information List</i> IE

Range bound	Explanation
maxnoofMeasurementInfo	Maximum no. of measurement types that can be reported by a single report. Value is <65535>.
maxnoofLabelInfo	Maximum no. of measurements values that can be reported for a single measurement type. Value is <2147483647>.

8.2.1.2.2 E2SM-KPM Action Definition Format 2

IE/Group Name	Presence	Range	IE type and reference	Semantics description
UE ID	M		8.3.24	Points to a specific UE of interest
Subscription Information	M		8.2.1.2.1 E2SM-KPM Action Definition Format 1	

8.2.1.2.3 E2SM-KPM Action Definition Format 3

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurement Information List		1.. <maxnoofMeasurementInfo>		
>CHOICE <i>Measurement Type</i>				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>Matching Condition		1.. <maxnoofConditionInfo>		The Matching Condition represents the Boolean expression, the components of which are connected with logical AND
>>CHOICE <i>Condition Type</i>	M			
>>>Label Information			8.3.11 Measurement Label	
>>>Test Information			8.3.22 Test Condition Information	
Granularity Period	M		8.3.8 Granularity Period	Collection interval of measurements
Cell Global ID	O		8.3.20 Cell Global ID	Points to a specific cell for generating measurements subscribed by the <i>Measurement Information List</i> IE

Range bound	Explanation
maxnoofMeasurementInfo	Maximum no. of measurement types that can be reported by a single report. Value is <65535>.
maxnoofConditionInfo	Maximum no. of conditions that can be subscribed for a single measurement type. Value is <32768>.

8.2.1.2.4 E2SM-KPM Action Definition Format 4

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Matching Condition		1.. <maxnoofConditionInfoPerSub>		The Matching Condition represents the Boolean expression, the components of which are connected with logical AND
>Test Information	M		8.3.22 Test Condition Information	Provides test condition to filter matching UEs
Subscription Information	M		8.2.1.2.1 E2SM-KPM Action Definition Format 1	

Range bound	Explanation
maxnoofConditionInfoPerSub	Maximum no. of conditions that can be subscribed for a single subscription. Value is <32768>.

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8.2.1.2.5 E2SM-KPM Action Definition Format 5

IE/Group Name	Presence	Range	IE type and reference	Semantics description
List of Subscribed UE IDs		2.. <maxnoofUEID PerSub>		Points to a list of UEs of interest
>UE ID	M		8.3.24	
Subscription Information	M		8.2.1.2.1 E2SM-KPM Action Definition Format 1	

3

Range bound	Explanation
maxnoofUEIDPerSub	Maximum no. of UE IDs that can be subscribed for a single subscription. Value is <65535>.

4

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8.2.1.3 RIC INDICATION HEADER IE

6

This information element is part of the RIC INDICATION message sent by the E2 Node to the Near-RT RIC and is required for REPORT action.

7

8

Direction: E2 Node → NEAR-RT RIC.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE <i>Indication Header Format</i>				
>E2SM-KPM Indication Header Format 1	M		8.2.1.3.1	

9

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8.2.1.3.1 E2SM-KPM Indication Header Format 1

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Collection Start Time	M		8.3.12 Time Stamp	
File Format Version	O		PrintableString (SIZE (0..15), ...)	
Sender Name	O		PrintableString (SIZE (0..400), ...)	
Sender Type	O		PrintableString (SIZE (0..8), ...)	
Vendor Name	O		PrintableString (SIZE (0..32), ...)	

11

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8.2.1.4 RIC INDICATION MESSAGE IE

13

This information element is part of the RIC INDICATION message sent by the E2 Node to the Near-RT RIC and is required for REPORT action.

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Direction: E2 Node → NEAR-RT RIC.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE <i>Indication Message Format</i>				
>E2SM-KPM Indication Message Format 1	M		8.2.1.4.1	
>E2SM-KPM Indication Message Format 2	M		8.2.1.4.2	
>E2SM-KPM Indication Message Format 3	M		8.2.1.4.3	

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8.2.1.4.1 E2SM-KPM Indication Message Format 1

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurements Data		1.. <maxnoofMeasurementRecord>		Contains a set of Measurement Records, each collected at each Granularity Period.
>Measurements Record		1.. <maxnoofMeasurementValue>		Contains measured values in same order as in the <i>Measurements Information List</i> IE if present, otherwise in the order defined in the subscription.
>>CHOICE <i>Measured Value</i>				
>>>Integer Value	M		INTEGER (0..4294967295)	
>>>Real Value	M		REAL	
>>>No Value	M		NULL	
>Incomplete Flag	O		ENUMERATED (true, ...)	Indicates that the measurements record is not reliable.
Measurement Information List		0.. <maxnoofMeasurementInfo>		
>CHOICE <i>Measurement Type</i>				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>List of Labels		1.. <maxnoofLabelInfo>		
>>Label Information	M		8.3.11 Measurement Label	
Granularity Period	O		8.3.8 Granularity Period	Collection interval of measurements

3

Range bound	Explanation
maxnoofMeasurementInfo	Maximum no. of measurement types that can be reported by a single report. Value is <65535>.
maxnoofLabelInfo	Maximum no. of measurements values that can be reported for a single measurement type. Value is <2147483647>.
maxnoofMeasurementRecord	Maximum no. of measurement records that can be reported by a single report. Value is <65535>.
maxnoofMeasurementValue	Maximum no. of measurement values that can be carried by a single measurement record. Value is <2147483647>.

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8.2.1.4.2 E2SM-KPM Indication Message Format 2

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IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurements Data		1.. <maxnoofMeasurementRecord>		Contains a set of Measurement Records, each collected at each Granularity Period.
>Measurements Record		1.. <maxnoofMeasurementValue>		Contains measured values in same order as in the <i>Measurements Information Condition UE List</i> IE.
>>CHOICE <i>Measured Value</i>				
>>>Integer Value	M		INTEGER (0..4294967295)	
>>>Real Value	M		REAL	
>>>No Value	M		NULL	
>Incomplete Flag	O		ENUMERATED (true, ...)	Indicates that the measurements record is not reliable.
Measurement Information Condition UE List		1.. <maxnoofMeasurementInfo>		
>CHOICE <i>Measurement Type</i>				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>Matching Condition		1.. <maxnoofConditionInfo>		
>>CHOICE <i>Condition Type</i>	M			
>>>Label Information			8.3.11 Measurement Label	
>>>Test Information			8.3.22 Test Condition Information	
>List of matched UE IDs		0.. <maxnoofUEID>		
>>UE ID	M		8.3.24	
Granularity Period	O		8.3.8 Granularity Period	Collection interval of measurements

3

Range bound	Explanation
maxnoofMeasurementInfo	Maximum no. of measurement types that can be reported by a single report. Value is <65535>.
maxnoofConditionInfo	Maximum no. of conditions that can be subscribed for a single measurement type. Value is <32768>.
maxnoofUEID	Maximum no. of UE IDs that can be reported for a single condition. Value is <65535>.
maxnoofMeasurementRecord	Maximum no. of measurement records that can be reported by a single report. Value is <65535>.
maxnoofMeasurementValue	Maximum no. of measurement values that can be carried by a single measurement record. Value is <2147483647>.

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8.2.1.4.3 E2SM-KPM Indication Message Format 3

IE/Group Name	Presence	Range	IE type and reference	Semantics description
List of UE Measurement Reports		1.. <maxnoofUEMeasurementsReport>		
>UE ID	M		8.3.24	
>Measurements Report	M		8.2.1.4.1 E2SM-KPM Indication Message Format 1	Contains Measurement Data for a UE for a Reporting Period.

3

Range bound	Explanation
maxnoofUEMeasReport	Maximum no. of UE Measurement Reports that can be reported. Value is <65535>.

4

5

8.2.1.5 RIC CALL PROCESS ID

6

Note: Not used in this service model

7

8.2.1.6 RIC CONTROL HEADER IE

8

Note: Not used in this service model

9

8.2.1.7 RIC CONTROL MESSAGE IE

10

Note: Not used in this service model

11

8.2.1.8 RIC CONTROL OUTCOME IE

12

Note: Not used in this service model

13

8.2.2 Messages for RIC Global Procedures

14

8.2.2.1 RAN Function Definition IE

15

This information element is part of the E2 SETUP REQUEST, and RIC SERVICE UPDATE message sent by the E2 Node to the Near-RT RIC and is used to provide all required information for the Near-RT RIC to determine how a given E2 Node has been configured to support a given RAN Function specific E2SM.

16

17

18

Direction: E2 Node → NEAR-RT RIC.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
RAN Function Name	M		8.3.2	
Sequence of Event Trigger styles		0.. <maxnoofRICStyles>		
>RIC Event Trigger Style Type	M		8.3.3	
>RIC Event Trigger Style Name	M		8.3.4	
>RIC Event Trigger Format Type	M		8.3.5	
Sequence of Report styles		0.. <maxnoofRICStyles>		
>RIC Report Style Type	M		8.3.3	
>RIC Report Style Name	M		8.3.4	
>RIC Report Action Format Type	M		8.3.5	
>Sequence of Measurement Info for Action		1.. <maxnoofMeasurementInfo>		
>>Measurement Type Name	M		8.3.9	
>>Measurement Type ID	O		8.3.10	
>RIC Indication Header Format Type	M		8.3.5	Indication header type used by Report style
>RIC Indication Message Format Type	M		8.3.5	Indication message type used by Report style

Range bound	Explanation
maxnoofCells	Maximum no. of cells supported by an E2 Node component. The value is <16384>.
maxnoofRICstyle	Maximum no. of Style of Report, Insert, Control or Policy actions supported by RAN Function. The value is <63>.
maxnoofMeasurementInfo	Maximum no. of measurement types that can be reported by a single report. The value is <65535>.

8.3 Information Element definitions

8.3.1 General

When specifying information elements which are to be represented by bit strings, if not otherwise specifically stated in the semantics description of the concerned IE or elsewhere, the following principle applies with regards to the ordering of bits:

- The first bit (leftmost bit) contains the most significant bit (MSB);
- The last bit (rightmost bit) contains the least significant bit (LSB);
- When importing bit strings from other specifications, the first bit of the bit string contains the first bit of the concerned information.

8.3.2 RAN Function Name

This IE is defined in [12] clause 6.2.2.1.

8.3.3 RIC Style Type

This IE is defined in [12] clause 6.2.2.2.

8.3.4 RIC Style Name

This IE is defined in [12] clause 6.2.2.3.

1 8.3.5 RIC Format Type

2 This IE is defined in [12] clause 6.2.2.4.

3 8.3.6 Void

4 8.3.7 Void

5 8.3.8 Granularity Period

6 This IE defines the measurement collection interval within a reporting period.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Granularity Period	M		INTEGER (1..4294967295)	Measurement collection interval expressed in unit of 1 millisecond.

7

8.3.9 Measurement Type Name

This IE defines the name of a given measurement type.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurement Name	M		PrintableString(SIZE(1..150, ...))	One of the measurement names specified in TS 28.552 [4], TS 32.425 [8], or Section 7.10. The subcounters are represented by the Measurement Labels defined in 8.3.11.

8.3.10 Measurement Type ID

This IE defines the identifier of a given measurement type.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurement ID	M		INTEGER (1.. 65535, ...)	

8.3.11 Measurement Label

This IE defines values of necessary subcounters applicable to an associated measurement type.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
No Label	O		ENUMERATED (true, ...)	Indicates the associated measurement type without any subcounter. If included, other IEs in 8.3.11 shall not be included in the same Measurement Label (and vice versa).
PLMN ID	O		8.3.15	Represents the PLMN subcounter
Slice ID	O		8.3.14	Represents the SNSSAI subcounter
5QI	O		8.3.17	Represents the 5QI subcounter
QFI	O		8.3.21	Represents the QFI subcounter
QCI	O		8.3.18	Represents the QCI subcounter
QCImax	O		8.3.18	Used only when the name of the associated measurement type ends with ' Filter'
QCImin	O		8.3.18	Used only when the name of the associated measurement type ends with ' Filter'
ARPmax	O		INTEGER (1.. 15, ...)	Used only when the name of the associated measurement type ends with ' Filter'
ARPmin	O		INTEGER (1.. 15, ...)	Used only when the name of the associated measurement type ends with ' Filter'
Bitrate Range	O		INTEGER (1.. 65535, ...)	Used only when the name of the associated measurement type ends with ' Filter'

Layer at MU-MIMO	O		INTEGER (1..65535, ...)	Represents the MIMO layer subcounter
Sum	O		ENUMERATED (true, ...)	Sum is calculated as cumulative sum from the start of the measurement.
Distribution Bin X	O		INTEGER (1..65535, ...)	An index of Bin X. Only applicable to distribution type measurement information.
Distribution Bin Y	O		INTEGER (1..65535, ...)	An index of Bin Y. Only applicable to distribution type measurement information. This IE may be present only when Distribution Bin X is present.
Distribution Bin Z	O		INTEGER (1..65535, ...)	An index of Bin Z. Only applicable to distribution type measurement information. This IE may be present only when Distribution Bin X and Distribution Bin Y are present.
Precedent Label Override Indication	O		ENUMERATED (true, ...)	Indicates that subcounters and their values of the precedent label applies in the same way except for the included subcounters. For included subcounters, new values shall apply.
Start End Indication	O		ENUMERATED (start, end, ...)	<p>Used to indicate a range of values. If "start" is used for a label, the subsequent label should include this IE with "end".</p> <p>If included together with Distribution Bin type subcounter(s), it can be used to indicate a range of multi-dimensional values in the ascending order of numbers from Bin Z (if included), then from Bin Y (if included), then from Bin X (if included). In this case, information of a label with "start" should be identical to that of the subsequent label with "end", except Distribution Bin type subcounter(s) used.</p> <p>Otherwise (included together with subcounter other than Distribution Bin type subcounter), it can be used to indicate one-dimensional range of values in the ascending order, and information of a label with "start" should be identical to that of the subsequent label with "end", except only one subcounter.</p>
Min	O		ENUMERATED (true, ...)	Minimum of the measured values over a granularity period.
Max	O		ENUMERATED (true, ...)	Maximum of the measured values over a granularity period.
Avg	O		ENUMERATED (true, ...)	Average of the measured values over a granularity period.

8.3.12 Time Stamp

This IE contains UTC time information

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Time Stamp	M		OCTET STRING (SIZE(4))	Encoded in the same format as the first four octets of the 64-bit timestamp format as defined in section 6 of IETF RFC 5905 [13].

8.3.13 Void

8.3.14 S-NSSAI

This IE is defined in [12] clause 6.2.3.12.

8.3.15 PLMN Identity

This IE is defined in [12] clause 6.2.3.1.

8.3.16 Void

8.3.17 5QI

This IE is defined in [12] clause 6.2.3.13.

8.3.18 QCI

This IE is defined in [12] clause 6.2.3.14.

8.3.19 Void

8.3.20 Cell Global ID

This IE is defined in [12] clause 6.2.2.5.

8.3.21 QFI

This IE is defined in [12] clause 6.2.3.15.

8.3.22 Test Condition Information

This IE defines a test condition for identifying UEs.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE <i>Test Condition Type</i>	M			
>GBR			ENUMERATED (true, ...)	Identifies UEs with the GBR flows or within the specified bitrate range
>AMBR			ENUMERATED (true, ...)	Identifies UEs with the AMBR within the specified bitrate range
>IsStat			ENUMERATED (true, ...)	Identifies UEs which are stationary
>IsCatM			ENUMERATED (true, ...)	Identifies UEs of Category M
>RSRP			ENUMERATED (true, ...)	Identifies UEs with the latest reported RSRP measurement for this cell within the specified range
>RSRQ			ENUMERATED (true, ...)	Identifies UEs with the latest reported RSRQ measurement for this cell within the specified range
Test Condition	O		ENUMERATED (equal, greaterthan, lessthan, contains, present, ...)	
Test Condition Value	O		8.3.23	

1

8.3.23 Test Condition Value

This IE defines the target value for a particular Test Condition Type IE element.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE <i>Test Value</i>	M			
>INTEGER			INTEGER	
>ENUMERATED			INTEGER	
>BOOLEAN			BOOLEAN	
>BIT STRING			BIT STRING	
>OCTET STRING			OCTET STRING	
>PRINTABLE STRING			PrintableString	

4

8.3.24 UE ID

This IE is defined in [12] clause 6.2.2.6.

6

8.4 Information Element Abstract Syntax (with ASN.1)

8.4.1 General

E2SM-KPM ASN.1 definition conforms to ITU-T Rec. X.680 [5] and ITU-T Rec. X.681 [6].

Sub clause 8.4.2 presents the Abstract Syntax of the E2SM information elements to be carried within the E2AP [3] protocol messages with ASN.1. In case there is contradiction between the ASN.1 definition in this sub clause and the tabular format in sub clause 8.2 and 8.3, the ASN.1 shall take precedence, except for the definition of conditions for the presence of conditional elements, in which the tabular format shall take precedence.

If an E2SM information element carried as an OCTET STRING in an E2AP [3] message that is not constructed as defined above is received, this shall be considered as Abstract Syntax Error, and the message shall be handled as defined for Abstract Syntax Error in clause 9.

8.4.2 Information Element definitions

```
-- ASN1START
-- *****
-- E2SM-KPM Information Element Definitions
-- *****

E2SM-KPM-IEs {
iso(1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) oran(53148) e2(1) version2(2) e2sm(2) e2sm-KPMON-IEs (2) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- *****
-- IEs
-- *****

IMPORTS
    CGI,
    FiveQI,
    PLMNIdentity,
    QCI,
    QosFlowIdentifier,
    RANfunction-Name,
    RIC-Format-Type,
    RIC-Style-Name,
    RIC-Style-Type,
```

```

1      S-NSSAI,
2      UEID
3  FROM E2SM-COMMON-IEs;
4
5  TimeStamp ::= OCTET STRING (SIZE(4))
6
7  GranularityPeriod ::= INTEGER (1.. 4294967295)
8
9  MeasurementType ::= CHOICE {
10     measName      MeasurementTypeName,
11     measID        MeasurementTypeID,
12     ...
13 }
14
15 MeasurementTypeName ::= PrintableString(SIZE(1.. 150, ...))
16
17 MeasurementTypeID ::= INTEGER (1.. 65536, ...)
18
19 MeasurementLabel ::= SEQUENCE {
20     noLabel          ENUMERATED {true, ...}          OPTIONAL,
21     plmnID           PLMNIdentity                    OPTIONAL,
22     sliceID          S-NSSAI                         OPTIONAL,
23     fiveQI           FiveQI                          OPTIONAL,
24     qFI              QosFlowIdentifier                OPTIONAL,
25     qCI              QCI                             OPTIONAL,
26     qCImax           QCI                             OPTIONAL,
27     qCImin           QCI                             OPTIONAL,
28     aRPmax           INTEGER (1.. 15, ...)            OPTIONAL,
29     aRPmin           INTEGER (1.. 15, ...)            OPTIONAL,
30     bitrateRange     INTEGER (1.. 65535, ...)         OPTIONAL,
31     layerMU-MIMO     INTEGER (1.. 65535, ...)         OPTIONAL,
32     sUM              ENUMERATED {true, ...}          OPTIONAL,
33     distBinX         INTEGER (1.. 65535, ...)         OPTIONAL,
34     distBinY         INTEGER (1.. 65535, ...)         OPTIONAL,
35     distBinZ         INTEGER (1.. 65535, ...)         OPTIONAL,
36     preLabelOverride ENUMERATED {true, ...}          OPTIONAL,
37     startEndInd      ENUMERATED {start, end, ...}     OPTIONAL,
38     min              ENUMERATED {true, ...}          OPTIONAL,
39     max              ENUMERATED {true, ...}          OPTIONAL,
40     avg              ENUMERATED {true, ...}          OPTIONAL,
41     ...
42 }
43
44 TestCondInfo ::= SEQUENCE{
45     testType      TestCond-Type,
46     testExpr      TestCond-Expression,
47     testValue     TestCond-Value,
48     ...

```

```

1  }
2
3  TestCond-Type ::= CHOICE{
4      gBR                ENUMERATED {true, ...},
5      aMBR                ENUMERATED {true, ...},
6      isStat              ENUMERATED {true, ...},
7      isCatM              ENUMERATED {true, ...},
8      rSRP                ENUMERATED {true, ...},
9      rSRQ                ENUMERATED {true, ...},
10     ...
11 }
12
13 TestCond-Expression ::= ENUMERATED {
14     equal,
15     greaterthan,
16     lessthan,
17     contains,
18     present,
19     ...
20 }
21
22 TestCond-Value ::= CHOICE{
23     valueInt             INTEGER,
24     valueEnum            INTEGER,
25     valueBool            BOOLEAN,
26     valueBitS            BIT STRING,
27     valueOctS            OCTET STRING,
28     valuePrtS            PrintableString,
29     ...
30 }
31
32 -- *****
33 --   Lists
34 -- *****
35
36 maxnoofCells            INTEGER ::= 16384
37 maxnoofRICStyles        INTEGER ::= 63
38 maxnoofMeasurementInfo  INTEGER ::= 65535
39 maxnoofLabelInfo        INTEGER ::= 2147483647
40 maxnoofMeasurementRecord INTEGER ::= 65535
41 maxnoofMeasurementValue INTEGER ::= 2147483647
42 maxnoofConditionInfo    INTEGER ::= 32768
43 maxnoofUEID             INTEGER ::= 65535
44 maxnoofConditionInfoPerSub INTEGER ::= 32768
45 maxnoofUEIDPerSub       INTEGER ::= 65535
46 maxnoofUEMeasReport     INTEGER ::= 65535

```

47

```

1
2 MeasurementInfoList ::= SEQUENCE (SIZE(1..maxnoofMeasurementInfo)) OF MeasurementInfoItem
3
4 MeasurementInfoItem ::= SEQUENCE {
5     measType      MeasurementType,
6     labelInfoList LabelInfoList,
7     ...
8 }
9
10 LabelInfoList ::= SEQUENCE (SIZE(1..maxnoofLabelInfo)) OF LabelInfoItem
11
12 LabelInfoItem ::= SEQUENCE {
13     measLabel      MeasurementLabel,
14     ...
15 }
16
17 MeasurementData ::= SEQUENCE (SIZE(1..maxnoofMeasurementRecord)) OF MeasurementDataItem
18
19 MeasurementDataItem ::= SEQUENCE {
20     measRecord      MeasurementRecord,
21     incompleteFlag  ENUMERATED {true, ...} OPTIONAL,
22     ...
23 }
24
25 MeasurementRecord ::= SEQUENCE (SIZE(1..maxnoofMeasurementValue)) OF MeasurementRecordItem
26
27 MeasurementRecordItem ::= CHOICE {
28     integer      INTEGER (0.. 4294967295),
29     real         REAL,
30     noValue      NULL,
31     ...
32 }
33
34 MeasurementInfo-Action-List ::= SEQUENCE (SIZE(1..maxnoofMeasurementInfo)) OF MeasurementInfo-Action-Item
35
36 MeasurementInfo-Action-Item ::= SEQUENCE {
37     measName      MeasurementTypeName,
38     measID        MeasurementTypeID OPTIONAL,
39     ...
40 }
41
42 MeasurementCondList ::= SEQUENCE (SIZE(1..maxnoofMeasurementInfo)) OF MeasurementCondItem
43
44 MeasurementCondItem ::= SEQUENCE {
45     measType      MeasurementType,
46     matchingCond  MatchingCondList,
47     ...
48 }

```



```

1
2 MeasurementCondUEidList ::= SEQUENCE (SIZE(1..maxnoofMeasurementInfo)) OF MeasurementCondUEidItem
3
4 MeasurementCondUEidItem ::= SEQUENCE {
5     measType           MeasurementType,
6     matchingCond       MatchingCondList,
7     matchingUEidList   MatchingUEidList      OPTIONAL,
8     ...
9 }
10
11 MatchingCondList ::= SEQUENCE (SIZE(1..maxnoofConditionInfo)) OF MatchingCondItem
12
13 MatchingCondItem ::= CHOICE{
14     measLabel          MeasurementLabel,
15     testCondInfo       TestCondInfo,
16     ...
17 }
18
19 MatchingUEidList ::= SEQUENCE (SIZE(1..maxnoofUEID)) OF MatchingUEidItem
20
21 MatchingUEidItem ::= SEQUENCE{
22     ueID               UEID,
23     ...
24 }
25
26 MatchingUeCondPerSubList ::= SEQUENCE (SIZE(1..maxnoofConditionInfoPerSub)) OF MatchingUeCondPerSubItem
27
28 MatchingUeCondPerSubItem ::= SEQUENCE{
29     testCondInfo       TestCondInfo,
30     ...
31 }
32
33 MatchingUEidPerSubList ::= SEQUENCE (SIZE(2..maxnoofUEIDPerSub)) OF MatchingUEidPerSubItem
34
35 MatchingUEidPerSubItem ::= SEQUENCE{
36     ueID               UEID,
37     ...
38 }
39
40 UEMeasurementReportList ::= SEQUENCE (SIZE(1..maxnoofUEMeasReport)) OF UEMeasurementReportItem
41
42 UEMeasurementReportItem ::= SEQUENCE{
43     ueID               UEID,
44     measReport         E2SM-KPM-IndicationMessage-Format1,
45     ...
46 }
47
48

```

```

1
2  -- *****
3  -- E2SM-KPM Service Model IEs
4  -- *****
5
6  -- *****
7  -- Event Trigger Definition OCTET STRING contents
8  -- *****
9
10 E2SM-KPM-EventTriggerDefinition ::= SEQUENCE{
11     eventDefinition-formats      CHOICE{
12         eventDefinition-Format1  E2SM-KPM-EventTriggerDefinition-Format1,
13         ...
14     },
15     ...
16 }
17
18 E2SM-KPM-EventTriggerDefinition-Format1 ::= SEQUENCE{
19     reportingPeriod              INTEGER (1.. 4294967295),
20     ...
21 }
22
23 -- *****
24 -- Action Definition OCTET STRING contents
25 -- *****
26
27 E2SM-KPM-ActionDefinition ::= SEQUENCE{
28     ric-Style-Type              RIC-Style-Type,
29     actionDefinition-formats    CHOICE{
30         actionDefinition-Format1  E2SM-KPM-ActionDefinition-Format1,
31         actionDefinition-Format2  E2SM-KPM-ActionDefinition-Format2,
32         actionDefinition-Format3  E2SM-KPM-ActionDefinition-Format3,
33         ...,
34         actionDefinition-Format4  E2SM-KPM-ActionDefinition-Format4,
35         actionDefinition-Format5  E2SM-KPM-ActionDefinition-Format5
36     },
37     ...
38 }
39
40 E2SM-KPM-ActionDefinition-Format1 ::= SEQUENCE {
41     measInfoList                MeasurementInfoList,
42     granulPeriod                GranularityPeriod,
43     cellGlobalID                CGI                      OPTIONAL,
44     ...
45 }
46
47 E2SM-KPM-ActionDefinition-Format2 ::= SEQUENCE {
48     ueID                        UEID,

```

```

1      subscriptInfo          E2SM-KPM-ActionDefinition-Format1,
2      ...
3  }
4
5  E2SM-KPM-ActionDefinition-Format3 ::= SEQUENCE {
6      measCondList           MeasurementCondList,
7      granulPeriod           GranularityPeriod,
8      cellGlobalID           CGI                      OPTIONAL,
9      ...
10 }
11
12 E2SM-KPM-ActionDefinition-Format4 ::= SEQUENCE {
13     matchingUeCondList       MatchingUeCondPerSubList,
14     subscriptionInfo         E2SM-KPM-ActionDefinition-Format1,
15     ...
16 }
17
18 E2SM-KPM-ActionDefinition-Format5 ::= SEQUENCE {
19     matchingUEidList         MatchingUEidPerSubList,
20     subscriptionInfo         E2SM-KPM-ActionDefinition-Format1,
21     ...
22 }
23
24
25 -- *****
26 -- Indication Header OCTET STRING contents
27 -- *****
28
29 E2SM-KPM-IndicationHeader ::= SEQUENCE{
30     indicationHeader-formats CHOICE{
31         indicationHeader-Format1 E2SM-KPM-IndicationHeader-Format1,
32         ...
33     },
34     ...
35 }
36
37 E2SM-KPM-IndicationHeader-Format1 ::= SEQUENCE{
38     collectStartTime         TimeStamp,
39     fileFormatversion        PrintableString (SIZE (0..15), ...) OPTIONAL,
40     senderName               PrintableString (SIZE (0..400), ...) OPTIONAL,
41     senderType               PrintableString (SIZE (0..8), ...) OPTIONAL,
42     vendorName               PrintableString (SIZE (0..32), ...) OPTIONAL,
43     ...
44 }
45
46 -- *****
47 -- Indication Message OCTET STRING contents
48 -- *****

```

```

1
2 E2SM-KPM-IndicationMessage ::= SEQUENCE{
3   indicationMessage-formats    CHOICE{
4     indicationMessage-Format1  E2SM-KPM-IndicationMessage-Format1,
5     indicationMessage-Format2  E2SM-KPM-IndicationMessage-Format2,
6     ...,
7     indicationMessage-Format3  E2SM-KPM-IndicationMessage-Format3
8   },
9   ...
10 }
11
12 E2SM-KPM-IndicationMessage-Format1 ::= SEQUENCE {
13   measData          MeasurementData,
14   measInfoList      MeasurementInfoList          OPTIONAL,
15   granulPeriod      GranularityPeriod            OPTIONAL,
16   ...
17 }
18
19 E2SM-KPM-IndicationMessage-Format2 ::= SEQUENCE {
20   measData          MeasurementData,
21   measCondUEidList  MeasurementCondUEidList,
22   granulPeriod      GranularityPeriod            OPTIONAL,
23   ...
24 }
25
26 E2SM-KPM-IndicationMessage-Format3 ::= SEQUENCE {
27   ueMeasReportList  UEMeasurementReportList,
28   ...
29 }
30
31
32 -- *****
33 --   RAN Function Definition OCTET STRING contents
34 -- *****
35
36 E2SM-KPM-RANfunction-Description ::= SEQUENCE{
37   ranFunction-Name    RANfunction-Name,
38   ric-EventTriggerStyle-List  SEQUENCE (SIZE(1..maxnoofRICStyles)) OF RIC-EventTriggerStyle-Item  OPTIONAL,
39   ric-ReportStyle-List    SEQUENCE (SIZE(1..maxnoofRICStyles)) OF RIC-ReportStyle-Item            OPTIONAL,
40   ...
41 }
42
43 RIC-EventTriggerStyle-Item ::= SEQUENCE{
44   ric-EventTriggerStyle-Type    RIC-Style-Type,
45   ric-EventTriggerStyle-Name    RIC-Style-Name,
46   ric-EventTriggerFormat-Type   RIC-Format-Type,
47   ...
48 }

```

```
1
2 RIC-ReportStyle-Item ::= SEQUENCE{
3   ric-ReportStyle-Type      RIC-Style-Type,
4   ric-ReportStyle-Name     RIC-Style-Name,
5   ric-ActionFormat-Type    RIC-Format-Type,
6   measInfo-Action-List     MeasurementInfo-Action-List,
7   ric-IndicationHeaderFormat-Type  RIC-Format-Type,
8   ric-IndicationMessageFormat-Type  RIC-Format-Type,
9   ...
10  }
11
12 END
13
14 -- ASN1STOP
15
```

1
2
3
4

9 Handling of Unknown, Unforeseen and Erroneous Protocol Data

Section 10 of TS 36.413 [13] is applicable for the purposes of the present document.

Annex A Further information on RAN Function Network KPM Monitor

A.1 Background Information

The RAN function “Key Performance Measurement” is used to provide RIC Service exposure of the performance measurement logical function of the E2 Nodes. Based on the O-RAN deployment architecture, available measurements could be different. Figure A.1-1 shows the target deployment architecture for E2SM-KPM.

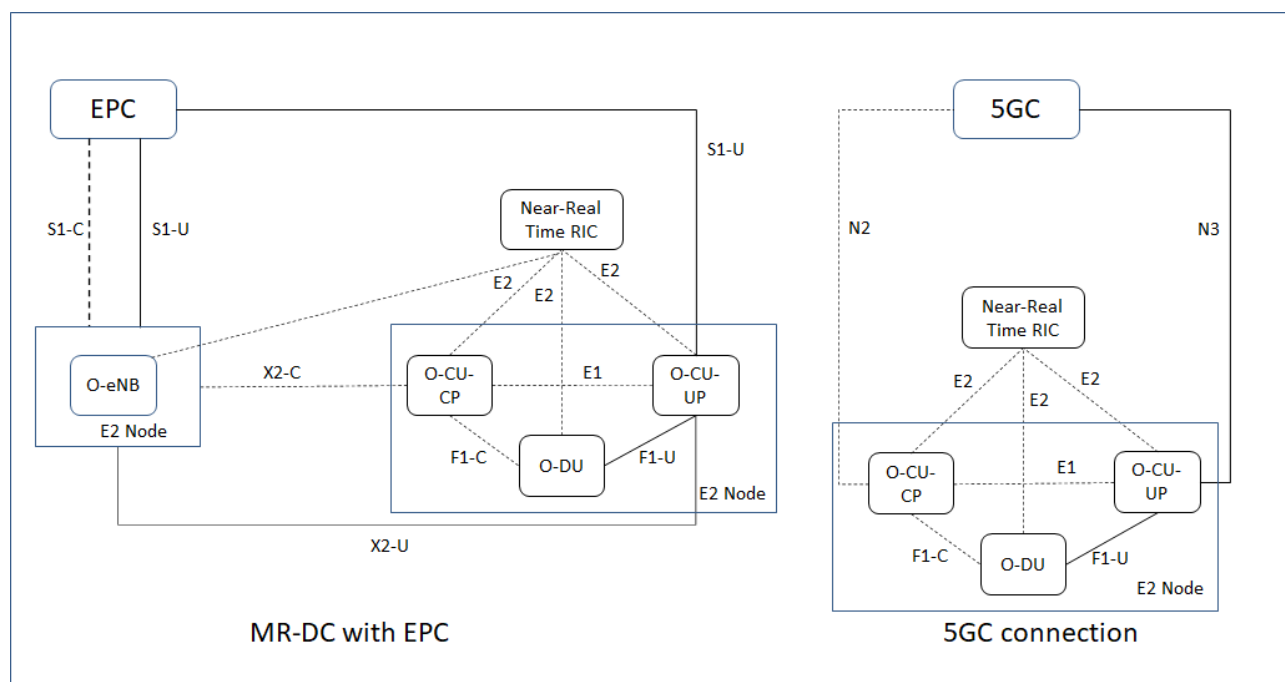


Figure A.1-1 E2SM-KPM Architecture

For each logical function the E2 Node shall use the RAN Function Definition IE to declare the list of available measurements and a set of supported RIC Services (**REPORT**).

Annex ZZZ : O-RAN Adopter License Agreement

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Section 1: DEFINITIONS

1.1 “Affiliate” means an entity that directly or indirectly controls, is controlled by, or is under common control with another entity, so long as such control exists. For the purpose of this Section, “Control” means beneficial ownership of fifty (50%) percent or more of the voting stock or equity in an entity.

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1.3 “Adopter(s)” means all entities, who are not Members, Contributors or Academic Contributors, including their Affiliates, who wish to download, use or otherwise access O-RAN Specifications.

1.4 “Minor Update” means an update or revision to an O-RAN Specification published by O-RAN Alliance that does not add any significant new features or functionality and remains interoperable with the prior version of an O-RAN Specification. The term “O-RAN Specifications” includes Minor Updates.

1.5 “Necessary Claims” means those claims of all present and future patents and patent applications, other than design patents and design registrations, throughout the world, which (i) are owned or otherwise licensable by a Member, Contributor or Academic Contributor during the term of its Member, Contributor or Academic Contributorship; (ii) such Member, Contributor or Academic Contributor has the right to grant a license without the payment of consideration to a third party; and (iii) are necessarily infringed by a Compliant Implementation (without considering any Contributions not included in the Final Specification). A claim is necessarily infringed only when it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the date any Final Specification was published by the O-RAN Alliance or the date the patent claim first came into existence, whichever last occurred, to make, sell, lease, otherwise dispose of, repair, use or operate a Compliant Implementation without infringing that claim. For the avoidance of doubt in exceptional cases where a Final Specification can only be implemented by technical solutions, all of which infringe patent claims, all such patent claims shall be considered Necessary Claims.

1.6 “Defensive Suspension” means for the purposes of any license grant pursuant to Section 3, Member, Contributor, Academic Contributor, Adopter, or any of their Affiliates, may have the discretion to include in their license a term allowing the licensor to suspend the license against a licensee who brings a patent infringement suit against the licensing Member, Contributor, Academic Contributor, Adopter, or any of their Affiliates.

Section 2: COPYRIGHT LICENSE

2.1 Subject to the terms and conditions of this Agreement, O-RAN Alliance hereby grants to Adopter a nonexclusive, nontransferable, irrevocable, non-sublicensable, worldwide copyright license to obtain, use and modify O-RAN Specifications, but not to further distribute such O-RAN Specification in any modified or unmodified way, solely in furtherance of implementations of an O-RAN Specification.

2.2 Adopter shall not use O-RAN Specifications except as expressly set forth in this Agreement or in a separate written agreement with O-RAN Alliance.

Section 3: FRAND LICENSE

3.1 Members, Contributors and Academic Contributors and their Affiliates are prepared to grant based on a separate Patent License Agreement to each Adopter under Fair Reasonable And Non- Discriminatory (FRAND) terms and conditions with or without compensation (royalties) a nonexclusive, non-transferable, irrevocable (but subject to

Defensive Suspension), non-sublicensable, worldwide patent license under their Necessary Claims to make, have made, use, import, offer to sell, lease, sell and otherwise distribute Compliant Implementations; provided, however, that such license shall not extend: (a) to any part or function of a product in which a Compliant Implementation is incorporated that is not itself part of the Compliant Implementation; or (b) to any Adopter if that Adopter is not making a reciprocal grant to Members, Contributors and Academic Contributors, as set forth in Section 3.3. For the avoidance of doubt, the foregoing licensing commitment includes the distribution by the Adopter's distributors and the use by the Adopter's customers of such licensed Compliant Implementations.

3.2 Notwithstanding the above, if any Member, Contributor or Academic Contributor, Adopter or their Affiliates has reserved the right to charge a FRAND royalty or other fee for its license of Necessary Claims to Adopter, then Adopter is entitled to charge a FRAND royalty or other fee to such Member, Contributor or Academic Contributor, Adopter and its Affiliates for its license of Necessary Claims to its licensees.

3.3 Adopter, on behalf of itself and its Affiliates, shall be prepared to grant based on a separate Patent License Agreement to each Members, Contributors, Academic Contributors, Adopters and their Affiliates under Fair Reasonable And Non-Discriminatory (FRAND) terms and conditions with or without compensation (royalties) a nonexclusive, non-transferable, irrevocable (but subject to Defensive Suspension), non-sublicensable, worldwide patent license under their Necessary Claims to make, have made, use, import, offer to sell, lease, sell and otherwise distribute Compliant Implementations; provided, however, that such license will not extend: (a) to any part or function of a product in which a Compliant Implementation is incorporated that is not itself part of the Compliant Implementation; or (b) to any Members, Contributors, Academic Contributors, Adopters and their Affiliates that is not making a reciprocal grant to Adopter, as set forth in Section 3.1. For the avoidance of doubt, the foregoing licensing commitment includes the distribution by the Members', Contributors', Academic Contributors', Adopters' and their Affiliates' distributors and the use by the Members', Contributors', Academic Contributors', Adopters' and their Affiliates' customers of such licensed Compliant Implementations.

Section 4: TERM AND TERMINATION

4.1 This Agreement shall remain in force, unless early terminated according to this Section 4.

4.2 O-RAN Alliance on behalf of its Members, Contributors and Academic Contributors may terminate this Agreement if Adopter materially breaches this Agreement and does not cure or is not capable of curing such breach within thirty (30) days after being given notice specifying the breach.

4.3 Sections 1, 3, 5 - 11 of this Agreement shall survive any termination of this Agreement. Under surviving Section 3, after termination of this Agreement, Adopter will continue to grant licenses (a) to entities who become Adopters after the date of termination; and (b) for future versions of O-RAN Specifications that are backwards compatible with the version that was current as of the date of termination.

Section 5: CONFIDENTIALITY

Adopter will use the same care and discretion to avoid disclosure, publication, and dissemination of O-RAN Specifications to third parties, as Adopter employs with its own confidential information, but no less than reasonable care. Any disclosure by Adopter to its Affiliates, contractors and consultants should be subject to an obligation of confidentiality at least as restrictive as those contained in this Section. The foregoing obligation shall not apply to any information which is: (1) rightfully known by Adopter without any limitation on use or disclosure prior to disclosure; (2) publicly available through no fault of Adopter; (3) rightfully received without a duty of confidentiality; (4) disclosed by O-RAN Alliance or a Member, Contributor or Academic Contributor to a third party without a duty of confidentiality on such third party; (5) independently developed by Adopter; (6) disclosed pursuant to the order of a court or other authorized governmental body, or as required by law, provided that Adopter provides reasonable prior written notice to O-RAN Alliance, and cooperates with O-RAN Alliance and/or the applicable Member, Contributor or Academic Contributor to have the opportunity to oppose any such order; or (7) disclosed by Adopter with O-RAN Alliance's prior written approval.

Section 6: INDEMNIFICATION

Adopter shall indemnify, defend, and hold harmless the O-RAN Alliance, its Members, Contributors or Academic Contributors, and their employees, and agents and their respective successors, heirs and assigns (the "Indemnitees"), against any liability, damage, loss, or expense (including reasonable attorneys' fees and expenses) incurred by or

imposed upon any of the Indemnitees in connection with any claims, suits, investigations, actions, demands or judgments arising out of Adopter's use of the licensed O-RAN Specifications or Adopter's commercialization of products that comply with O-RAN Specifications.

Section 7: LIMITATIONS ON LIABILITY; NO WARRANTY

EXCEPT FOR BREACH OF CONFIDENTIALITY, ADOPTER'S BREACH OF SECTION 3, AND ADOPTER'S INDEMNIFICATION OBLIGATIONS, IN NO EVENT SHALL ANY PARTY BE LIABLE TO ANY OTHER PARTY OR THIRD PARTY FOR ANY INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE OR CONSEQUENTIAL DAMAGES RESULTING FROM ITS PERFORMANCE OR NON-PERFORMANCE UNDER THIS AGREEMENT, IN EACH CASE WHETHER UNDER CONTRACT, TORT, WARRANTY, OR OTHERWISE, AND WHETHER OR NOT SUCH PARTY HAD ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES. O-RAN SPECIFICATIONS ARE PROVIDED "AS IS" WITH NO WARRANTIES OR CONDITIONS WHATSOEVER, WHETHER EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE. THE O-RAN ALLIANCE AND THE MEMBERS, CONTRIBUTORS OR ACADEMIC CONTRIBUTORS EXPRESSLY DISCLAIM ANY WARRANTY OR CONDITION OF MERCHANTABILITY, SECURITY, SATISFACTORY QUALITY, NONINFRINGEMENT, FITNESS FOR ANY PARTICULAR PURPOSE, ERROR-FREE OPERATION, OR ANY WARRANTY OR CONDITION FOR O-RAN SPECIFICATIONS.

Section 8: ASSIGNMENT

Adopter may not assign the Agreement or any of its rights or obligations under this Agreement or make any grants or other sublicenses to this Agreement, except as expressly authorized hereunder, without having first received the prior, written consent of the O-RAN Alliance, which consent may be withheld in O-RAN Alliance's sole discretion. O-RAN Alliance may freely assign this Agreement.

Section 9: THIRD-PARTY BENEFICIARY RIGHTS

Adopter acknowledges and agrees that Members, Contributors and Academic Contributors (including future Members, Contributors and Academic Contributors) are entitled to rights as a third-party beneficiary under this Agreement, including as licensees under Section 3.

Section 10: BINDING ON AFFILIATES

Execution of this Agreement by Adopter in its capacity as a legal entity or association constitutes that legal entity's or association's agreement that its Affiliates are likewise bound to the obligations that are applicable to Adopter hereunder and are also entitled to the benefits of the rights of Adopter hereunder.

Section 11: GENERAL

This Agreement is governed by the laws of Germany without regard to its conflict or choice of law provisions.

This Agreement constitutes the entire agreement between the parties as to its express subject matter and expressly supersedes and replaces any prior or contemporaneous agreements between the parties, whether written or oral, relating to the subject matter of this Agreement.

Adopter, on behalf of itself and its Affiliates, agrees to comply at all times with all applicable laws, rules and regulations with respect to its and its Affiliates' performance under this Agreement, including without limitation, export control and antitrust laws. Without limiting the generality of the foregoing, Adopter acknowledges that this Agreement prohibits any communication that would violate the antitrust laws.

By execution hereof, no form of any partnership, joint venture or other special relationship is created between Adopter, or O-RAN Alliance or its Members, Contributors or Academic Contributors. Except as expressly set forth in this Agreement, no party is authorized to make any commitment on behalf of Adopter, or O-RAN Alliance or its Members, Contributors or Academic Contributors.

In the event that any provision of this Agreement conflicts with governing law or if any provision is held to be null, void or otherwise ineffective or invalid by a court of competent jurisdiction, (i) such provisions will be deemed stricken

1 from the contract, and (ii) the remaining terms, provisions, covenants and restrictions of this Agreement will remain in
2 full force and effect.

3 Any failure by a party or third party beneficiary to insist upon or enforce performance by another party of any of the
4 provisions of this Agreement or to exercise any rights or remedies under this Agreement or otherwise by law shall not
5 be construed as a waiver or relinquishment to any extent of the other parties' or third party beneficiary's right to assert
6 or rely upon any such provision, right or remedy in that or any other instance; rather the same shall be and remain in full
7 force and effect.