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# Foreword

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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 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 MDA capabilities with corresponding analytics inputs and analytics outputs (reports), as well as processes and requirements for MDAS (Management Data Analytics Service), historical data handling for MDA, and ML support for MDA.

The present document also describes the MDA functionality and service framework, and MDA role in the management loop.

# 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] Void

[3] 3GPP TS 28.535: "Management and orchestration; Management services for communication service assurance; Requirements".

[4] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[5] 3GPP TS 28.554: "Management and orchestration;5G end to end Key Performance Indicators (KPI)".

[6] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

[7] 3GPP TS 32.423: "Telecommunication management; Subscriber and equipment trace; Trace data definition and management".

[8] 3GPP TS 28.405: "Telecommunication managemen; Quality of Experience (QoE) measurement collection; Control and configuration".

[9] 3GPP TS 28.406: "Telecommunication management; Quality of Experience (QoE) measurement collection; Information definition and transport".

[10] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[11] 3GPP TS 28.532: "Management and orchestration; Generic management services".

[12] 3GPP TS 32.425: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".

[13] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[14] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[15] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[16] 3GPP TS 28.658: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[17] 3GPP TS 28.662: "Telecommunication management; Generic Radio Access Network (RAN) Network Resource Model (NRM); Information Service (IS)".

[18] 3GPP TS 32.156: "Telecommunication management; Fixed Mobile Convergence (FMC) Model Repertoire".

[19] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[20] 3GPP TS 28.511: "Telecommunication management; Configuration Management (CM) for mobile networks that include virtualized network functions; Procedures".

[21] 3GPP TS 28.531: "Management and orchestration; Provisioning".

[22] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[23] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".

[24] 3GPP TS 28.105: "Management and orchestration; Artificial Intelligence/Machine Learning (AI/ML) management".

[25] 3GPP TS 32.160: "Management and orchestration; Management service template".

[26] ETSI GS NFV-IFA 011 (V3.3.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; VNF Descriptor and Packaging Specification".

[27] Recommendation ITU-T X.733: "Information technology - Open Systems Interconnection - Systems Management: Alarm reporting function".

[28] 3GPP TS 23.501: "System Architecture for the 5G System (5GS); Stage 2".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**MDA capability:** analytics capability corresponding to analytics of a set of analytics input data to provide analytics output data

**MDA Type:** type of analytics corresponding to specific MDA capability

## 3.2 Symbols

Void

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AI Artificial Intelligence

CHO Conditional Handover

DAPS Dual Active Protocol Stack

MDA MnS MDA Management service

MDA Management Data Analytics

MDAF Management Data Analytics Function

MDAS Management Data Analytics Service

ML Machine Learning

# 4 Concepts and overview

## 4.1 Overview

Management Data Analytics (MDA), as a key enabler of automation and intelligence, is considered a foundational capability for mobile networks and services management and orchestration.

The MDA provides a capability of processing and analysing data related to network and service events and status including e.g. performance measurements, KPIs, Trace/MDT/RLF/RCEF reports, QoE reports, alarms, configuration data, network analytics data, and service experience data from AFs, etc. to provide analytics output, i.e. statistics or predictions,, root cause analysis issues, and may also include recommendations to enable necessary actions for network and service operations. The MDA output is provided by the MDAS (Management Data analytics Service) producer to the corresponding consumer(s) that requested the analytics.

The MDA can identify ongoing issues impacting the performance of the network and services, and help to identify in advance potential issues that may cause potential failure and/or performance degradation. The MDA can also assist to predict the network and service demand to enable the timely resource provisioning and deployments which would allow fast time-to-market network and service deployments.

Management Data Analytics Service (MDAS), the services exposed by the MDA, can be consumed by various consumers, including for instance MnFs (i.e. MnS producers/consumers for network and service management), NFs (e.g. NWDAF), SON functions, network and service optimization tools/functions, SLS assurance functions, human operators, and AFs, etc.

NOTE: Throughout the present document the terms, MDAS and MDA MnS are equivalent and may be used interchangeably.

# 5 MDA functionality and service framework

## 5.1 General framework

MDA MnS (also referred to as MDAS) in the context of SBMA enables any authorized consumer to request and receive analytics as illustrated in Figure 5.1-1.



Figure 5.1-1: MDA functional overview and service framework

A management function (MDAF) may play the roles of MDA MnS producer, MDA MnS consumer, other MnS consumer, NWDAF consumer and LMF service consumer, and may also interact with other non-3GPP management systems.

The internal business logic related to MDA leverages the current and historical data related to:

- Performance Measurements (PM) as per TS 28.552 [4] and Key Performance Indicators (KPIs) as per TS 28.554 [5].

- Trace data, including MDT/RLF/RCEF, as per TS 32.422 [6] and TS 32.423 [7].

- QoE and service experience data as per TS 28.405 [8] and TS 28.406 [9].

- Analytics data offered by NWDAF as per TS 23.288 [10] including 5GC data and external web/app-based information (e.g. web crawler that provides online news) from AF.

- Alarm information and notifications as per TS 28.532 [11].

- CM information and notifications.

- UE location information provided by LMF as per TS 23.273 [14].

- MDA reports from other MDA MnS producers.

- Management data from non-3GPP systems.

Analytics output from the MDA internal business logic are made available by the management functions (MDAFs) playing the role of MDA MnS producers to the authorized consumers, (including but not limited to other management functions, network functions/entities, NWDAF, SON functions, optimization tools and human operators).

## 5.2 Interaction with CN and RAN domains

The MDA MnS producer provides analytics data for management purposes based on input data related to different types of NFs or entities in the network, e.g. data reported from gNB and/or specific core network function(s). Depending on the use case and when needed, the MDA MnS producer may use the analytics results produced by NWDAF as input.

Management Data Analytics Function (MDAF) may act as 3GPP domain-specific (e.g. RAN or CN) or as 3GPP cross-domain MDA MnS producer. Figure 5.2-1 illustrates the example of coordination between NWDAF, gNB and MDA MnS producer(s) for data analytics purpose.

RAN domain MDA MnS producer

MDA MnS

3GPP cross-domain MDA MnS consumer

3GPP cross-domain MDA MnS producer (domain MDA MnS consumer)

CN domain MDA MnS producer

gNB

MDA MnS

MDA MnS

NWDAF

Other 5GC NF

Nnf

Nnwdaf

MDA MnS

MDA MnS

MnS

MnS

Nwdaf

RAN domain

CN domain

MnS

MDA MnS

Figure 5.2-1: Example of coordination between NWDAF, gNB and MDAS (MDA MnS) producer

Any authorized MnS consumers get access to MDA reports by interacting with MDA MnS producers. These scenarios include but are not limited to the following:

- The NWDAF, leveraging MDA reports (e.g. for control purposes and other 5GC NFs), interacts with MDA MnS producers.

- The gNB may consume the MDA MnS for RAN control purpose.

- The 3GPP cross domain MDA MnS Producer may consume (acting as Domain MDA MnS consumer) MDA MnS provided by domain-specific (RAN and/or CN) MDA MnS producer(s) and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of domain MDA MnS producer may interact with 5GC and RAN MnSs and NFs to receive analytics inputs per MDA capability, including:

- The CN Domain MDA MnS producer may consume the service provided by NWDAF and other 5GC NFs for MDA purpose.

- The RAN Domain MDA MnS producer may consume the MnS provided by/for gNB for MDA purpose.

The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer consumes 5GC domain MDA, RAN domain MDA, 5GC MnS and RAN MnS to receive analytics inputs per each MDA use case/capability including:

- The cross domain MDA MnS producer may consume the MDA MnS provided by RAN and/or CN domains.

- The cross domain MDA MnS producer may consume MnS provided by RAN and/or CN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

## 5.3 Deployment of multiple MDAs

Multiple MDA instances may be deployed according to deployment needs.

The 3GPP cross domain management may consume MDA MnS provided by core network management as shown in Figure 5.3-1.

MDA MnS

MDA MnS

Core Domain

Core Network

Other 5GC NF

NWDAF

Nnf

Nnwdaf

MnS

Nnwdaf

3GPP Cross-domain management

Cross-domain MDA

3GPP Cross-domain MDA MnS consumer

MDA MnS

Core network management

CN domain MDA

Figure 5.3-1

The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer interacts with CN domain MDA per each MDA use case/capability as follows:

- The cross-domain MDA MnS producer may consume the CN domain MDA MnS.

- The cross-domain MDA MnS producer may consume MnS provided by CN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of CN domain MDA MnS producer interacts with MnS producers per each use case/capability as follows:

- The CN domain MDA MnS producer may consume analytics results produced by NWDAF, MnS provided by CN domain management, other MDA MnS producers, management data derived by subnetwork management function(s), and management data derived by element management function(s).

The 3GPP cross domain management may consume MDA MnS provided by RAN management as shown in Figure 5.3‑2.

MDA MnS

MDA MnS

MnS

RAN domain

Radio access network

gNB

Cross-domain management

MDA MnS

3GPP cross-domain MDA MnS consumer

Cross-domain MDA

RAN network management

RAN domain MDA

**…**

**…**

Radio access network

gNB

Radio access network

gNB

Figure 5.3-2: Example of coordination cross-domain MDA and RAN domain MDA

The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer interacts with RAN domain MDA per each MDA use case/capability as follows:

- The cross domain MDA MnS producer may consume the RAN domain MDA MnS.

- The cross domain MDA MnS producer may consume MnS provided by RAN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of RAN domain MDA MnS producer interacts with MnS producers per each use case/capability as follows:

- The RAN domain MDA MnS producer may consume MnS provided by RAN domain management, other MDA MnS producers, management data derived by subnetwork management function(s), and management data derived by element management function(s).

## 5.4 Network Context

An MDA MnS producer provides analytics with respect to a particular network context, i.e. network status, under which data is collected to produce analytics. For example, a prediction of load in an area of interest may differ when all gNBs and potential additional RATs are operating compared to case where certain gNBs or other RATs are experiencing a fault or are powered off to save energy. The analytics conducted and produced by the MDA MnS producer for these two example scenarios would be different and directly affected by the specific status of network. Although the network status (context) affects the produced analytics conducted by the MDA producer, awareness of the network context would fall on the consumer side to complement the obtained analytics results. This network context, reflecting network status at the time of enabling data collection, is important for the MDA MnS consumer to understand the network conditions related to the obtained analytics and hence be able to use such analytics more efficiently.

The MDA MnS consumer cannot expect the MDA producer to provide the network context, because the network context interest of each MDA MnS consumer may differ depending on the usage and purpose of analytics. The usage can include a proprietary algorithm that assist a decision-making process. For example, a load balancing algorithm may require the load and mobility information among neighbouring gNB whereas other load balancing algorithms may also require load and mobility information from a greater geographical area.

In addition, the selection of the parameters and their combinations may prove to be impractical for the MDA MnS producer to prepare and provide. Hence, it is efficient for the MDA MnS producer to prepare only the MDA output without including any network context and allow the MDA MnS consumer to obtain the required network context, to complement the obtained analytics, using conventional configuration management procedures as described in TS 28.511 [20] and TS 28.531 [21].

## 5.5 Historical data handling for MDA

Historical analytics reports may be saved and retrieved for use at later times by a MDA MnS consumer, and historical analytics input (enabling) data (along with current analytics input data) may be used for analytics by MDA MnS producer. Such a historical data usage may be applicable to both or one of the MDA MnS producer and MDA MnS consumer side.

NOTE: Historical data refers to (a) historical analytics reports that have been produced in the past, and (b) historical analytics input (enabling) data that had been collected in the past.

## 5.6 AI/ML support for MDA

The MDA process may utilize AI/ML technologies. An MDA Function may optionally be deployed as one or more AI/ML inference function(s) in which the relevant ML entities are used for inference per the corresponding MDA capability. Specifications for MDA ML entity training to enable ML entity deployments are given in TS 28.105 [24].

# 6 MDA in management loop

## 6.1 MDA role in the management loop

Intelligence in Analytics, played by MDA, in the management loop which can be open loop (operator controlled) or closed loop (autonomous) [1] as shown in Figure 6.1-1, generates value by processing and analysis of management and network data, where AI and ML techniques may be utilized (see TS 28.105 [24]).



Figure 6.1-1: Analytics in management loop

The management loop constitutes number of elements including the analytics, and these are briefly described below:

**Observation:** The observation of the managed networks and services. It involves monitoring and collection of events, status and performance of the managed networks and services, and providing the observed/collected data.

**Analytics:** The data analytics for the managed networks and services. MDA plays the role of Analytics in the management loop. It prepares, processes and analyses the observed/collected data or time series of the observed/collected data related to the managed networks and services. MDA reports may contain root cause analysis of ongoing issues, predictions of potential issues and corresponding relevant causes and recommended actions for preventions, and/or prediction of network and/or service demands.

**Decision:** The decision making for the management actions for the managed networks and services. The management actions are decided based on the analytics reports (provided by MDA) and other management data (e.g. historical decisions made previously) if necessary. The decision may be made by the consumer of MDAS (in the closed management control loop), or by a human operator (in the case of open management loop). The decision may include e.g. what actions to take, and when to take the actions.

**Execution:** The execution of the management actions according to the decisions. During the execution step, the actions are carried out to the managed networks and services, and the reports (e.g. notifications, logs) of the executed actions are provided.

## 6.2 MDA role in the management loop for service assurance

MDA represents Analytics roles in the management control loop for communications service assurance TS 28.535 [3]. The management and control of resources used by a communication service and the assurance of this communication service level agreements (e.g. per SLS) is provided by the management control loop involving different management services produced by the management system, which includes management data analytics service (MDAS, or MDA MnS). The MDAS (MDA MnS) may be produced based on a combination of information including e.g. the user quality of service experience, network performance and network resource utilization analysis and the SLS.

The MDAS complements other services in the management loop in order to perform SLS communication service assurance. Prior to operation phase, the MDA role in the management control loop is to prepare, process and analyse the data related to the managed communication service, in order to provide the analytics output (analytics report) which may include prediction and feasibility checks of network resource requirements to meet the SLS.

During the operation phase, the MDA can identify ongoing issues impacting the performance of the communication service per the SLS and identify in advance potential risks that would cause potential failure and/or performance degradation. The MDA can also predict the network and service demand to maintain delivery of communication service per the contracted SLS.

## 6.3 MDA role in cross-domain service assurance

Cross-domain MDA may base its analysis on the outputs from one or multiple single-domain MDA including analytics output and other input data (e.g. PM, alarm notifications, etc.). To facilitate service assurance the cross-domain MDA may adopt output from one or multiple single-domain MDA. Figure 6.3-1 shows the simplest case, where a cross-domain MDA incorporates the results of single-domain MDA(s).

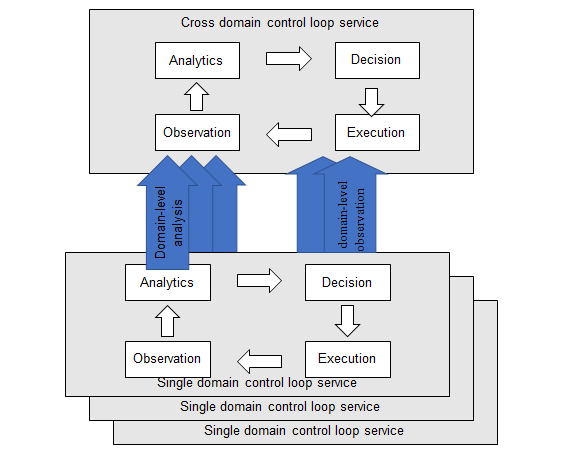


Figure 6.3-1 Cross-domain MDA based on single-domain MDA

Figure 6.3-2 shows the case where a cross-domain MDA incorporates the results of single-domain MDA(s) which are embedded within single-domain control loop service(s). Service assurance control loop may be conducted at single-domain bases where MDA role is assumed by analytics. The cross-domain MDA may further leverage the output from one or multiple single-domain control loops for its analytics for the e2e service assurance.

Cross domain MDA

Analytics

Single domain control loop service

Single domain control loop service

Single domain control loop service

Analytics

Execution

Observation

Decision

Domain-level analysis

Figure 6.3-2: Cross-domain MDA based on single-domain control loop service

Figure 6.3-3 shows the case where a cross-domain MDA is part of a cross-domain control loop service. Also in this case, cross-domain MDA incorporates the results of single-domain MDA(s). Service assurance control loop may be conducted at the cross-domain level in which the MDA role is assumed by analytics. The cross-domain control loop may adopt output from one or multiple single-domain MDA(s) for the e2e service assurance.

Cross domain control service

Analytics

Execution

Observation

Decision

Single domain MDA

Single domain MDA

Single domain MDA

Analytics

Domain-level analysis

Figure 6.3-3: Cross-domain control loop service based on single-domain MDA(s)

Figure 6.3-4 shows another case where a cross-domain MDA is part of a cross-domain control service. In this case, cross-domain MDA incorporates the results of single-domain MDA(s) which are embedded within single-domain control loop service(s). Service assurance control loop may be conducted at both levels where MDA role is assumed by analytics, i.e. at the cross-domain and single-domain. The cross-domain MDA may adopt output from one or multiple single-domain MDA(s) for the e2e service assurance.

Cross domain control loop service

Analytics

Execution

Observation

Decision

Single domain control loop service

Single domain control loop service

Single domain control loop service

Analytics

Execution

Observation

Decision

Domain-level analysis

Figure 6.3-4: Cross-domain control loop service based on single-domain control loop service(s)

# 7 Use cases and requirements for MDA capabilities and services

## 7.1 General

The following clauses describe the use cases and requirements for MDA capabilities and MDA MnSs. The MDA capabilities are grouped under specific categories.

## 7.2 MDA capabilities

### 7.2.1 Coverage related analytics

#### 7.2.1.1 Coverage problem analysis

##### 7.2.1.1.1 Description

This MDA capability is for analysis of coverage related problem.

##### 7.2.1.1.2 Use case

The RAN coverage problem may cause UEs to be out of service or result in a downgrade of network performance offered to the UEs, such as failure of random access, paging, RRC connection establishment or handover, low data throughput, abnormal releases of RRC connection or UE context, and dissatisfied QoE.

There are various types of coverage problems, e.g. weak coverage, a coverage hole, a pilot pollution, an overshoot coverage, or a DL and UL channel coverage mismatch, etc., caused by different sorts of reasons, such as insufficient or weak transmission power, blocked by constructions and/or restricted by terrain.

The 5G related coverage problem may exist in NR, in E-UTRA or both.

To unravel a coverage problem, it is necessary for MDAS consumer to determine the details about when and where the problem occurred or likely to occur, and the type and cause(s) of the problem. Therefore, it is desirable for MDA to correlate and analyze multifold data (such as performance measurements, MDT reports, RLF reports, RCEF reports, UE location reports, together with the geographical, terrain and configuration data of the RAN) to detect and describe the problem with detailed information.

The RAN coverage related problems can cause network performance degradation and in the extreme cases can result into service degradation. So besides identifying the problems after they have happened, it is also necessary to proactively avoid the RAN coverage related problems well before they occur.

To avoid coverage related problems or to proactively undertake actions to avoid their occurrence, the consumer of MDA MnS may wish to know the characteristics and quality of the coverage of the RAN. This may be expressed graphically on a Map, called a Radio Environment Map, that shows the coverage quality for a set of cells. Such a map may be constructed e.g. to show the RSRP or the SINR of the cells as derived from the observed UE performance and/or from radio configuration parameters of the cells including transmit powers, antenna gains, antenna tilts, etc. It is desirable that the MDAS producer can provide the Radio Environment Map in an appropriate graphical form.

Moreover, where a new RAN node is provisioned, the MDAS producer should be able to take into considerations the coverage of existing cells as defined by a Radio Environment Map and derive the configuration of the new cell(s) and the existing cells to optimize the coverage. Image analytics should help to identify the most optimized set of initial radio configurations that can be assigned to a new RAN NE.

To help MDAS consumer to solve the coverage problem as quickly as possible, MDA may also provide, along with the description of the problem, the recommended remedy actions (e.g. reconfigure or add cells, beams, antennas, etc.).

##### 7.2.1.1.3 Requirements

Table 7.2.1.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-COV\_MDA-01** | MDA capability for coverage problem analysis shall include providinganalytics for issues including, weak coverage, coverage holes, pilot pollution, overshoot coverage, or DL and UL channel coverage mismatch. | Coverage problem analysis |
| **REQ-COV\_MDA-02** | MDA capability for coverage problem analysis shall include providing analytics for area specific coverage problem analysis. | Coverage problem analysis |
| **REQ-COV\_MDA-03** | MDA capability for coverage problem analysis shall include providing a radio environment map that graphically describes the radio coverage characteristics (e.g. RSRP or SINR) of the selected cluster of cells. | Coverage problem analysis |
| **REQ-COV\_MDA-04** | MDA capability for coverage problem analysis shall include providing optimum configurations of a RAN node based on the radio environment map that graphically describes the radio coverage characteristics (e.g. RSRP or SINR) of a selected cluster of cells. | Coverage problem analysis |

#### 7.2.1.2 Slice coverage analysis

##### 7.2.1.2.1 Description

This MDA capability is for the slice coverage analysis.

##### 7.2.1.2.2 Use case

The slice coverage is one of the indicators when a 3rd party (i.e. slice tenant) issues a slice request and is mapped into the desired geographical coverage area with the available radio coverage which depends on the base station planning and deployment. In order to map the desired slice coverage perfectly, MDA can be used to optimize the slice coverage on the slice instantiation and runtime considering:

i) slice-aware statistics, e.g. slice-UE distributions and mobility patterns;

ii) slice SLA; and

iii) access node capabilities.

In 5G the notion of coverage is represented by a set of one or more Tracking Areas (TAs), which are contained in a Registration Area (RA), which is assigned to a UE once it registers to the network. Depending on the MDA MnS producer output, TA and RA planning, i.e. grouping cells to form a TA and then TAs to an RA, can be optimized and the RAN parameters can be adjusted to shape the cell edges and load distribution. The main objective is to fulfill a given slice SLA involving as few cells as possible by leveraging the benefits of adjusting cell configurations for satisfying the desired coverage.

##### 7.2.1.2.3 Requirements

Table 7.2.1.2.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-NS\_COV\_MDA-01** | MDA capability for slice coverage analysis shall include providing analytics output describing the slice coverage and slice availability. | Slice coverage analysis |
| **REQ-NS\_COV\_MDA-02** | MDA capability for slice coverage analysis shall include providing analytics of the mapping between slice coverage and actual radio deployment. | Slice coverage analysis |
| **REQ-NS\_COV\_MDA-03** | MDA capability for slice coverage analysis shall include providing recommended actions that involve options to reconfigure TA and/or RAN attributes including HO parameters, cell reselection parameters, beam configuration, computing resource and slice support in a cell. | Slice coverage analysis |

#### 7.2.1.3 Paging optimization analysis

##### 7.2.1.3.1 Description

This MDA capability is for enabling various functionalities related to paging optimization.

##### 7.2.1.3.2 Use Case

As per the current procedures, if the UE goes Out-Of-Coverage (OOC) the paging which was initiated by the network Access and Mobility Management Function (AMF) fails. The re-attempts continue to fail until UE enters the coverage and respond to the paging attempts. This repetitive paging attempts result in the wastage of network resources. As an example, the use case includes a user or a group of users getting into an area, with no cellular coverage on a regular basis for a considerably long duration, for e.g. the user gets into a shielded room for some testing purpose every day for a defined period. The Network initiated paging for such users will fail until they are back in the area with cellular coverage. This would result in in-efficient network resource usage.

It is desirable to use MDAS (Management data analytic service) to optimize the current paging procedures in 5G networks. MDAS producer provides an analytics output containing the user(s) paging analytics indicating the time window at which a group of users are OOC on a regular basis at the particular location. MDAS producer also provides the geographical map within which the UEs would experience paging issues and hence will not be able to respond on a network-initiated paging. Based on the provided MDA output, MDAS consumer (e.g. AMF, gNB) decides on whether, when and where to initiate or not to initiate the paging procedures, thereby ensuring the efficient paging procedures and optimal network resource utilization, as paging can be initiated only when there are more chances for it to be successful.

##### 7.2.1.3.3 Requirements

Table 7.2.1.3.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-PAG\_MDA-01** | MDA capability for paging optimization analysis shall include providing analytics output describing paging result patterns for a group of users. | Paging optimization analysis |
| **REQ-PAG\_MDA-02** | MDA capability for paging optimization analysis shall include providing analytics output describing paging result patterns based on geographical area. | Paging optimization analysis |
| **REQ-PAG\_MDA-03** | MDA capability for paging optimization analysis shall include providing analytics output describing the paging result patterns based on successful and un-successful paging attempts at a particular time and duration based on geographical area. | Paging optimization analysis |
| **REQ-PAG\_MDA-04** | MDA capability for paging optimization analysis shall include providing analytics output describing the paging result patters to contain the following information:  - Identification of a group of users.  - Identify the geographical area of concern.  - Prediction of the time window during which UE is out-of-coverage periodically.  - Prediction of the last known location before UE going out‑of‑coverage periodically.  - The recommended action which may suggest stopping paging the UE for Daily-OOC-Duration at Daily-OOC-Location. | Paging optimization analysis |

### 7.2.2 SLS analysis

#### 7.2.2.1 Service experience analysis

##### 7.2.2.1.1 Description

This MDA capability is for the service experience analysis.

##### 7.2.2.1.2 Use case

Service experience of end user is key indicator that directly reflects the user satisfaction degree. In 5G system, the diversity of network services is expanding all the time and the requirements of different services especially from vertical users are being standardized. Considering these diverse requirements and expectation from end user perspective (e.g. priorities of SLA related attributes such as latency, throughput, maximum number of users or different required values of these attributes), the service experience as a comprehensive indicator need to be extensively analysed.

##### 7.2.2.1.3 Requirements

Table 7.2.2.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-SER\_EXP\_MDA-01** | MDA capability for service experience analysis shall include identifying the source of service experience issue, e.g. RAN issue, CN issue, TN issue, UE issue, service provider issue. | Service experience analysis |
| **REQ-SER\_EXP\_MDA-02** | MDA capability for service experience analysis shall include providing the analytics output with following information describing the current service experience aspects and potentially future prediction:  - The predicted future service experience and/or observed service experience statistics.  - Service experience degradation root cause analysis. | Service experience analysis |
| **REQ-SER\_EXP\_MDA-03** | MDA capability for service experience analysis shall include providing the level of service experience. | Service experience analysis |
| **REQ-SER\_EXP\_MDA-04** | MDA capability for service experience analysis shall include providing the recommendation for improving service experience. | Service experience analysis |
| **REQ-SER\_EXP\_MDA-05** | MDA capability for service analysis should include the ability to provide service experience analysis across or within domains. | Service experience analysis |

#### 7.2.2.2 Network slice throughput analysis

##### 7.2.2.2.1 Description

This MDA capability is for the network slice throughput analysis.

##### 7.2.2.2.2 Use case

Throughput is of great importance which represents the end users' experiences and also reflects the network problems, e.g. low UE throughput may be caused by resource shortage. In order to satisfy the requirements of dL/ulThptPerSlice in the ServiceProfile, MDAS may be utilized for throughput related analysis/predictions for network slice instance.

MDAS producer allows the consumer to request analytics of network slice throughput related issues and identify the corresponding root cause(s) to assist throughput assurance. Network slice throughput analysis can be for a specific domain and/or for cross-domain. Domain-specific MDAS producer analyses the network slice subnet throughput, while the cross-domain MDAS producer analyses the network slice throughput. The two level MDAS producers, i.e. domain-specific and cross-domain may work in coordination to assure the optimum throughput performance.

##### 7.2.2.2.3 Requirements

Table 7.2.2.2.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-THR\_MDA-1** | MDA capability for network slice throughput analysis shall include identifying the network slice throughput issues, including those RAN‑related and CN-related issues. | Network slice throughput analysis |
| **REQ-THR\_MDA -2** | MDA capability for network slice throughput analysis shall include providing the root cause analysis of the network slice throughput issue(s). | Network slice throughput analysis |
| **REQ-THR\_MDA -3** | MDA capability for network slice throughput analysis shall include providing the analytics output of the network slice throughput which contain the following information:  - Network slice throughput statistics.  - Network slice throughput predictions. | Network slice throughput analysis |
| **REQ-THR\_MDA-04** | MDA capability for network slice throughput analysis shall include providing the prompt when the network slice throughput exceeds or falls below a certain threshold. | Network slice throughput analysis |

#### 7.2.2.3 Network slice traffic prediction

##### 7.2.2.3.1 Description

This MDA capability is for the prediction of network slice traffic patterns.

##### 7.2.2.3.2 Use case

It is desirable to use MDAS to get the network slice traffic predictions including individual traffic load predictions on each of the constituent network function instance present in the network slice. The traffic load predictions per constituent network function instances can be used for better resource provisioning of the network slice. For example, resources can be pre-configured considering the predicted traffic on the network slice.

##### 7.2.2.3.3 Requirements

Table 7.2.2.3.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-TRA\_MDA--01** | MDA capability for network slice traffic prediction shall include providing analytics output describing traffic load prediction of the network slice including traffic load prediction for each of its constituent network function instances. | Network slice traffic prediction |
| **REQ-TRA\_MDA-02** | MDA capability for network slice traffic prediction shall include providing analytics output describing traffic load prediction for the network slice which include the following information:  - Predicted uplink and downlink throughput on each User Plane Function instance (UPF) in the network slice.  - Predicted number of Packet Data Unit (PDU) session for each Session Management Function (SMF) instance in the network slice.  - Predicted number of UE or Registered subscriptions for each AMF instance in the network slice.  - Predicted maximum packet size for each UPF instance in the network slice.  - Predicted UE uplink and downlink throughput on each gNodeB (gNB) instance in the network slice.  - Predicted number of UE for each gNB/NR cell instance in the network slice. | Network slice traffic prediction |

#### 7.2.2.4 E2E latency analysis

##### 7.2.2.4.1 Description

This MDA capability is for E2E latency related issue analysis.

##### 7.2.2.4.2 Use case

E2E latency is an important parameter for URLLC services. User data packets should be successfully delivered within certain time constraints to satisfy the end users requirements. Latency could be impacted by the network capability and network configurations. These factors may be the root cause if the latency requirements cannot be achieved. Packet transmission latency may dynamically change if these factors change. The latency requirement should be assured even if some of the network conditions may degrade. It is important for the MDAS producer to analyze the latency related issues to support SLS assurance.

##### 7.2.2.4.3 Requirements

Table 7.2.2.4.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-LAT\_MDA-01** | MDA capability for E2E latency analytics shall include identifying the type of the E2E latency issue, including, RAN- related latency issue, CN‑related latency issue, TN-related latency issue, UE-related latency issue and service provider originated latency issue. | E2E latency analytics |
| **REQ-LAT\_MDA-02** | MDA capability for E2E latency analytics shall include providing the root cause analysis of the E2E latency issue. | E2E latency analytics |
| **REQ-LAT\_MDA-03** | MDA capability for E2E latency analytics shall include providing the recommended actions to solve the E2E latency issue. | E2E latency analytics |

#### 7.2.2.5 Network slice load analysis

##### 7.2.2.5.1 Description

This MDA capability is for network slice load analysis.

##### 7.2.2.5.2 Use cases

Network slice load may vary during different time periods. Therefore, network resources allocated initially could not always satisfy the traffic requirements, for example, the network slice may be overloaded or underutilized. Overload of signalling in control plane and/or user data congestion in user plane will lead to underperforming network. Besides, allocating excessive resources for network slice with light load will decrease resource efficiency.

The analysis of network slice load should consider the load of services with different characteristics (e.g. QoS information, service priority), load distribution to derive the corresponding resource requirements. Load distribution analytic result may be provided, e.g. load distribution for network slices, different locations and/or time periods etc.

Traffics and resources related performance measurements and UE measurements can be utilized by MDAS producer to identify degradation of the performance measurements and KPI documented in an SLS due to load issues, e.g. radio resource utilization. MDAS producer may further provide recommendations to the network slice load issue. This analytics results can be considered as an input to support SLA assurance to perform further evaluation.

##### 7.2.2.5.3 Requirements

Table 7.2.2.5.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-NS\_LOAD\_MDA-01** | MDA capability for network slice load analytics shall include identifying the domain of the network slice load issue, including, RAN issue, CN issue and TN-related issues. | network slice load analytics |
| **REQ-NS\_LOAD\_MDA-02** | MDA capability for network slice load analytics shall include identifying the phase of the network slice load issue, e.g. historic/ongoing/potential network slice load issue. | network slice load analytics |
| **REQ-NS\_LOAD\_MDA-03** | MDA capability for network slice load analytics shall include identifying the state of the network slice load issue, e.g. overload/underutilized network slice load issue. | network slice load analytics |
| **REQ-NS\_LOAD\_MDA-04** | MDA capability for network slice load analytics shall include identifying the list of the network entities which are involved in the network slice load issue. | network slice load analytics |
| **REQ-NS\_LOAD\_MDA-05** | MDA capability for network slice load analytics shall include providing analytics related to network slice load within specified time schedules and geographic locations or target objects. | network slice load analytics |
| **REQ-NS\_LOAD\_MDA-06** | MDA capability for network slice load analytics shall include providing the root cause and recommended actions to the network slice load issue. | network slice load analytics |

### 7.2.3 MDA assisted fault management

#### 7.2.3.1 Failure prediction

##### 7.2.3.1.1 Description

This MDA capability is for failure prediction.

##### 7.2.3.1.2 Use case

There are multiple sources of faults which may cause the 5G system to fail to provide the expected service. These faults and the associated failures need extensive troubleshooting. In order to reduce network and service failure time and performance degradation, it is necessary to supervise the status of various network functions and resources, and predict the running trend of network and potential failures to intervene in advance. These predictions can be used by the management system to autonomously maintain the health of the network, e.g. speedy recovery actions on a network function related to the predicted potential failure.

Due to the fact that failure prediction could depend on the existing alarm incidents and relevant historical and real‑time data (performance measurement information, configuration data, network topology information, etc.), there is a possibility for MDA to be used in conjunction with AI/ML technologies and model training to predict potential failures.

In order to avoid the occurrence of failures and abnormal network status, it is necessary for consumers of analytics to obtain the required details of potential failure and the corresponding degradation trend (abnormal KPI, performance measurement information, possible alarm type, fault root cause, etc.). Therefore, MDA, may in conjunction with AI/ML technology, be required to obtain basic health maintenance knowledge (e.g. the relationship between the failures or potential failures and the related maintenance actions) through predefined expertise or model training, so as to effectively predict potential failures. The basic health maintenance knowledge could be updated with feedback.

Besides the MDA capability to obtain basic health maintenance relationships between the service failure and related potential failures at network levels, the MDA capability for failure prediction may take role of coordination in cross domain. When MDA capability takes role of coordination in cross domain, the MDA capability for failure prediction can collect analytics output of fault prediction from single domain management and provide recommendation actions accordingly.

If necessary, MDA could also provide corresponding recommended actions for failure prevention.

##### 7.2.3.1.3 Requirements

Table 7.2.3.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-FAILURE\_PRED\_MDA-01** | Void | Void |
| **REQ-FAILURE\_PRED\_MDA-02** | MDA capability for failure prediction shall be able to obtain basic health maintenance knowledges (including, the relationship between the failures or potential failures and the related maintenance actions) through predefined expertise or model training. | Failure prediction |
| **REQ-FAILURE\_PRED\_MDA-03** | MDA capability for failure prediction shall be able to provide the analytics output including predictions of potential service failures, as well as the possible recommendation actions to prevent failures. | Failure Prediction |
| **REQ-FAILURE\_PRED\_MDA-04** | MDA capability for failure prediction should include the ability to predict failures across or within domains and provide analytics outputs for predicted failures. | Failure Prediction |

#### 7.2.3.2 Service failure recovery

##### 7.2.3.2.1 Description

This MDA capability is for service failure recovery.

##### 7.2.3.2.2 Use case

There are multiple sources of faults which may cause the 5G system to fail to provide the expected service. The potential management actions to support recovery of network service are some operational activities, such as switch to a redundancy NFs, modify configuration(s) of NFs based on different scenarios. When a service interruption disaster occurs (e.g. massive call disconnections), it is important for MDA to provide analytics to suggest management actions to quickly recover the service while avoiding causing other problems (e.g. signalling overload) during the recovery. The analysis of failure recovery can be used by the management system to recover from service interruptions in an orderly manner.

As an example, in case that the service interruption occurs, the MDA can provide analysis of the possible recovery plan and the recommended actions for service recovery (e.g., update NF, change configuration of core network NF etc.).

##### 7.2.3.2.3 Requirements

Table 7.2.3.2.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-FAILURE\_RECORV\_MDA-01** | MDA capability for failure recovery shall be able to collect, filter and analyse alarm information, KPI information and configuration information as inputs for analytics and provide the analytics output. | Failure recovery |
| **REQ-FAILURE\_RECORV\_MDA-02** | MDA capability for failure recovery shall be able to provide the analytics output including the possible recommendation actions to prevent failures or service recovery. | Failure recovery |

### 7.2.4 MDA assisted Energy Saving

#### 7.2.4.1 Energy saving analysis

##### 7.2.4.1.1 Description

This MDA capability is for the energy saving analysis.

##### 7.2.4.1.2 Use cases

Operators are aiming at decreasing power consumption in 5G networks to lower their operational expense with energy saving management solutions. Energy saving is achieved by activating the energy saving mode of the NR capacity booster cell or 5GC NFs (e.g. UPF etc.). The energy saving decision making is typically based on the load information of the related cells/UPFs, the energy saving policies set by operators and the energy saving recommendations provided by MDAS producer. To achieve an optimized balance between the energy consumption and the network performance, MDA can be used to assist the MDAS consumer to make energy saving decisions.

To make the energy saving decision, it is necessary for MDAS consumer to determine where the energy efficiency issues (e.g. high energy consumption, low energy efficiency) exist, and the cause of the energy efficiency issues. Therefore, it is desirable for MDA to correlate and analyze the energy saving related performance measurements (e.g. PDCP data volume of cells, power consumption, etc.) and the network analysis data (e.g. observed service experience related network data analytics) to provide the analytics results which indicate current network energy efficiency. In some low-traffic scenarios, MDA MnS consumers may expect to reduce energy consumption to save energy. In this case, the MDA MnS consumer may request the MDAS producer to report only high energy consumption issue related analytics results. When the consumer expects to improve energy efficiency, although it may lead to high energy consumption in network or in certain parts of network, then the related issue is the low energy efficiency one. In that case, the consumer may request analytics results related to low energy efficiency issue. So, the target could be to enhance the performance of NF for a given energy consumption. This will result in higher Energy Efficiency of network.

To make the energy saving decision, it is necessary for MDAS consumer to determine which Energy Efficiency (EE) KPI related factor(s) (e.g. traffic load, end-to-end latency, active UE numbers, etc.) are affected or potentially affected. The MDAS producer can utilize historical data to predict the EE KPI related factors (e.g. load variation of cells at some future time, etc.). The prediction result of these information can then be used by operators to make energy-saving decision to guarantee the service experience.

The MDAS producer may also provide energy saving related recommendation with the energy saving state to the MDAS consumer. Under the energy saving state, the required network performance and network experience should be guaranteed. Therefore, it is important to formulate appropriate energy saving policies (start time, dynamic threshold setting, base station parameter configuration, etc.). The MDAS consumer may take the recommendations with the energy saving state into account for making analysis or making energy saving decisions. After the recommendations have been executed, the MDA producer may start evaluating and further analyzing network management data to optimize the recommendations.

##### 7.2.4.1.3 Requirements

Table 7.2.4.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-ES\_MDA-01** | MDA capability for energy saving analysis shall include identifying the energy efficiency issue (including high energy consumption, low energy efficiency), and identify the cell/NFs or location area of where the indicated energy efficiency issue exists. | Energy saving analysis |
| **REQ-ES\_MDA-02** | MDA capability for energy saving analysis shall include identifying the root cause of the energy efficiency issue when necessary. | Energy saving analysis |
| **REQ-ES\_MDA-03** | MDA capability for energy saving analysis shall include utilizing the network status analysis and predictions information of the energy efficiency KPI factors (including, traffic load trends) to assist achieving energy saving. | Energy saving analysis |
| **REQ-ES\_MDA-04** | MDA capability for energy saving analysis shall include providing the energy saving recommendation, including policies and configuration actions to guarantee the network performance and end user service experience. | Energy saving analysis |

### 7.2.5 MDA assisted mobility management

#### 7.2.5.1 Mobility performance analysis

##### 7.2.5.1.1 Description

This MDA capability is for the mobility performance analysis.

##### 7.2.5.1.2 Use case

The mobility performance related problems may result from too-early/too-late/ping-pong handovers due to inappropriate handover parameters. MDAS can be used to analyse service experience and network performance during handover period in different mobility scenarios. MDAS producer may also be capable to provide the recommendations of optimal handover parameters to MDAS consumer.

In different NSA and SA deployment architecture scenarios, handover mechanisms (e.g. DAPS, CHO or RACH-less handover) will have different impacts on the mobility performance. The analytics report to identify the most optimal handover mechanism may be provided by MDAS producer.

##### 7.2.5.1.3 Requirements

Table 7.2.5.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-MRO\_MDA-01** | MDA capability for mobility performance issue analysis shall include providing the mobility performance in NSA and SA deployment architectures. | Mobility performance issue analysis |
| **REQ-MRO\_MDA-02** | MDA capability for mobility performance issue analysis shall include providing the mobility issue analysis including too-early handovers, too-late handovers and ping-pong handovers. | Mobility performance issue analysis |
| **REQ-MRO\_MDA-03** | MDA capability for mobility performance issue analysis shall include identifying the most optimal handover mechanism including DAPS, CHO or RACH-less handover. | Mobility performance issue analysis |
| **REQ-MRO\_MDA-04** | MDA capability for mobility performance issue analysis shall include providing the area specific mobility performance analysis. | Mobility performance issue analysis |

#### 7.2.5.2 Handover optimization analysis

##### 7.2.5.2.1 Description

This MDA capability is for the handover optimization analysis.

##### 7.2.5.2.2 Use cases

7.2.5.2.2.1 Handover optimization

Current handover procedures are mainly based on radio conditions for selecting the target gNB upon a handover. The target gNB accepts or rejects the Handover (HO) request depending on various conditions. In virtualized environment, the HO may be rejected due to inadequate available resources within the target gNB. The notion of resources may include virtual resources (e.g. compute, memory) and/or radio resources (e.g. PRB, RRC connected users). If the HO request is rejected, a UE will try to connect to a different gNB until the request is successfully accepted. Several target gNBs can be tried until the request is successfully accepted. This process can result in wastage of UE and network resources, while it may also introduce service disruption due to increased latency and Radio Link Failures (RLFs). It also introduces inefficiency in the HO or other network procedures.

To address this handover optimization issue, it is desirable to use MDA (Management Data Analytics) to provision and/or select a particular target gNB for handover in order to reduce or even avoid HO rejections. The MDAS producer provides a HO optimization analytics output containing the current and future/predicted resource consumption, resources capabilities and other KPIs' status for the available target gNB(s). The analytics output also provides recommended actions to optimize the target gNB for handover. This may include resource re-configuration or the updated selection criteria for target gNB. Based on the output, the MDAS consumer adjusts (e.g. scale-out/up the virtual resource, re-schedule/optimize radio resource) the resources before continuing with the handover and/or adjusts the selection criteria of the target gNB by also considering the overlapping coverages of inter‑frequency and inter-RAT deployments.

7.2.5.2.2.2 Handover optimization based on UE Load

The target node, eNB, may not have adequate resources to accept certain handover requests. In the context of network virtualization, these resources may include not only legacy radio resources, but also virtual resources such as processor and memory. Handover optimization can benefit from knowledge about the projected UE load on the target cell including additional radio and virtual resources.

##### 7.2.5.2.3 Requirements

Table 7.2.5.2.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-MOB\_MDA-01** | MDA capability for handover optimization shall include providing the analytics output related to current statistics and future predictions of virtual resource consumption of gNB. | Handover optimization |
| **REQ-MOB\_MDA-02** | MDA capability for handover optimization shall include providing the analytics output related to current statistics and future predictions of radio resource consumption of gNB. | Handover optimization |
| **REQ-MOB\_MDA-03** | MDA capability for handover optimization shall include providing an analytics output indicating a selection priority for the target cell, among a set of candidate inter-frequency cells. | Handover optimization |
| **REQ-MOB\_MDA-04** | MDA capability for handover optimization shall include providing an analytics output indicating a list of target cells to spare, i.e. avoid, a handover for an indicated time period. | Handover optimization |
| **REQ-MOB\_MDA-05** | MDA capability for handover optimization shall include providing the analytics output describing inter-frequency target cell selection for handover including information for provisioning or selecting a target gNB with respect to a specific service or slice, if the same Network Slice Instance (NSI) is available in both the current and target gNB. | Handover optimization |
| **REQ-MOB\_MDA-06** | MDA capability for handover optimization shall include providing the analytics output describing inter-frequency target cell selection for handover including indication of current and expected QoE (for the UE) at the current and target gNB. | Handover optimization |
| **REQ-MOB\_MDA-07** | MDA capability for handover optimization shall include providing the analytics output including the following information that can be used to optimize handover decisions:  - Indication on whether the target gNB is optimal for handover.  - Recommended action to optimize the target gNB and/or the selection of the target gNB for handover. | Handover optimization |
| **REQ-MOB\_MDA-08** | MDA capability for handover optimization shall include providing an analytics output indicating the projected UE load with respect to virtual resource and radio resource on the target cell. | Handover optimization based on UE Load |

#### 7.2.5.3 Inter-gNB beam selection optimization

##### 7.2.5.3.1 Description

This MDA capability is for inter-gNB beam selection optimization.

##### 7.2.5.3.2 Use case

With the deployment of 5G networks, Massive MIMO has been used on a large scale. Beamforming, as a key technology to reduce user interference, which can suppress interference signals in non-target directions and enhance sound signals in target directions, is always combined with Massive MIMO to further decrease interference. A cell can make use of multiple beams for serving residing users (SSB or CSI-RS) with each user served by a single beam at a time. The cell level quality can be represented as an aggregated metric over one or more beams. So, although handover is performed between two 5G cells, the granularity of handover can be further broken down to beam level.

The handover of beams could be performed if the network resource or the user's state have changed to obtain better network performance. Beam optimization includes the handover between different beams and configuration of beam parameters.

In order to avoid selecting the wrong beam to perform RACH on the target cell and causing RLF of the UE, MDA can be used to recommend a means to prioritize and/or select the beam in case of handover for a specific target cell. MDA can provide a beam level HO optimization analysis considering information on the handover performance of different beam combinations between the source and target cell pairs. Beams of the target cell with a successful handover are preferred in the selection.

MDA could also provide recommended actions and priority options for beam selection. Based on the recommended actions, the MDA MnS consumer adjusts the priorities for the beam selection at HO, i.e. the beam combinations that are likely to succeed are prioritized, less optimal beam combinations are down prioritized. The target cell may also obtain analytics to allocate RACH resources in a way that ensures HO success.

In order to optimize antenna and beam configuration, so as to reduce energy loss and enhance network performance, MDA can be used to analyze the current network status.

##### 7.2.5.3.3 Requirements

Table 7.2.5.3.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-HO\_BEAM\_OPT-01** | MDA capability for inter-gNB beam selection optimization shall include providing the analytics of the handover performance of beam pair combinations between cell pairs. | Inter-gNB beam selection optimization |
| **REQ-HO\_BEAM\_OPT-02** | MDA capability for inter-gNB beam selection optimization shall include providing an indication if a beam pair is to be prioritized or down prioritized. | Inter-gNB beam selection optimization |
| **REQ-HO\_BEAM\_OPT-03** | MDA capability for inter-gNB beam selection optimization shall include providing feasible antenna and beam configuration analysis. | Inter-gNB beam selection optimization |

### 7.2.6 MDA assisted critical maintenance management

#### 7.2.6.1 RAN Node Software Upgrade

##### 7.2.6.1.1 Description

This MDA capability is for network critical maintenance during RAN node software upgrade process.

##### 7.2.6.1.2 Use case

As per the current mechanism of software upgrade at RAN node results in service disruption or huge operational cost. Consider a scenario, when a RAN Node is required to shut down manually to undergo critical maintenance for a very short duration of time. Software upgrade can be one such critical maintenance scenario. In such cases, all the resources (bearer, security functions, mobility management) that are managed by this RAN Node need to be purged and reconfigured at another RAN Node (standby RAN Node) or if another RAN Node is not available then resources will be reconfigured again when former RAN Node comes up after software upgrade. Both the situations lead to additional operational expenses and data loss. Operational expense in terms of all the resources to be released/attached again and data loss for all GBR sessions/bearer.

It is expected to use MDAS to optimize the procedure of software upgrade at RAN Node by providing the right time to execute the required upgrade. The software upgrade should be automatically initiated by the OAM system, once configured, during the time frame when the expected impacts are minimum i.e. at the optimal time when there would be minimum expected operational cost and data loss. The Optimal Time (current or futuristic) can be derived by collecting and analysing the data related to DRBs including GBR/non-GBR, state, modification count, ongoing handover etc. MDAS can utilize historical data and AI/ML (e.g. time series based) algorithm to derive the future optimal time frame for software upgrade.

Note: RAN Node above refers to CU-CP in case of gNB split case.

##### 7.2.6.1.3 Requirements

Table 7.2.6.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-SWA\_MDA-01** | MDA capability for RAN Node software upgrade shall include providing the DRB info analytics output describing the DRBs info at a particular RAN Node(s). | RAN Node software upgrade |
| **REQ-SWA\_MDA-02** | MDA capability for RAN Node software upgrade shall include providing the DRB info analytics output describing the DRB info based on the following DRB characteristics; type (GBR/non-GBR), state (idle/active), modification count (indicating number of times, this bearer has gone for modification since its creation), handover in-progress (indicates whether the bearer is undergoing handover or not). | RAN Node software upgrade |
| **REQ-SWA\_MDA-03** | MDA capability for RAN Node software upgrade shall include providing output describing the DRB info that contain the following information:  - Time frame/duration at which the output is generated.  - Whether RAN Node is optimal for upgrade at present.  - Whether RAN Node will be optimal for upgrade during a future time frame. This will also provide a future frame.  - Total number of GBR and non-GBR DRBs at future point of time frame. This will also provide a future frame. | RAN Node software upgrade |

### 7.2.7 Resource related analytics

#### 7.2.7.1 NF resource utilization analysis

7.2.7.1.1 Description

This MDA capability is for analysis of resource utilization of 3GPP NFs.

7.2.7.1.2 Use case

The 3GPP system is a resource limited system, no matter whether the NF is working on virtualized resources or physical resources.

Resource shortage would affect the QoS and potentially impact users’ quality of experience (QoE), e.g., by lowering the users’ data throughput, prolonging the users’ data delay, raising the rejections for the establishment of new connections (e.g., RRC connection), sessions (e.g., PDU session) and resources (e.g., QoS flows, DRBs, etc.) and increasing the drops of the existing connections, sessions, and resources. This may also consequently lead to risking or failing SLAs.

On the other hand, resource excess would cause wastage that leads to additional CapEx and OpEx.

Therefore, it is imperative to ensure optimum and efficient resource utilization for the NFs.

The resource utilization of an NF is heavily dependent on load or traffic patterns, which could vary in different coverage areas (e.g., business area, entertainment area, and residential area) and in different time periods (weekdays and time of the day). It is desirable that the spare resource of the low-usage areas can be allocated to the busy areas.It is expected that MDA can perform an analysis of the resource utilization for physical resources or virtualized resources for the 3GPP NFs (in a specific domain or cross domains) to indicate the resource usage patterns in the past and predict the resource usage trend for some time periods in the future. The physical resources to be analyzed may include hardware resources (e.g., CPU), DL and UL PRBs (for gNB), etc., while the virtualized resources to be analyzed may include virtual CPU, virtual memory, virtual disk, etc.It is also very useful that MDA correlates the resource analytics across 3GPP NFs and provides recommendations that can be utlized to efficiently orchestrate the resources among NFs between the low usage and high usage areas for some time periods. The recommended actions could be for example to optimise, i.e., increase or decrease the capacity of gNB to enhance allocation of the physical resources or to schedule the "scale in" and "scale out" of VNFs via ETSI MANO system to optimize the allocation of the virtualized resources.

7.2.7.1.3 Requirements

**Table 7.2.7.1.3-1**

|  |  |  |
| --- | --- | --- |
| **Requirement label** | **Description** | **Related use case(s)** |
| **REQ-RES\_UTI\_ANA-01** | MDA capability for resource utilization analysis shall include identifying the 3GPP NFs with low usage of physical resources (see Note 1). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-02** | MDA capability for resource utilization analysis shall include identifying the 3GPP NFs with high usage of physical resources (see Note 1). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-03** | MDA capability for resource utilization analysis shall include providing the prediction of physical resource usage for a 3GPP NF (see Note 1). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-04** | MDA capability for resource utilization analysis shall include identifying the 3GPP NFs with low usage of virtualized resources (see Note 2). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-05** | MDA capability for resource utilization analysis shall include identifying the 3GPP NFs with high usage of virtualized resources (see Note 2). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-06** | MDA capability for resource utilization analysis shall include providing the prediction of virtualized resource usage for a 3GPP NF (see Note 2). | NF resource utilization analysis |
| **REQ-RES\_UTI\_ANA-07** | MDA capability for resource utilization analysis shall include providing recommended actions to manage and orchestrate one or more 3GPP NFs. e.g. to orchestrate the resource allocation or load balancing for one or multiple 3GPP NFs. | NF resource utilization analysis |
| NOTE 1: The requirement is valid only if the subject 3GPP NF uses physical resources.  NOTE 2: The requirement is valid only if the subject 3GPP NF uses virtualized resources. | | |

7.2.7.2 Control plane congestion analysis

7.2.7.2.1 Description

This MDA capability is for analysis of control plane congestion.

7.2.7.2.2 Use case

As described in TS 23.501 [28], a 5GC NF can become overloaded when it is operating over its nominal capacity resulting in diminished performance (including impacts to handling of incoming and outgoing traffic). Some mechanism, such as control plane congestion control as described in TS 23.501 [28] is designed for the purpose of avoiding and handling of 5GC NF overload. For example, as described in clause 5.19.7 of TS 23.501 [28], when the AMF is under overload conditions, it may reject the received request from the UE depending on various aspects. And the UE will send a new request after some time. It is possible that the new request will be rejected again because of the load of the AMF. In virtualized environment, the signaling request may be rejected due to inadequacy of available resources at the target 5GC NF e.g. AMF or SMF. If such situation can not be resolved, it will probably cause signalling storm for the whole network and affect the services (e.g. calls and data connections) provided by the network.

It is desirable to use MDA to assist control plane congestion analysis in order to detect, prevent or resolve identified congestion issue happened at the control plane. MDAS producer may utilize the collected PM, FM, network topology data, virtual resource information provided from ETSI NFV MANO and etc.) for control plane congestion analysis and provides analytics report containing identified or predicted congestion issue for the target 5GC NF (e.g. AMF, SMF). The analytics report also provides recommended actions to optimize the target 5GC NF for avoiding or resolving congestion issue. Based on the recommendation in the report, 3GPP management system can adjust (e.g., scale-up the virtual resource) the resources to better facilitate processing of the received control plane messages.

7.2.7.2.3 Requirements

**Table 7.2.7.2.3-1**

|  |  |  |
| --- | --- | --- |
| **Requirement label** | **Description** | **Related use case(s)** |
| **REQ-CP\_ANA-01** | MDA capability for control plane congestion analysis shall include identifying the 3GPP 5GC NFs with congestion issue. | Control plane congestion analysis |
| **REQ-CP\_ANA-02** | MDA capability for control plane congestion analysis shall include providing the prediction of congestion issue for a 3GPP 5GC NF. | Control plane congestion analysis |
| **REQ-CP\_ANA-03** | MDA capability for control plane congestion analysis shall include providing recommended actions to prevent congestion issue for 3GPP 5GC NFs. | Control plane congestion analysis |
| **REQ-CP\_ANA-04** | MDA capability for control plane congestion analysis shall include providing recommended actions to resolve identified congestion issue for 3GPP 5GC NFs. | Control plane congestion analysis |

### 7.2.8 Prediction and statistics of Management data

##### 7.2.8.1 Description

This use case is for the analytics (predictions and statistics) of the management data including 5G PMs defined in TS 28.552 [4] and 5G KPIs defined in TS 28.554 [5].

##### 7.2.8.2 Use case

Certain scenarios might need a prediction or statistics on existing management data, e.g. prediction or statistics of single or multiple PMs and KPIs. The MnS consumer of this use case (who may also be a MnS producer) might be interested in the analytics (statistics or prediction) on existing management data (PMs and KPIs) which can be then consumed to produce services on other use cases such as mobility optimization or load balancing etc. The MnS consumer gets a specific type of prediction or statistics (e.g., mean, standard deviation, correlation, etc.) of specific management data (PMs/KPIs) on network objects.

Statistics of the management data include the statistical calculation on the data themselves over a period in the past and/or statistics of management data following a sliding window procedure to produce statistics. Predictions of management data may include predictions of the data themselves over a future period, and/or predictions of the data following a sliding window procedure.

The main objective of this use case is to provide analytics (statistics and/or predictions) on the existing management data.

##### 7.2.8.3 Requirements

Table 7.2.8.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-SPM\_MDA-01** | MDA capability for management data analytics shall be able to produce predictions for the requested management data. | Prediction and statistics of Management data |
| **REQ-SPM\_MDA-02** | MDA capability for management data analytics shall be able to produce statistics for the requested management data. | Prediction and statistics of Management data |

## 7.3 MDA MnS

### 7.3.1 MDA request and control

#### 7.3.1.1 Description

The MDA request and control allow any authorized MDA MnS consumer to request management data analytics.

#### 7.3.1.2 Use case

The MDA MnS consumer can request the MDA MnS producer to provide MDA output for a list of specified MDA type of analytics, i.e. MDA type, which corresponds to an MDA capability, which is to support analytics for a set of data or analytics for a certain PM, KPI, trace or QoE data. The MDA MnS consumer may introduce control attributes related to the MDA output with respect to the geographical location (i.e. area scope) and/or the target objects, e.g. managed elements, time schedule for obtaining an MDA output, time conditions related to the preparation of MDA output (i.e. time schedule for start, end and duration of analytics, etc.), and potential filter conditions to be met before an MDA output is made available, e.g. load or delay threshold crossing related to a target object. The geographical location indicates an area of interest for obtaining MDA output and/or target objects include affected objects or objects of interest for obtaining MDA output.

The MDA MnS consumer may control the MDA output attributes related to, e.g. time schedule, geographical location, target objects, etc., and has the capability to modify them at any point in time. The MDA MnS consumer can request the MDA MnS producer to generate an MDA output that contains numeric output results, e.g. average, normal distribution, etc., recommendation options, e.g. potential handover target cells, or root cause analysis, e.g. alarm prediction.

The MDA MnS consumer can be informed with an acknowledgment if the request was successful. If the request was not successful, the consumer is informed about potential errors indicating the reasons. The attributes related to time can provide the flexibility to configure the MDA reporting control to provide analytics indefinitely. The MDA MnS consumer should delete the MDA request MOI after the requested analytics has been performed. The MDA MnS consumer can also deactivate the MDA reporting control request once it is no longer needed.

#### 7.3.1.3 Requirements

Table 7.3.1.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-MDA-CONT-01** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the MDA type. | **All use cases** |
| **REQ-MDA-CONT-02** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the reporting time schedule. | **All use cases** |
| **REQ-MDA-CONT-03** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on geographic location and/or the target objects if applicable. | **All use cases** |
| **REQ-MDA-CONT-04** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the time schedule related to specific part of MDA results. | **All use cases** |
| **REQ-MDA-CONT-05** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to modify the attributes related to the requested MDA output. | **All use cases** |
| **REQ-MDA-CONT-6** | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to specify filter conditions on target objects based on threshold crossing for MDA output when this is applicable. | **All use cases** |

### 7.3.2 Obtaining MDA Output

#### 7.3.2.1 Description

Following a successful MDA request any authorized MDA MnS consumer can obtain management data analytics from the corresponding MDA MnS producer. The MDA MnS consumer can control the MDA output by modifying the attributes related to the MDA request at any point in time.

#### 7.3.2.2 Use case

The MDA MnS producer allow consumers to obtain MDA output when the conditions indicated in the MDA request are met. The level of details and granularity of MDA output results would depend on the MDA request and nature of MDA capability. Therefore an MDA output can vary in complexity and may contain one or more MDA results, which may be:

i) numeric, e.g. average, etc.;

ii) recommendation options, e.g. potential handover target cells; or

iii) root cause analysis, e.g. alarm prediction.

These results may be related to one or more MDA types, which correspond to MDA capabilities, and can also contain information regarding the time schedule or the validity time of the provided MDA output.

MDA MnS producer may allow consumers to request and obtain different MDA output results. The MDA MnS producer may also allow consumers to obtain information regarding the geographical location and/or the target objects, e.g. managed elements, related to the provided MDA result - from the corresponding element.

The MDA MnS producer may allow consumers options to obtain MDA output results either by pulling or pushing mechanisms. Any MDA output may be obtained once it is prepared or when the specified MDA request and control conditions are met.

#### 7.3.2.3 Requirements

Table 7.3.2.3-1

|  |  |  |
| --- | --- | --- |
| Requirement label | Description | Related use case(s) |
| **REQ-MDA\_REP-01** | The MDA MnS producer shall have a capability allowing MDA MnS consumers to obtain analytics output per the MDA request. | **All use cases** |
| **REQ-MDA\_REP-02** | The MDA MnS producer shall have a capability allowing MDA MnS consumers to indicate if produced analytics output shall be pushed to the MDA MnS consumer or whether the MDA MnS consumer pulls the data. | **All use cases** |
| **REQ-MDA\_REP-03** | The MDA MnS producer shall allow MDA MnS consumer to obtain the geographical location and/or the target objects related to the MDA output if applicable. | **All use cases** |
| **REQ-MDA\_REP-04** | The MDA MnS producer shall allow MDA MnS consumer to obtain time schedule information related to the MDA output. | **All use cases** |

### 7.3.3 Filtering analytics recommendations

#### 7.3.3.1 Description

The MDA MnS consumer may configure the MDA request in the MDA MnS producer to avoid providing recommendation on certain entities.

#### 7.3.3.2 Use Case

When MDA provides prescriptive recommendations, the recommendations may include actions targeted towards entities for which the MDA MnS consumer cannot execute actions.

In some cases, this may cause erroneous behaviour. As an example, ACCL (Assurance Closed Control Loop) may receive recommendations from MDA which are in conflict with the ACCL “CLDisallowedList” indicating the objects for which the ACCL should not take any actions. If ACCL is only able to act on a subset of the recommendations received from MDA, ACCL will not be able to implement the full change as recommended by MDA. This could result in an incomplete solution to an issue. At worst, this could cause imbalance or oscillation within the network.

As another example, the recommendations provided by EnergySavingAnalysis may recommend multiple changes across the network which are intended to balance the network load as efficiently as possible to reduce energy usage. However, the MDA MnS consumer may not be authorized to change/configure all of the recommended RAN and/or CN nodes. This is unlikely to attain the expected reduction in energy usage and may cause imbalanced traffic in the network.

These problems may be avoided if the MDA MnS consumer could specify a set of objects for which no actions can be taken and thus no recommendations should be provided. The MDA MnS consumer could also indicate the objects, for which it does not want to receive recommendations, based on a geographical area. Recommendations should not be provided for the object(s) in that geographical area.

#### 7.3.3.3 Requirements

**Table 7.3.3.3-1**

|  |  |  |
| --- | --- | --- |
| **Requirement label** | **Description** | **Related use case(s)** |
| **REQ-MDA\_FILT-01** | The MDA MnS producer shall have a capability to allow an authorized MDA MnS consumer to indicate the scope for which no recommendations shall be included in the analytics report. | **All use cases** |

# 8 Data definitions for MDA capabilities

## 8.1 Introduction

### 8.1.1 MDA Types

The output of MDA can be related to a particular capability as described in clause 7, where an MDA type can indicate a specific MDA capability corresponding to a predefined use case(s).

The MDA capabilities may also support analytics of a set of data or analytics for certain PMs, KPIs, trace data, QoE or other type of data. Analytics related to the set of data relies on multiple raw, or already processed input data enabling an MDA MnS producer to provide more complex MDA output. Analytics related to certain set of data including PMs, KPIs, trace or QoE data may rely on these specific categories of data.

MDA MnS consumers may request and obtain output for MDA types related to analytics of a set of data or analytics for certain PMs, KPIs, trace or QoE data.

## 8.2 About analytics

### 8.2.1 About enabling data

Analytics are capability-specific, and the present document provides the enabling data for each MDA capability in the respective tables. It is not restrictive or mandatory to use the analytics inputs exactly the same as the provided enabling data (including historical and current data) for implementation, and other (additional or different) data are also allowed in order to facilitate the production of analytics outputs.

### 8.2.2 About analytics outputs

For analytics outputs, there are:

1) common information elements that can be generated by MDA and be applicable for all MDA capabilities;

2) capability-specific information elements; and

3) optionally, vendor specific extensions.

The common information elements are provided in clause 8.3, and the capability-specific information elements are provided per MDA capability in clause 8.4 of the present document.

## 8.3 Common information elements of analytics outputs

### 8.3.0 General

There are some information elements that are common for all analytics outputs and MDA capabilities, i.e. these common information elements form a subset of all analytics outputs of all MDA capabilities.

### 8.3.1 Common information element definitions

The common information elements of the analytics outputs are defined in Table 8.3.1-1.

Table 8.3.1-1: Common information elements of analytics outputs

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| analyticsId | The identifier of the analytics output. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |
| analyticsOutputGenerationTime | It indicates the time when the analytics output is generated. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

## 8.4 Data definitions per MDA capability

### 8.4.1 Coverage related analytics

#### 8.4.1.1 Coverage problem analysis

##### 8.4.1.1.1 MDA type

The MDA type for coverage problem analysis is: CoverageAnalytics.CoverageProblemAnalysis.

##### 8.4.1.1.2 Enabling data

The enabling data for CoverageAnalytics.CoverageProblemAnalysis MDA type are provided in table 8.4.1.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.1.1.2-1: Enabling data for coverage problem analysis

| Data category | Description | References |
| --- | --- | --- |
| Performance measurements | SS-RSRP distribution per SSB (beam) of serving NR cell | SS-RSRP distribution per SSB (clause 5.1.1.22.1 of TS 28.552 [4]). |
| SS-RSRP distribution per SSB (beam) of neighbor NR cell | SS-RSRP distribution per SSB of neighbor NR cell (clause 5.1.1.22.2 of TS 28.552 [4]) |
| RSRP distribution of neighbor E-UTRA cell for an NR cell | RSRP distribution per neighbor E‑UTRAN cell (clause 5.1.1.22.3 of TS 28.552 [4]) |
| Power headroom distribution for NR cell | Type 1 power headroom distribution (clause 5.1.1.26.1 of TS 28.552 [4]). |
| Wideband CQI distribution for NR cell | Wideband CQI distribution (clause 5.1.1.11.1 of TS 28.552 [4]). |
| Timing Advance distribution for NR cell | Timing Advance distribution for NR Cell (clause 5.1.1.33.1 of TS 28.552 [4]) |
| Number of UE Context Release Request (gNB-DU initiated) | Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]). |
| Number of UE Context Release Request per SSB (gNB-DU initiated) | Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]). |
| Number of UE Context Release Requests (gNB-CU initiated) | Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]). |
| Number of UE Context Release Requests per SSB (gNB-CU initiated) | Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]). |
| RSRP related measurements for ng-eNB | RSRP related measurements (clause 6.1 of TS 32.425 [12]). |
| UE power headroom related measurements for ng-eNB | UE power headroom related measurements (clause 6.3 of TS 32.425 [12]). |
| Wideband CQI distribution for ng-eNB | Wideband CQI distribution (clause 4.10.1.1 of TS 32.425 [12]). |
| Average sub-band CQI for ng-eNB | Average sub-band CQI (clause 4.10.1.2 of TS 32.425 [12]). |
| UE Rx - Tx time difference related measurements for ng-eNB | UE Rx - Tx time difference related measurements (clause 6.4 of TS 32.425 [12]). |
| AOA related measurements for ng-eNB | AOA related measurements (clause 6.5 of TS 32.425 [12]). |
| Timing Advance distribution for ng-eNB | Timing Advance Distribution (clause 4.10.2 of TS 32.425 [12]). |
| Number of UE CONTEXT Release Request initiated by ng-eNodeB | Number of UE CONTEXT Release Request initiated by eNodeB/RN (clause 4.1.5.1 of TS 32.425 [12]). |
| MDT reports | MDT reports containing RSRPs of the serving cell and neighbour cells, and UE location. | RSRPs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7]. |
| RLF reports | RLF reports containing RSRPs of the last serving cell and neighbour cells, and UE location. | RLF data collection and RLF reporting in TS 32.422 [6], and rlf-Report-r16 in TS 38.331 [13]. |
| RCEF reports | RCEF reports containing RSRPs of NR cell where the RRC connection establishment failed and neighbour cells, and UE location. | RCEF data collection and RCEF reporting in TS 32.422 [6], and ConnEstFailReport-r16 in TS 38.331 [13]. |
| UE location reports | UE location information provided by the LMF services which can be used to correlate with the MDT reports. | The UE location information provided by LMF via service-based interface (see TS 23.273 [14]). |
| Geographical data | The geographical information (longitude, latitude, altitude) of the deployed RAN (NG-RAN and E-UTRAN). | The geographical information (longitude, latitude, altitude) information (see the peeParametersList attribute of the ManagedFunction IOC in TS 28.622 [19]). |
| Configuration data | The NRMs containing the attributes affecting the coverage for (NG-RAN and E-UTRAN). | NRCellDU IOC, NRSectorCarrier IOC, BWP IOC, CommonBeamformingFunction IOC, and Beam IOC in TS 28.541 [15];  EUtranGenericCell IOC in TS 28.658 [16];  SectorEquipmentFunction IOC, AntennaFunction IOC, and TMAFunction IOC in TS 28.662 [17]. |

##### 8.4.1.1.3 Analytics output

The specific information elements of the analytics output for coverage problem analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.1.1.3-1.

Table 8.4.1.1.3-1: Analytics output for coverage problem analysis

| Information element | Definition | Support qualifier | Properties |
| --- | --- | --- | --- |
| coverageProblemId | The identifier of the coverage problem. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| coverageProblemType | Indication of type of the coverage Problem.  The allowed value is one of the enumerated values: WeakCoverage, CoverageHole, PilotPollution, Overshoot coverage, DlUlChannelCoverageMismatch, Other. | M | type: enumeration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| coverageProblemAreas | Geographical location areas where the coverage problem occurred. | O | type: GeoArea (see TS 28.622 [19])  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| problematicCells | The CGIs of cells where the coverage problem occurred. | M | type: Integer  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendedActions | The recommended actions to solve the coverage problem.  The recommended action may be (but not limited to):  - creation of new beam(s), or cell(s);  - change the transmission power of the NR sector carrier;  - delete some unwanted beam(s) or cell(s). | M | type: RecommendedAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| radioEnvironmentMap | The graphical description of the observed radio coverage characteristics. The graphic may be for the RSRP or SINR of the selected cluster of cells mapped against the physical geographical information (longitude, latitude, altitude) of the area where the RAN (NG-RAN and E-UTRAN) cells are deployed.  It is a list of paired tuples of geographical information (longitude, latitude, altitude) and coverage (RSRP or SINR) values. | O | type: List  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| cellConfigurations | The cell configurations for a new cell or reconfigurations of existing cells derived based on the characteristics in the radioEnvironmentMap.  The cell configurations are the changes to the NRMs attributes affecting the cell coverage (NG-RAN and E-UTRAN). | O | type: may differ as defined in  NRCellDU IOC, NRSectorCarrier IOC, BWP IOC, CommonBeamformingFunction IOC, and Beam IOC in TS 28.541 [15]; EUtranGenericCell IOC in TS 28.658 [16];  SectorEquipmentFunction IOC, AntennaFunction IOC, and  TMAFunction IOC in TS 28.662 [17].  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

#### 8.4.1.2 Paging Optimization

##### 8.4.1.2.1 MDA type

The MDA type for Capability-Paging Optimization: CoverageAnalytics.PagingOptimization.

##### 8.4.1.2.2 Enabling data

The enabling data for paging optimization are provided in table 8.4.1.2.2-1.

Table 8.4.1.2.2-1: Enabling data for Paging Optimization Analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| MDT reports | MDT reports indicating UE location information | MDT measurements defined in TS 32.422 [6] and TS 32.423 [7]. |
| Performance measurements | Measurement for 5G Paging from AMF | See clause 5.2.5.2 in TS 28.552 [4]. |

##### 8.4.1.2.3 Analytics output

The specific information elements of the analytics output for paging optimization, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.1.2.3-1.

**Table 8.4.1.2.3-1: Analytics output for paging optimization analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| oOCDuration | This specify the time window during which UE is out-of-coverage. | M | type: ProjectionDuration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| oOCLocation | This specifies the last known location of the UEs before it goes out-of-coverage. This would be within the area indicated by the "areaScope" of the MDA request. | CM | type: GeoCoordinate  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| oOCMap | This specifies the geographical region within which the paging issues are experienced by a group of UEs. This would be within the area indicated by the "areaScope" of the MDA request. | CM | type: GeoArea (see TS 28.622 [19])  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.4.2 SLS analysis

#### 8.4.2.1 Service experience analysis

##### 8.4.2.1.1 MDA type

The MDA type for Capability-Service experience analysis is: SLSAnalysis.ServiceExperienceAnalysis.

##### 8.4.2.1.2 Enabling data

The enabling data for SLSAnalysis.ServiceExperienceAnalysis MDA type are provided in table 8.4.2.1.2-1.

Table 8.4.2.1.2-1: Enabling data for service experience analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | Average e2e uplink/downlink delay for a network slice | Average e2e uplink/downlink delay for a network slice (in clause 6.3.1.8 in TS 28.554 [5]). |
| Integrated uplink/downlink delay in RAN | Integrated downlink delay in RAN (clause 6.3.1.2 in TS 28.554 [5]); Integrated uplink delay in RAN (clause 6.3.1.7 in TS 28.554 [5]). |
| Round-trip packet delay | Round-trip packet delay between PSA UPF and NG‑RAN (clause 5.4.8 in TS 28.552 [4]). |
| UL/DL throughput for network and Network Slice Instance | Upstream throughput for network and Network Slice Instance (clause 6.3.2 in TS 28.554 [5]); Downstream throughput for Single Network Slice Instance (clause 6.3.3 in TS 28.554 [5]). |
| RAN UE Throughput | RAN UE Throughput (clause 6.3.6 in TS 28.554 [5]) |
| Throughput at N3 interface | Upstream Throughput at N3 interface (clause 6.3.4 in TS28.554 [5]); Downstream Throughput at N3 interface (clause 6.3.5 in TS28.554 [5]). |
| QoE Data | The QoE data of the different services | QoE data (TS 26.247 [22] and TS 26.114 [23] can be acquired through the procedures defined in TS 28.405 [8]). |

##### 8.4.2.1.3 Analytics output

The specific information elements of the analytics output for service experience analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.1.3-1.

Table 8.4.2.1.3-1: Analytics output for Service experience analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| serviceExperienceId | The identifier indicates the analytics report is related with service experience analysis. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| serviceInformation | This field include the service information related to this analysis such as service name.  See NOTE 1. | O | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| serviceExperienceIssueType | Indication of the service experience issue type.  The allowed value is one of the enumerated values:  - RAN issue;  - CN issue;  - both | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| affectedObjects | The managed object instances where the service experience is applicable, e.g. SubNetwork Instance, NetworkSlice Instance, NetworkSlice subnetwork Instance. The subset values of this field may be different due to cross domain management and domain management. | O | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| serviceExperienceStatistics | The statistics of the level of service experience for a service in a certain time period, e.g. there are five levels which are represented by 1, 2, 3, 4, 5 where level 1 represents the users are enduring bad experience while level 5 represents the users' requirements are perfectly satisfied. | O | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| serviceExperiencePredictions | The predictions of the level of service experience for a service in a certain time period. | O | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| NOTE 1: This field of serviceInformation is used for MDA MnS producer to include the names of e2e services (e.g., browsring, video streaming etc.) and detail information (specific information of an e2e service). | | | |

#### 8.4.2.2 Network slice throughput analysis

##### 8.4.2.2.1 MDA type

The MDA type for Capability-Network slice throughput analysis is: SLSAnalysis.NetworkSliceThroughputAnalysis.

##### 8.4.2.2.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceThroughputAnalysis MDA type are provided in table 8.4.2.2.2-1.

**Table 8.4.2.2.2-1: Enabling data for network slice throughput analysis**

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | UL/DL throughput for network and Network Slice Instance | Upstream throughput for network and Network Slice Instance as defined in clause 6.3.2 in TS 28.554 [5]; Downstream throughput for Single Network Slice Instance as defined in clause 6.3.3 in TS 28.554 [5]. |
| RAN UE Throughput | RAN UE Throughput as defined in clause 6.3.6 in TS 28.554 [5]. |
| Throughput at N3 interface | Upstream Throughput at N3 interface as defined in clause 6.3.4 in TS 28.554 [5]; Downstream Throughput at N3 interface as defined in clause 6.3.5 in TS 28.554 [5]. |

##### 8.4.2.2.3 Analytics output

The specific information elements of the analytics output for network slice throughput analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.2.3-1.

Table 8.4.2.2.3-1: Analytics output for network slice throughput analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| networkSliceThroughputAnalysisId | Network slice throughput analysis identifier | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceThroughputIssueType | Indication of the network slice throughput issue type  The allowed value is one of the enumerated values: None, RAN issue, CN issue, both | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceThroughputUserStatistics | The statistics of the UL and/or DL network slice throughput in a certain time period. The value indicates  the average percentage of users, for which the required SLS throughput is met.  Allowed values: 0 to 100 | O | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceThroughputTimeStatistics | The statistics of the UL and/or DL network slice throughput in a certain time period. The value indicates the  average percentage of time, during which the required SLS throughput is met.  Allowed values: 0 to 100 | O | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceThroughputUserPredictions | The predictions of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of users, for which the required SLS throughput is predicted to be met.  Allowed values: 0 to 100 | O | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceThroughputTimePredictions | The predictions of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of time, during which the required SLS throughput is predicted to be met.  Allowed values: 0 to 100 | O | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

#### 8.4.2.3 Network slice traffic prediction

##### 8.4.2.3.1 MDA type

The MDA type for capability Network slice traffic prediction is: SLSAnalysis.NetworkSliceTrafficAnalysis.

##### 8.4.2.3.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceTrafficAnalysis MDA type are provided in table 8.4.2.3.2-1.

Table 8.4.2.3.2-1: Enabling data for network slice traffic prediction analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | UL/DL throughput for network slice. | Upstream throughput for network and Network Slice Instance (clause 6.3.2 in TS 28.554 [5]); Downstream throughput for Single Network Slice Instance (clause 6.3.3 in TS 28.554 [5]). |
| Number of incoming and outgoing octets of GTP packet on N3 | See clauses 5.4.1.4 and 5.4.1.3 in TS 28.552 [4]). |
| UL/DL UE throughput for network slice | RAN UE Throughput (clause 6.3.6 in TS 28.554 [5]). |
| Number of PDU sessions of network slice | Mean number of PDU sessions of network and network Slice Instance (clause 6.4.1 in TS 28.554 [5]). |
| Number of registered subscribers of a network slice instance | Mean registered subscribers of network and network slice through AMF (see clause 6.2.1 in TS 28.554 [5]). |
| Maximum packet size for a network slice | Maximum packet size for a network slice (see clause 6.3.11 of TS 28.541 [15]). |

##### 8.4.2.3.3 Analytics output

The specific information elements of the analytics output for network slice traffic prediction analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.3.3-1.

Table 8.4.2.3.3-1: Analytics output for network slice traffic prediction analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| trafficProjections | This specifies the traffic projections for a slice. | M | type: TrafficProjections  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

#### 8.4.2.4 E2E latency analysis

##### 8.4.2.4.1 MDA type

The MDA type for Capability-E2E latency analysis is: SLSAnalysis.E2ElatencyAnalysis.

##### 8.4.2.4.2 Enabling data

The enabling data for SLSAnalysis.E2ElatencyAnalysis MDA type are provided in table 8.4.2.4.2-1.

Table 8.4.2.4.2-1: Enabling data for E2E latency analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | Average e2e UL/DL delay for a network slice | Average e2e uplink delay for a network slice (clause 6.3.1.8.1 in TS 28.554 [5]); Average e2e downlink delay for a network slice (clause 6.3.1.8.2 in TS 28.554 [5]). |
| Integrated uplink/downlink delay in RAN | Integrated downlink delay in RAN (clause 6.3.1.2 in TS 28.554 [5]); Integrated uplink delay in RAN (clause 6.3.1.7 in TS 28.554 [5]). |
| Round-trip Packet Delay | Round-trip packet delay between PSA UPF and NG-RAN (clause 5.4.8 TS 28.552 [4]). |

##### 8.4.2.4.3 Analytics output

The specific information elements of the analytics output for E2E latency analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.4.3-1.

**Table 8.4.2.4.3-1: Analytics output for E2E latency analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| e2ELatencyIssueId | The identifier indicates the output is for E2E latency issue analysis | M | type: String  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| e2ELatencyIssueType | Indication the type of the E2E latency issue.  The allowed value is one of the enumerated values: RAN latency issue, CN latency issue | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| affectedObjects | The managed object instances of subnetwork, managed elements or network slices where the latency issue happens | O | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

#### 8.4.2.5 Network slice load analysis

##### 8.4.2.5.1 MDA type

The MDA type for Capability- Network slice load analysis is: SLSAnalysis.NetworkSliceLoadAnalysis.

##### 8.4.2.5.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceLoadAnalysis MDA type are provided in table 8.4.2.5.2-1.

Table 8.4.2.5.2-1: Enabling data for network slice load analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | Number of PDU sessions of network slice | Mean number of PDU sessions of network and network Slice Instance (clause 6.4.1 in TS 28.554 [5]). |
| Number of PDU Sessions successfully setup | Number of PDU Sessions successfully setup (clause 5.1.1.5 in TS28.552 [4]). |
| Mean Number of PDU sessions | Number of PDU sessions(Mean) (clause 5.3.1.1 in TS 28.552 [4]). |
| Network Data Analytics | Analysis results from the control plane produced by NWDAF | Analytics data from NWDAF in TS 23.288 [10] including e.g. Slice load level related network data analytics clause 6.3, and the analytics for user plane performance (i.e. average/maximum traffic rate, average/maximum packet delay, average packet loss rate in clause 6.14. |
| Configuration data | MOIs of the cells, NW slice/NW slice subnet, 5GC NFs | NRM information TS 28.541 [15]. |

##### 8.4.2.5.3 Analytics output

The specific information elements of the analytics output for network slice load analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.5.3-1.

Table 8.4.2.5.3-1: Analytics output for network slice load analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| networkSliceLoadIssueId | The identifier indicates the output is for Network slice instance load analysis | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceLoadIssueDomain | Indicates the domain of the network slice instance load issue  The allowed value is one of the enumerated values:  - RAN issue;  - CN issue | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceLoadIssuePhase | Indicates the phase of the network slice instance load issue  The allowed value is one of the enumerated values: historic network slice load issue, ongoing network slice load issue, potential network slice load issue | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| networkSliceLoadIssueType | Indicates the type of the network slice instance load issue  The allowed value is one of the enumerated values: overload network slice load issue, underutilized network slice load issue | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| affectedObjects | The managed object instances involved in the network slice instance load problem | O | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| networkSliceLoadDistribution | Describes the detailed load distribution or predictive distribution, e.g. load distribution for a network slice instance at a certain location or in a certain time period | O | type: Integer  multiplicity: \*  isOrdered: True  isUnique: False  defaultValue: None  isNullable: False |

### 8.4.3 MDA assisted fault management

#### 8.4.3.1 MDA assisted failure prediction

##### 8.4.3.1.1 MDA type

The MDA type for failure prediction analysis is: MDAAssistedFaultManagement.FailurePrediction.

##### 8.4.3.1.2 Enabling data

The enabling data for MDAAssistedFaultManagement.FailurePrediction MDA type are provided in table 8.4.3.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.3.1.2-1: Enabling data for fault prediction analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | The deteriorated performance or the abnormal performance measurements based on certain performance monitoring threshold.  3GPP management system may monitor a set of performance measurements and their thresholds, so as to support the analytics of prediction of a network service failure. | The performance measurements as defined in TS 28.552 [4] |
| Alarm notifications | Alarm information, e.g. the alarm notification of network functions. | Alarm information and notifications as per TS 28.532 [11] |
| Configuration data | MOIs of the cells and 5GC NFs. | TS 28.541 [15] |
| Network analytics data | The control plane analysis result from the NWDAF, e.g. observed service experience related network data analytics. | TS 23.288 [10] |

##### 8.4.3.1.3 Analytics output

The specific information elements of the analytics output for failure prediction and service failure recovery analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.3.1.3-1.

Table 8.4.3.1.3-1: Analytics output for fault prediction analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| failurePredictionObject | Indication of NR cells or NFs where the failure related issues occurred or potentially occur. | M | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| potentialFailureType | Indication of type of issues that can cause the failures.  NOTE 1: The values can be defined as a list of example values: "Operational Violation", "Physical Violation" and "Time Domain Violation". See alarmType described in TS 28.532 [11]. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| eventTime | This field holds the time of potential failure predicted.  Examples: "20:15:00", "20:15:00-08:00" (for 8 hours behind UTC). | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| issueID | This filed holds the ID of this failure prediction which is reported.  When reports, this identifier can be used to provide the information to management system to maintain. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| perceivedSeverity | This field holds the value to indicate relative level of urgency for operator attention.  NOTE 2: The value can be Critical, Major, Minor, Warning, Indeterminate, Cleared, see Recommendation ITU-T X.733 [27]. | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| recommendedActions | This field holds the recommended actions to failure prevention and recovery.  The recommended action may be (but not limited to):  Update 5GC NF (e.g., AMF and SMF) profile | O | type: RecommendedAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.4.4 MDA assisted energy saving

#### 8.4.4.1 Energy saving analysis

##### 8.4.4.1.1 MDA type

The MDA type for energy saving analysis is: MDAAssistedEnergySaving.EnergySavingAnalysis.

##### 8.4.4.1.2 Enabling data

The enabling data for MDAAssistedEnergySaving.EnergySavingAnalysis MDA type are provided in table 8.4.4.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.4.1.2-1: Enabling data for energy saving analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | PNF Power Consumption: power consumed over the measurement period | Clause 5.1.1.19.2 of TS 28.552 [4]. |
| PNF Energy consumption: energy consumed | Clause 5.1.1.19.3 of TS 28.552 [4]. |
| SS-RSRP distribution per SSB (beam) of serving NR cell | Clause 5.1.1.22.1 of TS 28.552 [4]. |
| SS-RSRP distribution per SSB (beam) of neighbor NR cell | Clause 5.1.1.22.1 of TS 28.552 [4]. |
| PDCP Data Volume of NR cells: PDCP data volume delivered in the downlink and uplink | Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4] |
| Traffic load variation:  - PRB utilization rate;  - RRC connection number;  - etc. | Clause 5.1.1.2 and 5.1.1.4 of TS 28.552 [4]. |
| UE throughput:  - UE throughput in downlink and uplink | Clause 5.1.1.3 of TS 28.552 [4]. |
| Delay related measurements of UPF | Clause 5.4 of TS 28.552 [4]. |
| Data volume of UPF | Clause 5.4 of TS 28.552 [4]. |
| Virtual resource usage of NF: The virtual CPU usage, virtual memory usage, virtual disk usage of virtual network functions | Clause 5.7.1 of TS 28.552 [4]. |
| MDT reports | The RSRPs of UE measurements | RSRPs of M1 measurements in TS 32.422 [6] and TS 32.423 [7]. |
| The RSRQs of UE measurements | RSRQs of M1 measurements in TS 32.422 [6] and TS 32.423 [7]. |
| The UE location information | UE location of M1 measurements in TS 32.422 [6] and TS 32.423 [7]. |
| QoE Data | The measurements that are collected are DASH and MTSI measurements | TS 28.406 [9]. |
| Configuration data | MOIs of the cells, UPFs and SMFs | TS 28.541 [15]. |
| Network analytics data | The control plane analysis result from the NWDAF, e.g. observed service experience related network data analytics | TS 23.288 [10]. |

##### 8.4.4.1.3 Analytics output

The specific information elements of the analytics output for energy saving analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.4.1.3-1.

Table 8.4.4.1.3-1: Analytics output for energy saving analysis

| Information element | Definition | Support qualifier | Properties |
| --- | --- | --- | --- |
| energyEfficiencyProblematicObject | Indication of NR cells or NFs where the energy efficiency issues occurred or potentially occur. | M | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| energyEfficiencyProblemType | Indication of type of the energy efficiency issues.  The allowed value is one of the enumerated values: HighEnergyConsumption, LowEenergyEfficiency, Other, Unknown. | M | type: enumeration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| trafficLoadTrends | The predictions of the trends of traffic load in a certain time period. The predictions include the traffic load of the issue cell(s) and neighboring cell(s). | M | type:TrafficLoadTrend  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| rANenergySavingRecommendations | For ES on NR cells. It may contain a set of:  - Recommended NR Cell (ES-Cell) to enter energySaving state.  - Recommended candidate cells with precedence for taking over the traffic of the ES-Cell.  - The time to enter and terminate the energy saving state.  - The load threshold to enter and terminate the energy saving state for the ES-Cell.  This exist only in case of RAN energy saving is supported. | CM | type: EsRecommendationsOnNRcell  multiplicity: 1..\*  isOrdered: True  isUnique: True  defaultValue: None  isNullable: False |
| cNenergySavingRecommendations | For ES on UPFs. It contains a set of:  - Recommended UPF (ES-UPF) to conduct energy saving.  - Recommended candidate UPFs with precedence for taking over the traffic of the ES-UPF.  - The time to conduct energy saving for the ES-UPF.  This exist only in case of CN energy saving is supported.. | CM | type: EsRecommendationsOnUPF  multiplicity: 1..\*  isOrdered: True  isUnique: True  defaultValue: None  isNullable: False |
| statisticsOfCellsEsState | The statistic result of current energy saving state of the cells at a certain time, which can be used by consumers to make analysis (e.g. observed service experience analysis made by NWDAF) or to make decision (e.g. enter/exit the energy saving state based on the current energy saving state). | O | type: StatisticOfCellEsState  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.4.5 MDA assisted mobility management

#### 8.4.5.1 Mobility performance analysis

##### 8.4.5.1.1 MDA type

The MDA type for mobility performance analysis is: MobilityManagementAnalytics.MobilityPerformanceAnalysis.

##### 8.4.5.1.2 Enabling data

The enabling data for MobilityManagementAnalytics.MobilityPerformanceAnalysis MDA type are provided in table 8.4.5.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.5.1.2-1: Enabling data for mobility performance analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance measurements | Inter-gNB handovers | Inter-gNB handovers (clause 5.1.1.6.1 of TS 28.552 [4]). |
| Intra-gNB handovers | Inter-gNB handovers (clause 5.1.1.6.4 of TS 28.552 [4]). |
| Inter-gNB DAPS handovers | Inter-gNB handovers (clause 5.1.1.6.2 of TS 28.552 [4]). |
| Intra-gNB DAPS handovers | Inter-gNB handovers (clause 5.1.1.6.3 of TS 28.552 [4]). |
| Inter-gNB conditional handovers | Inter-gNB handovers (clause 5.1.1.6.6 of TS 28.552 [4]). |
| Intra-gNB conditional handovers | Inter-gNB handovers (clause 5.1.1.6.7 of TS 28.552 [4]). |

##### 8.4.5.1.3 Analytics output

The specific information elements of the analytics output (MDA report) for mobility performance analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.5.1.3‑1.

Table 8.4.5.1.3-1: Analytics output for Mobility Performance analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| mobilityPerformance IssueIdentifier | The identifier of the mobility performance issue analysis; | M | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mobilityPerformance IssueRootCause | The root cause of mobility performance issues.  The allowed value is one of the enumerated values: too long mobility interruption time, poor coverage of the cell-edge, inappropriate handover parameters, other. | M | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mobilityPerformance IssueLocation | Geographical location areas where the mobility performance issue occurred. | O | type: GeoArea (see TS 28.622 [19])  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

#### 8.4.5.2 Handover Optimization analysis

##### 8.4.5.2.1 MDA type

The MDA type for handover optimization is: MobilityManagementAnalytics.HandoverOptimization.

##### 8.4.5.2.2 Enabling data

The enabling data for handover optimization analysis are provided in table 8.4.5.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.5.2.2-1: Enabling data for handover optimization analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | Consumed virtual resources of target gNB | Virtualised resource usage measurement (clause 6.2 of TS 28.552 [4]) |
| The physical radio resource utilization of each target cells | Physical radio resource utilization of the target gNB, see clause 5.1.1.2 of TS 28.552 [4]; |
| PDCP Data Volume of NR cells | Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4]. |
| MDT reports | UE measurements related to RSRP, RSRQ, SINR (serving cell and neighbour cells) and UE location information | RSRPs, RSRQs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7]. |

##### 8.4.5.2.3 Analytics output

The specific information elements of the analytics output for handover optimization analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.5.2.3-1.

Table 8.4.5.2.3-1: Analytics output for handover optimization analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| hOTarget | This provides analytics report for each target cell, of a target gNB, for handover optimization. | M | type: HOTargetType  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.4.6 Maintenance management related analytics

#### 8.4.6.1 Maintenance management analysis

##### 8.4.6.1.1 MDA type

The MDA type for maintenance management is: Maintenance.MaintenanceAnalytics.

##### 8.4.6.1.2 Enabling data

The enabling data for Maintenance.MaintenanceAnalytics MDA type are provided in table 8.4.6.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.6.1.2-1: Enabling data for maintenance analysis

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | Number of Active DRB | Mean number of DRBs being allocated (clause 5.1.1.10.9 of TS 28.552 [4]). |
| Number of bearers undergoing handover | Number of requested preparations for handovers from 5GS to EPS (clause 5.1.1.6.3.1 of TS 28.552 [4]).  Number of requested resource allocations for handovers from EPS to 5GS (clause 5.1.1.6.3.4 of TS 28.552 [4])  Number of requested preparations for EPS fallback handovers (clause 5.1.1.6.3.10 of TS 28.552 [4])  Number of successful executions for EPS fallback handovers (clause 5.1.1.6.3.13 of TS 28.552 [4]) |
| Number of bearers being recovered from the error state | Editors Note: to be defined in TS 28.552. |
| Number of successful bearer modification | Number of QoS flows attempted to modify (clause 5.1.1.13.4.1 of TS 28.552 [4]) |

##### 8.4.6.1.3 Analytics output

The specific information elements of the analytics output for maintenance management analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.6.1.3-1.

Table 8.4.6.1.3-1: Analytics output for maintenance analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| currentUpgradeOptimal | This data type defines whether gNB can be upgrade at present | M | type: CurrentUpgrade  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: none  isNullable: False |
| futureUpgradeOptimal | This data type defines whether the gNB can be upgrade in future and when | M | type: FutureUpgrade  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: none  isNullable: False |
| gNBID | This identifies the gNB |  | type: String  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: none  isNullable: False |

8.4.7 Resource related analytics

8.4.7.0 General

The present clause specifies the resource utilization analysis which can be provided by an MDAF, which can indicate the virtualized resource or physical resource usage patterns in the past and predict the resource usage trend for some time periods in the future. The analytics results, provided in the form of statistics or predictions, contain recommended actions to orchestrate the resource allocation for the NFs.

8.4.7.1 NF resource utilization analysis

8.4.7.1.1 Virtualized resource utilization analysis

8.4.7.1.1.1 MDA type

The MDA type for virtualized resource utilization analysis is: ResourceAnalytics.virtualizedResourceUtilizationAnalysisNF.

8.4.7.1.1.2 Enabling data

The enabling data for virtualized resource utilization analysis are provided in table 8.4.7.1.1.2-1.

For general information about enabling data, see clause 8.2.1.

NOTE: The MDA output of ETSI NFV MANO should be reused as much as possible for virtualized resource analysis for 3GPP NFs, by mapping from the ETSI MANO VNF/VNFCs to 3GPP NFs.

**Table 8.4.7.1.1.2-1: Enabling data for virtualized resource utilization analysis**

| **Data category** | **Description** | **References** |
| --- | --- | --- |
| Performance measurements | VR (including Virtual CPU, Virtual Memory, and Virtual Disk) usage of NF | VR usage of NF (clause 5.7.1 of TS 28.552 [4]) |
| Connection Point data volumes of NF | Connection data volumes of NF (clause 5.7.2 of TS 28.552 [4]) |
| N3 interface data volume | N3 interface related measurements (clause 5.4.1 of TS 28.552 [4]) |
| N4 interface session establishments | N4 session establishments (clause 5.4.3.1 of TS 28.552 [4]) |
| N6 interface link usage | N6 related measurements (clause 5.4.2 of TS 28.552 [4]) |
| N9 interface data volume | GTP Data Packets and volume on N9 interface (clause 5.4.4.2 of TS 28.552 [4]) |
| Number of PDU sessions | Number of PDU sessions (mean) (clause 5.3.1.1 of TS 28.552 [4]) |
| Number of QoS flows | Mean number of QoS flows (clause 5.3.2.1.7 of TS 28.552 [4]) |
| Configuration data | The NRMs of the analyzed NFs | The NRMs defined in TS 28.622 [19] and TS 28.541 [15]. |
| Network Data Analytics | Analysis data from the control plane produced by NWDAF including NF load, observed/predicted service experience, user plane performance, and slice load level analytics. | Analytics data from NWDAF in TS 23.288 [10] including e.g. NF load analytics (clause 6.5), observed/ predicted service experience related network data analytics (clause 6.4), analytics for user plane performance (i.e. average/maximum traffic rate, average/maximum packet delay, average packet loss rate in clause 6.14), and Slice load level related network data analytics (clause 6.3). |

8.4.7.1.1.3 Analytics output

The specific information elements of the analytics output for virtualized resource utilization analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.7.1.1.3-1.

**Table 8.4.7.1.1.3-1: Analytics output for virtualized resource utilization analysis**

| **Information element** | **Definition** | **Support qualifier** | **Properties** |
| --- | --- | --- | --- |
| lowVRUsageNFs | The NFs with low virtualized resource usage (see Note 1) during some time periods in the past. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| highVRUsageNFs | The NFs with high virtualized resource usage (see Note 1) during some time periods in the past. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| predictedVRUsageForNFs | The predicted virtualized resource usage for NFs during some time periods in the future. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendedActions | The recommended actions to orchestrate the resource allocation for NFs.  The recommended action may be (but not limited to):  - scale in a list of NFs;  - scale out a list of NFs. | M | type: RecommendedAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| NOTE 1: It is up to the MDA MnS producer to decide the thresholds for low and high usage. | | | |

##### 8.4.7.1.2 Physical resource utilization analysis

###### 8.4.7.1.2.1 MDA type

The MDA type for physcial resource utilization analysis is: ResourceAnalytics.PhyiscalResourceUtilizationAnalysisNF.

8.4.7.1.2.2 Enabling data

The enabling data for physical resource utilization analysis are provided in table 8.4.7.1.2.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.7.1.2.2-1: Enabling data for physical resource utilization analysis**

| **Data category** | **Description** | **References** |
| --- | --- | --- |
| Performance measurements | Radio resource utilization | Radio resource utilization (clause 5.1.1.2 of TS 28.552 [4]) |
| RRC connection number | RRC connection number (clause 5.1.1.4 of TS 28.552 [4]) |
| Mean number of PDU sessions in NR cell | Mean number of PDU sessions being allocated (clause 5.1.1.5.4 of TS 28.552 [4]) |
| Mean number of DRBs in NR cell | Mean number of DRBs being allocated ( clause 5.1.1.10.9 of TS 28.552 [4]) |
| QoS flow release in NR cell | QoS flow release (clause 5.1.1.13.1 of TS 28.552 [4]) |
| Number of Active UEs | Number of Active UEs (clause 5.1.1.23 of TS 28.552 [4]) |
| PDCP Data Volume | PDCP Data Volume (clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4]) |
| Geographical data | The geographical information (longitude, latitude, altitude) of the deployed RAN (NG-RAN and E-UTRAN). | The geographical information (longitude, latitude, altitude) information (see the peeParametersList attribute of the ManagedFunction IOC in TS 28.622 [19]). |
| Configuration data | The NRMs of the analyzed gNB-CUs, and gNB-DUs | The GNBCUCPFunction, GNBCUUPFunction and GNBDUFunction defined in TS 28.622 [19] and TS 28.541 [15]. |
| Network Data Analytics | Analysis data from the control plane produced by NWDAF including NF load, observed/predicted service experience, user plane performance, and slice load level analytics. | Analytics data from NWDAF in TS 23.288 [10] including e.g. NF load analytics (clause 6.5), observed/predicted service experience related network data analytics (clause 6.4), analytics for user plane performance (i.e. average/maximum traffic rate, average/maximum packet delay, average packet loss rate in clause 6.14), and Slice load level related network data analytics (clause 6.3). |

8.4.7.1.2.3 Analytics output

The specific information elements of the analytics output for physical resource utilization analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.7.1.2.3-1.

**Table 8.4.7.1.2.3-1: Analytics output for physical resource utilization analysis**

| **Information element** | **Definition** | **Support qualifier** | **Properties** |
| --- | --- | --- | --- |
| lowPRUsageNFs | The NFs with low physical resource usage (see Note 1) during some time periods in the past. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| highPRUsageNFs | The NFs with high physical resource usage (see Note 1) during some time periods in the past. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| predictedPRUsageForNFs | The predicted physical resource usage for NFs during some time periods in the future. | M | type: ResourceUsageNF  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendedActions | The recommended actions to orchestrate the resource allocation for NFs.  The recommended action may include (but not limited to) optimising the capacity of gNB (e.g., increasing or decreasing physical resources). | M | type: RecommendedAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| NOTE 1: It is up to the MDA MnS producer to decide the thresholds for low and high usage. | | | |

##### 8.4.7.1.3 5GC Control plane congestion analysis

###### 8.4.7.1.3.1 MDA type

The MDA type for 5GC control plane congestion analysis is: ResourceAnalytics.5GCControlPlaneCongestionAnalysis.

###### 8.4.7.1.3.2 Enabling data

The enabling data for ResourceAnalytics.5GCControlPlaneCongestionAnalysis MDA type are provided in table 8.4.7.1.3.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.7.1.3.2-1: Enabling data for 5GC control plane congestion analysis**

|  |  |  |
| --- | --- | --- |
| **Data category** | **Description** | **References** |
| Performance measurements | Registration procedure related measurements for AMF. | Number of registration requests (clause 5.2.2 of TS 28.552 [4])  Mean time of Registration procedure (clause 5.2.2.9 of TS 28.552 [4]) |
| Service Request procedure related measurements for AMF. | Number of service requests (clause 5.2.3.3 and clause 5.2.3.4 of TS 28.552 [4]) |
| Number of PDU sessions measurements for SMF | Number of PDU sessions (clause 5.3.1 of TS 28.552 [4]) |
| QoS flows measurements for SMF | QoS flows monitoring (clause 5.3.2 of TS 28.552 [4]) |
| VR (including Virtual CPU, Virtual Memory, and Virtual Disk) usage of NF | VR usage of NF (clause 5.7.1 of TS 28.552 [4]) |
| Alarm notifications | Alarm information, e.g. the alarm notification of network functions. | Alarm information and notifications as per TS 28.532 [11] |
| Configuration data | MOIs of 5GC NFs. | 5GC NRM as defined in TS 28.541 [15] |

###### 8.4.7.1.3.3 Analytics output

The specific information elements of the analytics output for control plane congestion analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.7.1.3.3-1.

**Table 8.4.7.1.3.3-1: Analytics output for 5GC control plane congestion analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Information element** | **Definition** | **Support qualifier** | **Properties** |
| affectedObject | Indication of 5GC NFs where congestion issues occurred or potentially may occur. | M | type: DN  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| cPCongestionIssueID | This field holds the analysis report identifier of the control plane congestion analytics. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| recommendedActions | The recommended actions to orchestrate the resource allocation for 5GC NFs.  The recommended action may be (but not limited to):  - scale out a list of 5GC NFs; | O | type: RecommendedAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.4.8 Predictions of Management data

#### 8.4.8.0 General

This clause specifies the predictions of PMs and KPIs which can be provided by an MDAF, which can predict mobility management performance, coverage related performance, SLS related performance and energy saving related performance. The analytics results, provided in the form of predictions, contain specific type of prediction of specific management data (PMs/KPIs) on network objects.

#### 8.4.8.1 MDA assisted PM predictions

##### 8.4.8.1.1 MDA type

The MDA type for predictions of management data is: Predictions.PMData.

##### 8.4.8.1.2 Enabling data

###### 8.4.8.1.2.1 Mobility management performance related predictions

The enabling data for mobility management related performance measurements are provided in table 8.4.8.1.2.1-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.8.1.2.1-1: Enabling data for mobility management related PMs

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | Handover related performance measurements | Inter-gNB handovers (clause 5.1.1.6.1 of TS 28.552 [4]).  Inter-gNB handovers (clause 5.1.1.6.4 of TS 28.552 [4]).  Inter-gNB handovers (clause 5.1.1.6.2 of TS 28.552 [4]).  Inter-gNB handovers (clause 5.1.1.6.3 of TS 28.552 [4]).  Inter-gNB handovers (clause 5.1.1.6.6 of TS 28.552 [4]).  Inter-gNB handovers (clause 5.1.1.6.7 of TS 28.552 [4]).  Virtualised resource usage measurement (clause 6.2 of TS 28.552 [4])  Physical radio resource utilization of the target gNB, see clause 5.1.1.2 of TS 28.552 [4];  Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4]. |
| MDT reports | UE measurements related to RSRP, RSRQ, SINR (serving cell and neighbour cells) and UE location information | RSRPs, RSRQs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7]. |

###### 8.4.8.1.2.2 Coverage related predictions

The enabling data for coverage related performance measurements are provided in the table 8.4.8.1.2.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.8.1.2.2-1: Enabling data for coverage analytics related PMs

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | Coverage related performance measurements | SS-RSRP distribution per SSB (clause 5.1.1.22.1 of TS 28.552 [4]).  SS-RSRP distribution per SSB of neighbor NR cell (clause 5.1.1.22.2 of TS 28.552 [4])  RSRP distribution per neighbor E UTRAN cell (clause 5.1.1.22.3 of TS 28.552 [4])  Type 1 power headroom distribution (clause 5.1.1.26.1 of TS 28.552 [4]).  Wideband CQI distribution (clause 5.1.1.11.1 of TS 28.552 [4]).  Timing Advance distribution for NR Cell (clause 5.1.1.33.1 of TS 28.552 [4])  Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]).  Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]).  Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]).  Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]).  RSRP related measurements (clause 6.1 of TS 32.425 [12]).  UE power headroom related measurements (clause 6.3 of TS 32.425 [12]).  Wideband CQI distribution (clause 4.10.1.1 of TS 32.425 [12]).  Average sub-band CQI (clause 4.10.1.2 of TS 32.425 [12]).  UE Rx - Tx time difference related measurements (clause 6.4 of TS 32.425 [12]).  AOA related measurements (clause 6.5 of TS 32.425 [12]).  Timing Advance Distribution (clause 4.10.2 of TS 32.425 [12]).  Number of UE CONTEXT Release Request initiated by eNodeB/RN (clause 4.1.5.1 of TS 32.425 [12]). |
| MDT reports | UE measurements related to RSRP, RSRQ, SINR (serving cell and neighbour cells) and UE location information | RSRPs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7]. |

###### 8.4.8.1.2.3 SLS related predictions

The enabling data for SLS related performance measurements are provided in the table 8.4.8.1.2.3-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.8.1.2.3-1: Enabling data for SLS related PMs

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | SLS related performance measurements | RAN UE Throughput (clause 6.3.6 in TS 28.554 [5]).  Mean number of PDU sessions of network and network Slice Instance (clause 6.4.1 in TS 28.554 [5]).  Mean registered subscribers of network and network slice through AMF (see clause 6.2.1 in TS 28.554 [5]).  Maximum packet size for a network slice subnet (see clause 6.3.11 of TS 28.541 [5]). |
| QoE data | The QoE data of the different services | QoE data (TS 26.247 [22] and TS 26.114 [23] can be acquired through the procedures defined in TS 28.405 [8]). |

###### 8.4.8.1.2.4 Energy Saving related predictions

The enabling data for energy saving related performance measurements are provided in the table 8.4.8.1.2.4-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.8.1.2.4-1: Enabling data for Energy Saving related PMs

|  |  |  |
| --- | --- | --- |
| Data category | Description | References |
| Performance Measurements | Energy saving related performance measurements | PNF Power Consumption: (Clause 5.1.1.19.2 of TS 28.552 [4].)  PNF Energy consumption (Clause 5.1.1.19.3 of TS 28.552 [4].)  SS-RSRP distribution per SSB (beam) of serving NR cell (Clause 5.1.1.22.1 of TS 28.552 [4].)  SS-RSRP distribution per SSB (beam) of neighbor NR cell (Clause 5.1.1.22.1 of TS 28.552 [4].)  PDCP Data Volume of NR cells (Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4])  Traffic load variation (Clause 5.1.1.2 and 5.1.1.4 of TS 28.552 [4].)  UE throughput (Clause 5.1.1.3 of TS 28.552 [4].)  Delay related measurements of UPF (Clause 5.4 of TS 28.552 [4].)  Data volume of UPF (Clause 5.4 of TS 28.552 [4].)  Virtual resource usage of NF (Clause 5.7.1 of TS 28.552 [4].) |
| QoE data | The QoE data of the different services | The measurements that are collected are DASH and MTSI measurements (TS 28.406 [9]). |

###### 8.4.8.1.2.5 Critical Maintenance management related predictions

The enabling data for critical maintenance management related performance measurements are provided in the table 8.4.8.1.2.5-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.8.1.2.5-1: Enabling data for Critical Maintenance management related PMs

|  |  |  |
| --- | --- | --- |
| **Data category** | **Description** | **References** |
| Performance Measurements | Critical Maintenance management related performance measurements | Mean number of DRBs being allocated (clause 5.1.1.10.9 of TS 28.552 [4]).  Number of requested preparations for handovers from 5GS to EPS (clause 5.1.1.6.3.1 of TS 28.552 [4]).  Number of requested resource allocations for handovers from EPS to 5GS (clause 5.1.1.6.3.4 of TS 28.552 [4])  Number of requested preparations for EPS fallback handovers (clause 5.1.1.6.3.10 of TS 28.552 [4])  Number of successful executions for EPS fallback handovers (clause 5.1.1.6.3.13 of TS 28.552 [4])  Number of QoS flows attempted to modify (clause 5.1.1.13.4.1 of TS 28.552 [4]) |

##### 8.4.8.1.3 Analytics output

The specific information elements of the analytics output for predictions, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.8.1.3-1.

Table 8.4.8.1.3-1: Analytics output for predictions

|  |  |  |  |
| --- | --- | --- | --- |
| Information element | Definition | Support qualifier | Properties |
| pmPredictions | This information element defines the predicted values for the below performance measurements.   * Mobility related performance measurements listed in table 8.4.5.1.2-1 and 8.4.5.2.2-1 in the current document. * Coverage related performance measurements listed in table 8.4.1.1.2-1 and 8.4.1.2.2-1 in the current document. * SLS related performance measurements listed in table 8.4.2.1.2-1, 8.4.2.2.2-1, 8.4.2.3.2-1, 8.4.2.4.2-1 and 8.4.2.5.2-1 in the current document. * Energy saving related performance measurements listed in table 8.4.4.1.2-1 in the current document. * Maintenance management related performance measurements listed in table 8.4.6.1.2-1 in the current document. | M | type: PmPrediction  multiplicity: 1..\*  isOrdered: False  isUnique: True  defaultValue: none  isNullable: False |

## 8.5 Data type definitions

### 8.5.1 RecommendedAction <<dataType>>

#### 8.5.1.1 Definition

This data type specifies the type of recommended action in the analytics output.

#### 8.5.1.2 Information elements

Table 8.5.1.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| recommended3GPPActions | It contains the recommendations actions concerning 3GPP defined operations on MOIs. | O | type: Recommended3GPPAction  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendedNon3GPPActions | It contains the recommended actions related to non-3GPP operations for 3GPP management system to interact with non-3GPP management system. | O | type: string  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendedHumanReadableActions | It contains the recommendations on human readable actions.  NOTE: Further details of recommended human readable actions are not specified. | O | type: string  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

### 8.5.2 Recommended3GPPAction <<dataType>>

#### 8.5.2.1 Definition

This data type specifies the data type of recommended 3GPP action.

#### 8.5.2.2 Information elements

Table 8.5.2.2-1

| Name | Definition | Support qualifier | Properties |
| --- | --- | --- | --- |
| mOInstance | Identifies the instance of a common ancestor object of the objects for which changes are recommended. | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| path | The "path" and "mOInstance" identify the object, attribute, attribute field or multi-value attribute element, that are recommended for creation, deletion or modification. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| op | It specifies the type of operation that is recommended for the MOI specified by the path.  Allowed values: "add", "remove" and "replace".  The operation describes what is recommended to do to the NRM.  "add" shall be used for recommending the creation of an object, attribute, attribute field or multi-value attribute element.  "remove" shall be used for recommending the deletion of an object, attribute, attribute field or multi-value attribute element.  "replace" shall be used for recommending the replacement of an existing attribute value, attribute field value or multi-value attribute element. | M | type: enumeration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| value | If an object creation is recommended with "add", the "value" shall carry a complete representation of the created object. If an object deletion is recommended with "remove", the "value" shall be absent. It may optionally carry a complete representation of the deleted object.  If an attribute, attribute field or multi-value attribute element creation is recommended with "add", the "value" shall carry the value of the recommended attribute, attribute field or multi-value attribute element.  If an attribute, attribute field or multi-value attribute element deletion is recommended with "remove", the "value" shall be absent.  If the replacement of an attribute, attribute field or multi-value attribute element value is recommended with "replace", the "value" shall carry the new value of the attribute, attribute field or multi-value attribute element.  If multiple objects are recommended for creation, the creation of parent objects shall be recommended before the child objects. | CM | type: AttributeValuePair (see TS 32.156 [18])  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| additionalText | It provides the additional text for the recommended change. | O | type: string  multiplicity: \*  isOrdered: False  isUnique: False  defaultValue: None  isNullable: False |

#### 8.5.2.3 Constraints

Table 8.5.2.3-1

|  |  |
| --- | --- |
| Name | Definition |
| value Support Qualifier | Condition: value of op attribute is "add", or "replace". |

### 8.5.3 TrafficLoadTrend <<dataType>>

#### 8.5.3.1 Definition

This data type specifies the type of TrafficLoadTrend.

#### 8.5.3.2 Information elements

Table 8.5.3.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| cellId | It indicates the cell for which the traffic load prediction is performed. | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| startTime | It indicates the start time that are used for traffic load prediction. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| endTime | It indicates the end time that are used for traffic load prediction. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| trafficLoadList | It provides a list of PRB usage based on a specific granularity. | M | type: Integer  multiplicity: 1..\*  isOrdered: True  isUnique: False  defaultValue: None  isNullable: False |

### 8.5.4 Void

### 8.5.5 EsRecommendationsOnNRcell <<dataType>>

#### 8.5.5.1 Definition

This data type specifies the type of energy saving recommendations on NR cells.

#### 8.5.5.2 Information elements

Table 8.5.5.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| esNRcell | It provides the DN of NR cell (ES-Cell) which is recommended to enter energySaving state. | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| candidateNRcells | It provides the DN of candidate NR cells which are recommended with precedence for taking over the traffic of ES-Cell. | M | type: DN  multiplicity: \*  isOrdered: True  isUnique: True  defaultValue: None  isNullable: False |
| enterTime | It provides the recommended time to enter the energy saving state for the ES-Cell. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| endTime | It provides the recommended time to terminate the energy saving state for the ES-Cell. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| trafficThresholds | It provides the recommended traffic threshold information. The ES-Cell can enter the energy saving state when the traffic is below the threshold value defined in the thresholdValue. | M | type: ThresholdInfo  multiplicity: \*  isOrdered: False  isUnique: False  defaultValue: None  isNullable: False |

### 8.5.6 EsRecommendationsOnUPF <<dataType>>

#### 8.5.6.1 Definition

This data type specifies the type of energy saving recommendations on UPFs.

#### 8.5.6.2 Information elements

Table 8.5.6.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| esUPF | It provides the DN of UPF (ES-UPF) which is recommended to conduct energy saving. | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| candidateUPFs | It provides the DN of candidate UPFs which are recommended with precedence for taking over the traffic of ES-UPF. | O | type: DN  multiplicity: \*  isOrdered: True  isUnique: True  defaultValue: None  isNullable: False |
| conductTime | It indicates the recommended time period to conduct energy saving for the ES-UPF. | M | type: TimeWindow  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.7 StatisticOfCellEsState <<dataType>>

#### 8.5.7.1 Definition

This data type specifies the type of statistics of cells energy saving state in the analytics output.

#### 8.5.7.2 Information elements

Table 8.5.7.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| cellId | It indicates the cell for which the statistics is performed. | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| startTime | It indicates the start time that are used for statistics. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| endTime | It indicates the end time that are used for statistics. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| ratioOfEsStateTime | It provides the ratio of the time when the cell is in the energy saving state to the total time between StartTime and EndTime. | M | type: Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.8 CurrentUpgrade <<dataType>>

#### 8.5.8.1 Definition

This data type specifies whether it is optimal to upgrade the gNB at present.

#### 8.5.8.2 Information elements

Table 8.5.8.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| currentUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade at present. |  | type: Boolean  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| numberOfGBRDRB | This specifies the total number of GBR bearer at present. |  | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| numberOfNonGBRDRB | This specifies the total number of non-GBR bearer at present. |  | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.9 FutureUpgrade <<dataType>>

#### 8.5.9.1 Definition

This data type specifies whether it is optimal to upgrade the gNB at a future point of time.

#### 8.5.9.2 Information elements

Table 8.5.9.2-1

| Name | Definition | Support qualifier | Properties |
| --- | --- | --- | --- |
| futureUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade at a future point of time. | M | type: Boolean  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| optimalTime | This specifies the future time period during which the gNB can be upgraded optimally.  This shall be present only if the FutureUpgradeOptimal is TRUE. | CM | type: TimeWindow  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| numberOfGBRDRB | This specifies the total number of GBR bearer which will be present at the time stamp provided by the attribute OptimalTime.  This shall be present only if the FutureUpgradeOptimal is TRUE. | CM | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| numberOfNonGBRDRB | This specifies the total number of non-GBR bearer which will be present at the time stamp provided by the attribute OptimalTime.  This shall be present only if the FutureUpgradeOptimal is TRUE. | CM | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.10 TrafficProjections <<dataType>>

#### 8.5.10.1 Definition

This data type specifies the traffic projection for a slice.

#### 8.5.10.2 Information elements

Table 8.5.10.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| projectionTime | The time duration for which the projections are made. | M | type: ProjectionDuration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| uPFProjections | This specifies the traffic projection of a UPF in the slice.  It shall be present only if the analysis target contains CN part. | CM | type: UPFProj  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| gNBProjections | This specifies the traffic projection of a gNB in the slice.  It shall be present only if the analysis target contains AN part. | CM | type: gNBProj  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| sMFProjections | This specifies the projected number of PDU session of a SMF in the slice.  It shall be present only if the analysis target contains CN part. | CM | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| aMFProjections | This specifies the projected number of registered subscriber of an AMF in the slice.  It shall be present only if the analysis target contains CN part. | CM | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.11 UPFProj <<dataType>>

#### 8.5.11.1 Definition

This data type specifies the traffic projection for a UPF.

#### 8.5.11.2 Information elements

Table 8.5.11.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| uLThroughput | The projected average UL throughput for a single UPF in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.  This is the projection of the Upstream Throughput at N3 interface KPI defined in TS 28.554 [5] | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| dLThroughput | The projected average DL throughput for a single UPF in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.  This is the projection of the Downstream Throughput at N3 interface KPI defined in TS 28.554 [5]. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| maxPktSize | The projected average maximum packet size for a single UPF in the slice, over the time duration indicated by projectionTime attribute. | O | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |

### 8.5.12 gNBProj <<dataType>>

#### 8.5.12.1 Definition

This data type specifies the traffic projection for a gNB.

#### 8.5.12.2 Information elements

Table 8.5.12.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| uLUEThroughput | The projected average UL UE throughput in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.  This is the projection of the UL RAN UE throughput KPI defined in TS 28.554 [5]. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |
| dLUEThroughput | The projected average DL throughput in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.  This is the projection of the DL RAN UE throughput KPI defined in TS 28.554 [5]. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |

### 8.5.13 HOTargetType <<dataType>>

#### 8.5.13.1 Definition

This data type specifies the information about the target cell and gNB for handover.

The attribute isOptimal specify if the cell (served by gNB) is optimal for handover considering the current virtual, physical and radio resource consumption by the gNB and/or the cell. The value TRUE imply that the target is not resource deprived at present and can be selected for handover.

The attribute futureOptimalInfo specify if the cell (served by the gNB) will be optimal for handover at a future point of time considering the future virtual and radio resource consumption by the gNB and/or the cell . This will also provide projection of future virtual, and radio resource consumptions.

#### 8.5.13.2 Information elements

Table 8.5.13.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| gNBId | See clause 4.4.1 of TS 28.541 [15]. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| cellLocalId | See clause 4.4.1 of TS 28.541 [15]. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| isOptimal | This specifies if the cell (served by the gNB) is optimal for handover with respect to the virtual and physical resource consumption of its gNB and its own radio resource consumption. The value TRUE indicates that the gNB is optimal at present.  Allowed Values: TRUE and FALSE. | M | type: Boolean  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: TRUE  isNullable: False |
| futureOptimalInfo | This specifies related information when the cell is optimal for handover in future. | O | type: FutureOptimal  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.14 FutureOptimal <<dataType>>

#### 8.5.14.1 Definition

This data type specifies the time duration for which the gNB is optimal for upgrade. This also provide virtual, physical and radio resource projections.

#### 8.5.14.2 Information elements

Table 8.5.14.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| futureOptimalTime | This specifies the time duration during which the cell is optimal for handover. | M | type: ProjectionDuration  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| projectedVResCon | This specifies the projected virtual resource consumption of the gNB.  This exist only in case of virtual gNB. | CM | type: VirRes  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| projectedRResCon | This specifies the projected radio resource consumption of the cell. | M | type: RadRes  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.15 VirRes <<dataType>>

#### 8.5.15.1 Definition

This data type specifies the virtual resource consumption.

#### 8.5.15.2 Information elements

Table 8.5.15.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| virtualCPU | It indicates the average number of virtual CPU (see definition of numVirtualCpu in clause 7.1.9.2.3.2 of ETSI GS NFV‑IFA 011 [26]) usage over the time duration indicated by FutureOptimalTime attribute. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| virtualMemory | It indicates the average virtual memory size (see definition of virtualMemSize in clause 7.1.9.2.3.2 of ETSI GS NFV‑IFA 011  [26]) usage over the time duration indicated by FutureOptimalTime attribute. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| virtualDisk | It indicates the average virtual storage size (see definition of sizeOfStorage in clause 7.1.9.2.3.2 of ETSI GS NFV‑IFA 011  [26]) usage over the time duration indicated by FutureOptimalTime attribute. | M | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.16 RadRes <<dataType>>

#### 8.5.16.1 Definition

This data type specifies the radio resource consumption.

#### 8.5.16.2 Information elements

Table 8.5.16.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| dLPRBUsage | This specifies the average total usage (in percentage) of Physical Resource Blocks (PRBs) on the downlink for any purpose, over the time duration indicated by projectionTime attribute. | M | type: Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| uLPRBUsage | This specifies the average total usage (in percentage) of Physical Resource Blocks (PRBs) on the uplink for any purpose, over the time duration indicated by projectionTime attribute. | M | type: Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

### 8.5.17 ProjectionDuration <<dataType>>

#### 8.5.17.1 Definition

This data type specifies the time duration for which the projections are made.

#### 8.5.17.2 Information elements

Table 8.5.17.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| fromTime | This specifies the timestamp from when the projection are made | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| toTime | This specifies the timestamp till when the projection are made | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

8.5.18 ResourceUsageNF <<dataType>>

8.5.18.1 Definition

This data type specifies the type of resource usage for an NF.

8.5.18.2 Information elements

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Definition** | **Support qualifier** | **Properties** |
| nFId | It provides the DN of the NF (which can be a 5GC or an NG-RAN NF). | M | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| startTime | It indicates the start time of the time period. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| endTime | It indicates the end time of the time period. | M | type: DateTime  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| overallResourceUsage | It provides the statistical or predicted overall average usage (in percentage) of all of the resources. | M | type: Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| specificResourceUsage | It provides the statistical or predicted average usage of the specific type(s) of resources. | M | type: ResourceUsage  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

8.5.18.3 Constraints

None.

8.5.19 ResourceUsage <<dataType>>

8.5.19.1 Definition

This data type specifies the type of resource usage.

8.5.19.2 Information elements

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 8.5.19.2-1Name** | **Definition** | **Support qualifier** | **Properties** |
| resourceType | It indicates the type of resource.  The allowed value is “VirtualCpu”, “VirtualMemory”, “VirtualDisk”, “DLPRBTotal”, “ULPRBTotal”, or a vendor-specific value. | M | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| meanUsage | It provides the mean usage or predicted mean usage (in percentage) of the resource (indicated by the “resourceType” information element). | M | type: Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

8.5.19.3 Constraints

### None.8.5.20 PmPredictions <<dataType>>

#### 8.5.20.1 Definition

This data type specifies PMs and its predicted values.

#### 8.5.20.2 Information elements

Table 8.5.20.2-1

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Definition | Support qualifier | Properties |
| pmName | This specifies the name of the PM that is predicted. | M | type: String  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| pmPredictedValue | This specifies the predicted value of the PM specified by “pmName” attribute. | M | type: Integer/Real  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

# 9 Information model definitions for MDA

## 9.1 Imported and associated information entities

### 9.1.1 Imported information entities and local labels

Table 9.1.1-1

|  |  |
| --- | --- |
| Label reference | Local label |
| TS 28.622 [19], IOC, Top | Top |
| TS 28.622 [19], IOC, SubNetwork | SubNetwork |
| TS 28.622 [19], IOC, ManagedElement | ManagedElement |
| TS 28.622 [19], IOC, ManagedFunction | ManagedFunction |

### 9.1.2 Associated information entities and local labels

Table 9.1.2-1

|  |  |
| --- | --- |
| Label reference | Local label |
| TS 28.105 [24], IOC, AIMLInferenceFunction | AIMLInferenceFunction |
| TS 28.105 [24], IOC, MLEntity | MLEntity |

## 9.2 Class diagram

### 9.2.1 Relationships

This clause provides the relationships of relevant classes in UML.



NOTE: When the MDAEntity represents the ManagedElement or ManagedFunction, it means the MDAFunction is located in the NE/NF that the ManagedElement or ManagedFunction represents, but it does not mean the MDA is the feature of the NE/NF.

Figure 9.2.1-1: NRM fragment for MDA request and MDA report

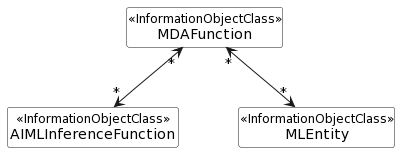


Figure 9.2.1-2: Relations for AI/ML supported MDA function

### 9.2.2 Inheritance



Figure 9.2.2-1: Inheritance Hierarchy

## 9.3 Class definitions

### 9.3.1 MDAFunction

#### 9.3.1.1 Definition

The IOC MDAFunction represents the MDA function which supports one or more MDA capabilities. The MDA function may be supported by AI/ML. Attribute MLEntityRef indicates that AI/ML is supported for this function. Attribute AIMLInferenceFuntionRef indicates that AI/ML Inference Function is supported for this function.

#### 9.3.1.2 Attributes

Table 9.3.1.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| supportedMDACapabilities | M | T | F | F | T |
| **Attribute related to role** |  | | | | |
| mlEntityRef | CM | T | F | F | T |
| aIMLInferenceFunctionRef | CM | T | F | F | T |

#### 9.3.1.3 Attribute constraints

|  |  |
| --- | --- |
| Name | Definition |
| mlEntityRef CM S | The condition is "The MDA function is supported by ML Entity". |
| aIMLInferenceFunctionRef CM S | The condition is "The MDA function is supported by AI/ML inference function". |

#### 9.3.1.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

### 9.3.2 MDARequest

#### 9.3.2.1 Definition

The IOC MDARequest represents the MDA output request created by an MnS consumer.

The attribute requestedMDAOutputs contains one or multiple MDAOutputPerMDAType elements, and each MDAOutputPerMDAType element supports filtering of MDA output for a certain MDA type.

The attribute reportingTarget may contain the target address, which instructs the MDA MnS producer to create, on behalf of the MnS consumer, a subscription of MDA report.

The MDA MnS consumer may state a filter to exclude recommended actions targeted towards entities for which the MDA MnS consumer cannot execute actions. The IE “recommendationFilter” can contain a list of DNs as “ManagedEntitiesScope” or can contain a list of geographical areas indicating all the entities falling under these areas are not considered for analytics recommendations. The “recommendationFillter” indicates the list of objects for which no actions can be taken and thus no prescriptive recommendations should be given.

#### 9.3.2.2 Attributes

Table 9.3.2.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| requestedMDAOutputs | M | T | T | F | T |
| reportingMethod | M | T | T | F | T |
| reportingTarget | M | T | T | F | T |
| analyticsScope | M | T | T | F | T |
| startTime | CM | T | T | F | T |
| stopTime | CM | T | T | F | T |
| recommendationFilter | O | T | T | F | T |

#### 9.3.2.3 Attribute constraints

Table 9.3.2.3-1

|  |  |
| --- | --- |
| Name | Definition |
| startTime | Condition: at least one MDA output IE in requestedMDAOutputs attribute is requested based on the choice of granularityPeriod. |
| stopTime | Condition: at least one MDA output in requestedMDAOutputs attribute is requested based on the choice of granularityPeriod. |

#### 9.3.2.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

### 9.3.3 MDAReport

#### 9.3.3.1 Definition

The IOC MDAReport represents the report containing the outputs for one or more MDA types delivered to the MDA consumer.

#### 9.3.3.2 Attributes

Table 9.3.3.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| mDAReportID | M | T | F | T | T |
| mDAOutputs | M | T | F | F | T |
| Attribute related to roles |  |  |  |  |  |
| mDARequestRef | M | T | F | F | F |
| NOTE: The content represented by this IOC can be reported by notification, file and streaming. | | | | | |

#### 9.3.3.3 Attribute constraints

None.

#### 9.3.3.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

## 9.4 Data type definitions

### 9.4.1 MDAOutputPerMDAType <<dataType>>

#### 9.4.1.1 Definition

This <<dataType>> represents the analytics output filters for each MDA type for an MDA request.

If only mDAType element is present (i.e. mDAOutputIEFilters element is not present), then all of the MDA output information elements for this mDAType (see analytics output definitions per MDA capability in clause 8) are requested.

if mDAOutputIEFilters element is present, then only the listed analytics output information elements are requested and shall be reported according to the corresponding threshold.

#### 9.4.1.2 Attributes

Table 9.4.1.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| mDAType | M | T | T | F | T |
| mDAOutputIEFilters | O | T | T | F | T |

#### 9.4.1.3 Attribute constraints

None.

#### 9.4.1.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.2 MDAOutputIEFilter <<dataType>>

#### 9.4.2.1 Definition

This <<dataType>> represents the filter for an MDA output information element for an MDA request.

If only mDAOutputIEName element is present (i.e. filterValue and threshold elements are not present), then the MDA output information element indicated by the mDAOutputIEName is requested and reported without filter or threshold.

If filterValue element is present (only applicable when the MDA output information element indicated by mDAOutputIEName is non-numeric type (e.g. enum, string)), then the MDA output information element indicated by the mDAOutputIEName is only requested and reported when its value equals to the value of filterValue.

If threshold element is present (only applicable when the MDA output information element indicated by mDAOutputIEName is numeric type (e.g. integer, real)), then the MDA output information element indicated by the mDAOutputIEName is only requested and reported when its value reaches or crosses the threshold.

If analyticsPeriod element is present (only applicable when filterValue and threshold elements are not present), then the MDA output information element indicated by the mDAOutputIEName is only requested and reported, at specified time or periodically, i.e. when time reaches the indicated time schedule.

timeOut element is present optionally when an MDA MnS consumer needs an mDAOutputIEName element before a specified time only.

#### 9.4.2.2 Attributes

Table 9.4.2.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable | isWritable | isInvariant | isNotifyable |
| mDAOutputIEName | M | T | T | F | T |
| filterValue | CO | T | T | F | T |
| threshold | CO | T | T | F | T |
| analyticsPeriod | O | T | T | F | T |
| timeOut | O | T | T | F | T |

#### 9.4.2.3 Attribute constraints

Table 9.4.2.3-1

|  |  |
| --- | --- |
| Name | Definition |
| filterValue | Condition: the MDA output information element indicated by the mDAOutputIEName element is non‑numeric type (e.g. enum, string). |
| threshold | Condition: the MDA output information element indicated by the mDAOutputIEName element is numeric type (e.g. integer, real). |

#### 9.4.2.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.3 AnalyticsScopeType <<choice>>

#### 9.4.3.1 Definition

This <<choice>> represents the scope of analytics.

When the managedEntitiesScope attribute is present, the MnS producer identify the analytics scope by the DNs of the managed entities.

When the areaScope attribute is present, the MnS producer identify the analytics scope by the geographical area information.

The managedEntitiesScope attribute and areaScope attribute shall not be present at the same time.

#### 9.4.3.2 Attributes

Table 9.4.3.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| Choice\_1 managedEntitiesScope | CM | T | T | F | T |
| Choice\_2 areaScope | CM | T | T | F | T |

#### 9.4.3.3 Attribute constraints

Table 9.4.3.3-1

|  |  |
| --- | --- |
| Name | Definition |
| Choice\_1 managedEntitiesScope | Condition: the MDA MnS producer supports to identify the scope by managed entities. |
| Choice\_2 areaScope | Condition: MDA MnS producer supports to identify the scope by geographical area information. |

#### 9.4.3.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.4 TimeWindow <<dataType>>

#### 9.4.4.1 Definition

This <<dataType>> represents the time duration related to the MDA output sent to the MDA MnS consumer.

#### 9.4.4.2 Attributes

Table 9.4.4.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| mDAOutputStartTime | M | T | T | F | T |
| mDAOutputEndTime | M | T | T | F | T |

#### 9.4.4.3 Attribute constraints

None.

#### 9.4.4.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.5 MDAOutputs <<dataType>>

#### 9.4.5.1 Definition

The <<dataType>> represents the MDA outputs created by a MDA MnS producer for a specific MDA type.

#### 9.4.5.2 Attributes

Table 9.4.5.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| mDAType | M | T | T | F | T |
| mDAOutputList | M | T | T | F | T |
| analyticsWindow | M | T | F | F | T |
| confidenceDegree | O | T | F | F | T |

#### 9.4.5.3 Attribute constraints

None.

#### 9.4.5.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.6 MDAOutputEntry <<dataType>>

#### 9.4.6.1 Definition

This data type specifies an MDA output.

#### 9.4.6.2 Attributes

Table 9.4.6.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| mDAOutputIEName | M | T | T | F | T |
| mDAOutputIEValue | M | T | T | F | T |

#### 9.4.6.3 Attribute constraints

None.

#### 9.4.6.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.7 AnalyticsSchedule <<choice>>

#### 9.4.7.1 Definition

The <<choice>> represents the time schedule for MDA.

When the timeDurations attribute is present, the MnS producer identifies the analytics schedule by the TimeWindow.

When the granularityPeriod attribute is present, the MnS producer identifies the analytics schedule by the granularity period (in unit of second).

#### 9.4.7.2 Attributes

Table 9.4.7.2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| Choice\_1 timeDurations | C | T | T | F | T |
| Choice\_2 granularityPeriod | CM | T | T | F | T |

#### 9.4.7.3 Attribute constraints

Table 9.4.7.3-1

|  |  |
| --- | --- |
| Name | Definition |
| Choice\_1 timeDurations | Condition: the MDA MnS producer supports to identify the time schedule by timeDurations. |
| Choice\_2 granularityPeriod | Condition: the MDA MnS producer supports to identify the time schedule by granularityPeriod. |

#### 9.4.7.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.8 ThresholdInfo <<dataType>>

#### 9.4.8.1 Definition

This data type defines a single threshold level.

#### 9.4.8.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| monitoredMDAOutputIE | M | T | T | F | T |
| thresholdDirection | M | T | T | F | T |
| thresholdValue | M | T | T | F | T |
| hysteresis | O | T | T | F | T |

#### 9.4.8.3 Attribute constraints

None

#### 9.4.8.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

## 9.5 Attribute definitions

### 9.5.1 Attribute properties

Table 9.5.1-1

| Attribute Name | Documentation and Allowed Values | Properties |
| --- | --- | --- |
| mDAType | It indicates the type of MDA type (corresponding to the MDA capability).  AllowedValues: the value of MDA type defined for each MDA capability in clause 8. | type: String  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| requestedMDAOutputs | It indicates the requested analytics outputs for an MDA request. | type: MDAOutputPerMDAType  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| mDAOutputIEFilters | It provides the filters for the analytics output information elements of an MDA type for an MDA request. | type: MDAOutputIEFilter  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| mDAOutputIEName | It indicates the analytics output information element name.  AllowedValues: the analytics output information element names for each MDA type as specified in clause 8. | type: string  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| filterValue | It indicates the filter value for analytics output information element for an MDA request.  The MDA output information element is only requested and reported when its value equals to the value of this attribute.  allowedValues: depends on the definitions of the analytics output information element (see clause 8) indicated by mDAOutputIEName attribute. | The type for the corresponding mDAOutputIEName as defined in clause 8 |
| threshold | It indicates the threshold for analytics output information element for an MDA request. | type: ThresholdInfo  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| analyticsPeriod | It indicates a list of time durations, or a time-period related to a time schedule for analytics. | type: AnalyticsSchedule  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| timeOut | It indicates a time until which an MDA MnS consumer needs to obtain an MDA output. Beyond this time the MDA output is no longer needed by the MDA MnS consumer. | type: DateTime (see TS 32.156 [18])  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| reportingMethod | It indicates the reporting method of the analytics output selected by the MnS consumer.  allowedValues: File, Streaming, Notification. | type: Enum  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| reportingTarget | It indicates the reporting target of the MDA outputs.  Allowed values: URI. | type: String  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| analyticsScope | It indicates the scope of the analytics requested by the MnS consumer. | type: AnalyticsScopeType  multiplicity: 0..1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |
| managedEntitiesScope | It indicates the scope of the analytics by the DNs of the managed entities.  It carries the DN(s) of SubNetwork MOI(s), ManagedElement MOI(s), and/or the MOI(s) of the derivative IOCs of ManagedFunction (see TS 28.622 [19]).  For each MOI provided by this attribute, the MOI itself and all of its subordinated MOIs are in the scope of analytics. | type: DN  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| areaScope | It indicates the scope of the analytics by the geographical area information. | type: GeoArea (see TS 28.622 [19])  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| startTime | It indicates the start time of the periodical analytics requested by the MnS consumer. | type: DateTime (see TS 32.156 [18])  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| stopTime | It indicates the stop time of the periodical analytics requested by the MnS consumer.  This attribute shall contain a NULL value in case the analytics is requested for an indefinite time period. | type: DateTime (see TS 32.156 [18])  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mDAReportID | It indicates the identifier for the MDAReport. | type: string  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mDAOutputList | It indicates a list of output results related to particular MDA type. | type: MDAOutputEntry  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| analyticsWindow | It indicates the time duration related to an MDA output. It can be in the past, when the analytics is statistics, or in the future for a prediction. | type: TimeWindow  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mDAOutputIEValue | It indicates the MDA output result that can be numeric or non-numeric. | The type for the corresponding mDAOutputIEName as defined in clause 8 |
| confidenceDegree | A probability range that contains the degree of accuracy of the analytics output statistics or prediction. | type: Real  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| supportedMDACapabilities | It indicates the MDA capabilities supported by the MDA function.  AllowedValues: the value of MDA types defined for the MDA capabilities in clause 8. | type: String  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| mDAOutputs | It indicates the analytics output results of one or more MDA types delivered to MDA consumer. | type: MDAOutputs  multiplicity: \*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| mDARequestRef | It indicates the DN of the MDARequest MOI for which the results are generated by the MDA producer. | type: DN  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| monitoredMDAOutputIE | It indicates the analytics output information element name monitored by a threshold.  AllowedValues: the analytics output information element names for each MDA type as specified in clause 8. | type: string  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| thresholdValue | It specifies the value against which the monitored MDA output information element is compared at a threshold level in case the hysteresis is zero.  allowedValues: float or integer | type: Union  multiplicity: 1  isOrdered: NA  isUnique: NA  defaultValue: None  isNullable: False |
| hysteresis | It specifies the hysteresis of a threshold. If this attribute is present the monitored MDA output information element value is not compared against the threshold value as specified by the thresholdValue attribute but against a high and low threshold value given by  highThresholdValue- = thresholdValue + hysteresis  lowThresholdValue = thresholdValue - hysteresis  When going up, the threshold is triggered when the MDA output information element value reaches or crosses the high threshold value. When going down, the threshold is triggered when the MDA output information element value reaches or crosses the low threshold value.  allowedValues: non-negative float or integer | type: Union  multiplicity: 0..1  isOrdered: NA  isUnique: NA  defaultValue: None  isNullable: False |
| thresholdDirection | It indicates the direction of a threshold indicating the direction for which a threshold crossing triggers a threshold.  When the threshold direction is configured to "UP", the associated treshold is triggered only when the subject MDA output information element value is going up upon reaching or crossing the threshold value. The treshold is not triggered, when the MDA output information element value is going down upon reaching or crossing the threshold value.  Vice versa, when the threshold direction is configured to "DOWN", the associated treshold is triggered only when the MDA output information element value is going down upon reaching or crossing the threshold value. The treshold is not triggered, when the MDA output information element value is going up upon reaching or crossing the threshold value.  When the threshold direction is set to "UP\_AND\_DOWN" the treshold is active in both direcions.  In case a threshold with hysteresis is configured, the threshold direction attribute shall be set to "UP\_AND\_DOWN".  allowedValues:  - UP  - DOWN  - UP\_AND\_DOWN | type: ENUM  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mDAOutputStartTime | It indicates the analytics start time for an MDA output. | type: DateTime (see TS 32.156 [18])  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mDAOutputEndTime | It indicates the analytics end time for an MDA output. | type: DateTime (see TS 32.156 [18])  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| timeDurations | It indicates a list of time duration. | type: TimeWindow  multiplicity: \*  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |
| granularityPeriod | It indicates the granularity period (in unit of second) of the analytics for an MDA output. In case of PM prediction, this indicates the granularity period of the prediction of the PMs. | type: integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| mlEntityRef | This attribute holds a DN of MLEntity (See TS 28.105 [24]). | type: DN  multiplicity: 0..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| aIMLInferenceFuntionRef | This attribute holds a DN of AIMLInferenceFuntion (See TS 28.105 [24]) | type: DN  multiplicity: 0..\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |
| recommendationFilter | It indicates the entities for which no recommendation should be generated for the specific MDAOutputPerMDAType. This could be provided either as managedEntitiesScope or as areaScope. | type: AnalyticsScopeType  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

## 9.6 Common notifications

### 9.6.1 Configuration notifications

This clause presents a list of notifications, defined in TS 28.532 [11], that an MnS consumer may receive. The notification header attribute objectClass/objectInstance shall capture the DN of an instance of a class defined in the present document.

Table 9.6.1-1

| Name | Qualifier | Notes |
| --- | --- | --- |
| notifyMOICreation | O | -- |
| notifyMOIDeletion | O | -- |
| notifyMOIAttributeValueChanges | O | -- |
| notifyEvent | O | -- |

# 10 MDA related service components

## 10.1 MDA MnS Service components

### 10.1.1 General

The MDA MnS service components are defined below for both MDA request and control and for MDA reporting taking into consideration the requirements defined in clause 7.3, the MDA capability data definitions in clause 8 and information models for MDA defined in clause 9

### 10.1.2 MDA report request and control

#### 10.1.2.1 Service components

Table 10.1.2.1-1: Components of MDA MnS for MDA request and control

|  |  |  |
| --- | --- | --- |
| Management service | Management service component type A | Management service component type B |
| MnS for MDA request and control | The operations and notifications can be referred in TS 28.532 [11]. Which can be supported by all use cases.  Operation:  - createMOI  - getMOIAttributes  - modifyMOIAttributes  - deleteMOI  Notification:  - notifyMOICreation  - notifyMOIDeletion  - notifyMOIAttributeValueChanges  - notifyEvent  - notifyMOIChanges | MDARequest IOC defined in clause 9.3.2. |

### 10.1.3 MDA reporting

#### 10.1.3.1 Service components

**Table 10.1.3.1-1: Components of MDA MnS for MDA reporting**

|  |  |  |  |
| --- | --- | --- | --- |
| Management service | Management service  component type A | Management service component type B | Management service component type C |
| MnS for MDA reporting - File based reporting | The operations and notifications in TS 28.532 [11], clause 11.6 are applicable and shall be supported for all MDA capabilities.  Operations:  - subscribe  - unsubscribe  - listAvailableFiles  Notifications:  - notifyFileReady  - notifyFilePreparationError | MDAReport IOC defined in clause 9. | The file containing the content defined by MDAReport IOC with the format specified in clause A.2.2. |
| MnS for MDA reporting - Streaming based reporting | The operations and notifications in TS 28.532 [11], clause 11.5 are applicable and shall be supported for all MDA capabilities.  Operations:  - establishStreamingConnection  - terminateStreamingConnection  - reportStreamData  - addStream  - deleteStream  - getConnectionInfo  - getStreamInfo | MDAReport IOC defined in clause 9. | The stream data containing the content defined by MDAReport IOC with the format specified in clause A.2.2. |
| MnS for MDA reporting - NRM notification based reporting | The following operations and notifications in TS 28.532 [11], clause 11.1 are applicable and shall be supported for all MDA capabilities.  Operations:  - getMOIAttributes  Notifications:  - notifyMOICreation  - notifyMOIDeletion  - notifyMOIChanges | MDAReport IOC defined in clause 9. |  |

# 11 Workflows for MDA management

## 11.1 MDA request and reporting workflow



Figure 11.1-1: Generic MDA request/reporting workflow

1 MDAS Producer creates MOI for MDARequest IOC (see createMOI operation defined in TS 28.532 [11]) for the MDAS Consumer with MDA request related information.

Note: Void

2. The MDAS producer subscribes to the relevant notifications or setup the streaming connections, per the selected reporting method (identified by reportingMethod attribute in the MDARequest MOI):

- If the reportingMethod designated in the MDARequest MOI is "File":

2a. if subscription for the reporting target (specified by the reportingTarget attribute in the MDARequest MOI) do not exist, the MDAS producer subscribes to the file data reporting related notifications (see TS 28.532 [11]) for the reporting target;

- If the reportingMethod designated in the MDARequest MOI is "Streaming":

2b/2c. if the streaming connection with the reporting target does not exist, the MDAS producer invokes the establishStreamingConnection operation (see TS 28.532 [11]) to setup the streaming connection with the streaming target;

2d/2e. if the streaming connection with the reporting target exists, the MDAS producer invokes the addStream operation (see TS 28.532 [11]) to add the stream for the expected MDA reports. And,

2f/2g. if the newly added stream is to replace an existing one, the MDAS producer invokes the deleteStream operation (see TS 28.532 [11]) to delete the stream.

NOTE 1: the order of 2d/2e and 2f/2g is not significant and could be swapped too.

- If the reportingMethod designated in the MDARequest MOI is "Notification":

2h. if subscription for the reporting target do not exist, the MDAS producer subscribes to the provisioning related notifications (see TS 28.532 [11]) for the reporting target.

NOTE 2: Although, the workflow assumes that different entities are playing the role of "MDAS Consumer" and "Reporting target", it is possible and allowed to have single entity playing the role of both "MDAS Consumer" and "Reporting target".

3. While the MDARequest is active, the MDAS Producer keeps performing MDA, and making the MDA report (see the MDAReport IOC defined in clause 9) according to the MDARequest MOI.

3a. the MDAS producer makes the MDA report ready and sends the MDA report to the reporting target per the selected reporting method (identified by reportingMethod attribute in the MDARequest MOI):

- If the reportingMethod designated in the MDARequest MOI is "File":

3b. the MDAS producer makes the MDA report into a file;

3c. the MDAS producer emits the notifyFileReady notification (see TS 28.532 [11]) to the reporting target for the MDA report.

- If the reportingMethod designated in the MDARequest MOI is "Streaming":

3d. the MDAS producers makes the MDA report into a stream data unit;

3e. invokes the reportStreamData operation (see TS 28.532 [11]) to the reporting target for the MDA report.

- If the reportingMethod designated in the MDARequest MOI is "Notification":

3f. the MDAS producer creates and MDAReport MOI (see clause 9) for the MDA report;

3g. if notifyMOICreation is used, the MDAS producer emits the notifyMOICreation notification (see TS 28.532 [11]) to the reporting target for the MDA report.

3h. if notifyMOIChanges is used, the MDAS producer emits the notifyMOIChanges notification (see TS 28.532 [11]) to the reporting target for the MDA report.

# 12 Solution Set (SS)

The present document defines the following NRM Solution Set definitions for MDA:

- YAML based Solution Set (Annex A).

Annex A (normative):  
OpenAPI definitions of the MDA NRM and MDA report

# A.1 General

This annex contains the OpenAPI definitions of the MDA NRM and MDA report in YAML format.

The information models of the MDA NRM and MDA report are defined in clause 9.

Mapping rules to produce the OpenAPI definition based on the information model are defined in TS 32.160 [25].

# A.2 Solution Set (SS) definitions

## A.2.1 OpenAPI document "TS28104\_MdaNrm.yaml"

<CODE BEGINS>

openapi: 3.0.1

info:

title: MDA NRM

version: 18.3.0

description: >-

OAS 3.0.1 specification of the MDA NRM

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externalDocs:

description: 3GPP TS 28.104; MDA

url: http://www.3gpp.org/ftp/Specs/archive/28\_series/28.104/

paths: {}

components:

schemas:

#-------- Definition of types-----------------------------------------------------

MDATypes:

type: array

items:

type: string

MDAOutputs:

type: array

items:

$ref: '#/components/schemas/MDAOutputPerMDAType'

AnalyticsScopeType:

oneOf:

- type: object

properties:

managedEntitiesScope:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DnList'

- type: object

properties:

areaScope:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/GeoArea'

MDAOutputPerMDAType:

type: object

properties:

mDAType:

type: string

mDAOutputIEFilters:

type: array

items:

$ref: '#/components/schemas/MDAOutputIEFilter'

MDAOutputIEFilter:

type: object

properties:

mDAOutputIEName:

type: string

filterValue:

type: string

threshold:

$ref: '#/components/schemas/ThresholdInfo'

analyticsPeriod:

$ref: '#/components/schemas/AnalyticsSchedule'

timeOut:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DateTime'

ReportingMethod:

type: string

enum:

- FILE

- STREAMING

- NOTIFICATION

ReportingTarget:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/Uri'

AnalyticsSchedule:

oneOf:

- type: object

properties:

timeDurations:

type: array

items:

$ref: 'TS28104\_MdaReport.yaml#/components/schemas/TimeWindow'

- type: object

properties:

granularityPeriod:

type: integer

ThresholdInfo:

type: object

properties:

monitoredMDAOutputIE:

type: string

thresholdDirection:

type: string

enum:

- UP

- DOWN

- UP\_AND\_DOWN

thresholdValue:

oneOf:

- type: integer

- $ref: 'TS28623\_ComDefs.yaml#/components/schemas/Float'

hysteresis:

oneOf:

- type: integer

minimum: 0

- type: number

format: float

minimum: 0

#-------- Definition of types for name-containments ------

SubNetwork-ncO-MdaNrm:

type: object

properties:

MDAFunction:

$ref: '#/components/schemas/MDAFunction-Multiple'

MDAReport:

$ref: '#/components/schemas/MDAReport-Multiple'

ManagedElement-ncO-MdaNrm:

type: object

properties:

MDAFunction:

$ref: '#/components/schemas/MDAFunction-Multiple'

#-------- Definition of abstract IOCs --------------------------------------------

#-------- Definition of concrete IOCs --------------------------------------------

MDAFunction-Single:

allOf:

- $ref: 'TS28623\_GenericNrm.yaml#/components/schemas/Top'

- type: object

properties:

attributes:

allOf:

- $ref: 'TS28623\_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'

- type: object

properties:

supportedMDACapabilities:

$ref: '#/components/schemas/MDATypes'

- $ref: 'TS28623\_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'

- type: object

properties:

MDARequest:

$ref: '#/components/schemas/MDARequest-Multiple'

MDARequest-Single:

allOf:

- $ref: 'TS28623\_GenericNrm.yaml#/components/schemas/Top'

- type: object

properties:

attributes:

allOf:

- type: object

properties:

requestedMDAOutputs:

$ref: '#/components/schemas/MDAOutputs'

reportingMethod:

$ref: '#/components/schemas/ReportingMethod'

reportingTarget:

$ref: '#/components/schemas/ReportingTarget'

analyticsScope:

$ref: '#/components/schemas/AnalyticsScopeType'

startTime:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DateTime'

stopTime:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DateTime'

recommendationFilter:

$ref: '#/components/schemas/AnalyticsScopeType'

MDAReport-Single:

$ref: 'TS28104\_MdaReport.yaml#/components/schemas/MDAReport'

#-------- Definition of JSON arrays for name-contained IOCs ----------------------

MDAFunction-Multiple:

type: array

items:

$ref: '#/components/schemas/MDAFunction-Single'

MDARequest-Multiple:

type: array

items:

$ref: '#/components/schemas/MDARequest-Single'

MDAReport-Multiple:

type: array

items:

$ref: '#/components/schemas/MDAReport-Single'

#-------- Definitions in TS 28.104 for TS 28.532 ---------------------------------

resources-mdaNrm:

oneOf:

- $ref: '#/components/schemas/MDAFunction-Single'

- $ref: '#/components/schemas/MDARequest-Single'

- $ref: '#/components/schemas/MDAReport-Single'

<CODE ENDS>

## A.2.2 OpenAPI document "TS28104\_MdaReport.yaml"

<CODE BEGINS>

openapi: 3.0.1

info:

title: MDA Report

version: 18.3.0

description: >-

OAS 3.0.1 specification of the MDA Report

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externalDocs:

description: 3GPP TS 28.104; MDA Report

url: http://www.3gpp.org/ftp/Specs/archive/28\_series/28.104/

paths: {}

components:

schemas:

#-------- Definition of types-----------------------------------------------------

MDAOutputs:

type: object

properties:

mDAType:

type: string

mDAOutputList:

type: array

items:

$ref: '#/components/schemas/MDAOutputEntry'

analyticsWindow:

$ref: '#/components/schemas/TimeWindow'

confidenceDegree:

type: number

format: float

MDAOutputEntry:

type: object

properties:

mDAOutputIEName:

type: string

mDAOutputIEValue: {}

TimeWindow:

type: object

properties:

mDAOutputStartTime:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DateTime'

mDAOutputEndTime:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/DateTime'

#-------- Definition of MDA Report --------------------------------------------

MDAReport:

allOf:

- $ref: 'TS28623\_GenericNrm.yaml#/components/schemas/Top'

- type: object

properties:

attributes:

allOf:

- type: object

properties:

mDAReportID:

type: string

mDAOutputs:

$ref: '#/components/schemas/MDAOutputs'

mDARequestRef:

$ref: 'TS28623\_ComDefs.yaml#/components/schemas/Dn'

<CODE ENDS>

Annex B (informative):  
PlantUML source code

# B.1 PlantUML code for MDA workflow

## B1.0 Introduction

This annex contains the PlantUML source code for the MDA workflow specified in clause 11 of the present document.

## B.1.1 PlantUML code for MDA requesting and reporting workflow

@startuml

skinparam shadowing false

skinparam monochrome true

hide footbox

participant "MDAS consumer" as MC

participant "MDAS producer" as MP

participant "Reporting target" as RT

ref over MP, MC : 1. create MOI for MDARequest IOC

Alt reportingMethod is "File"

opt if the file data reporting related \nnotifications are not subscribed yet

ref over MP, RT : 2a. subscription creation of the file data reporting related notifications \nfor the reporting target

end

else reportingMethod is "Streaming"

alt if streaming(WebSocket) connection does not exist

MP -> RT: 2b establishStreamingConnection request

RT --> MP: 2c establishStreamingConnection response

else if streaming(WebSocket) connection exists

MP -> RT: 2d. addStream

RT --> MP: 2e addStream response

opt if an existing stream is replaced

MP -> RT: 2f. deleteStream

RT --> MP: 2g deleteStream response

end

end

else reportingMethod is "Notification"

opt if the provisioning related notifications are not \nsubscribed for the reporting target yet

ref over MP, RT : 2h. subscription creation of the provisioning related notifications \nfor the reporting target

end

end

loop while the MDARequest MOI exists and not stopped

MP -> MP: 3a. perform MDA and make the MDA report ready \n (according to the MDAReport IOC)

Alt reportingMethod is "File"

MP -> MP: 3b. make the MDA report into a file

MP -> RT: 3c. notifyFileReady (for the MDA report)

else reportingMethod is "Streaming"

MP -> MP: 3d. make the MDA report into a stream data unit

MP -> RT: 3e. reportStreamData (for the MDA report)

else reportingMethod is "Notification"

MP -> MP: 3f. create an MDAReport MOI for the MDA report

Alt notifyMOICreation is used \nto notify the creation of MDAReport MOI

MP -> RT: 3g. notifyMOICreation \n (for MDAReport IOC)

else notifyMOIChanges is used \nto notify the creation of MDAReport MOI

MP -> RT: 3h. notifyMOIChanges \n (for MDAReport IOC)

end

end

end

@enduml

# B.2 PlantUML code for class diagrams

## B.2.1 General

The present annex contains the PlantUML source code for the NRM diagrams defined in clause 9 of the present document.

### B.2.1 PlantUML code for Figure 9.2.1-2: Relations for AI/ML supported MDA function

@startuml

skinparam ClassStereotypeFontStyle normal

skinparam ClassBackgroundColor White

skinparam shadowing false

skinparam monochrome true

hide members

hide circle

'skinparam maxMessageSize 250

skinparam nodesep 60

class AIMLInferenceFunction <<InformationObjectClass>>

class MLEntity <<InformationObjectClass>>

class MDAFunction <<InformationObjectClass>>

MDAFunction "\*" <--> "\*" AIMLInferenceFunction

MDAFunction "\*" <--> "\*" MLEntity

@enduml

Annex C (informative):  
Change history

| **Change history** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2022-06 | SA#96 |  |  |  |  | Removal of comments | 17.0.1 |
| 2022-09 | SA#97e | SP-220850 | 0001 | 1 | F | Rectifying attribute properties | 17.1.0 |
| 2022-09 | SA#97e | SP-220850 | 0013 | - | F | Corrections to MDAOutputIEFilte | 17.1.0 |
| 2022-09 | SA#97e | SP-220850 | 0014 | 1 | F | fix incorrect yaml file name in TS28.104 | 17.1.0 |
| 2022-09 | SA#97e | SP-220851 | 0015 | 1 | F | Correction of MDA request and reporting workflow | 17.1.0 |
| 2022-09 | SA#97e |  |  |  |  | Alignment with the code in FORGE (MCC) | 17.1.1 |
| 2022-12 | SA#98e | SP-221166 | 0017 | - | F | Adding Stage 2 definitions of missing attributes | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0018 | - | F | Changing recommendation attributes of time from type DateTime to TimeWindow | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0019 | - | F | Adding appropriate reference to GeoArea from NRM definition - Stage 2 and Stage 3 | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0020 | - | F | Correcting the attribute properties for MDA request and response IOCs | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0024 | - | F | Add the missing data type definition for threshold | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0025 | 1 | F | Correction of definition for analytics window | 17.2.0 |
| 2022-12 | SA#98e | SP-221167 | 0026 | - | F | Remove S-NSSAI from example of analytics output | 17.2.0 |
| 2022-12 | SA#98e | SP-221166 | 0029 | 1 | F | Update MDA assisted energy saving | 17.2.0 |
| 2023-03 | SA#99 | SP-230193 | 0030 | - | F | Fixing inconsistencies in Energy Saving related attribute definitions | 17.3.0 |
| 2023-03 | SA#99 | SP-230193 | 0031 | - | F | Correct error of references number | 17.3.0 |
| 2023-03 | SA#99 | SP-230193 | 0033 | - | F | Correct errors in HOTargetType and NRM fragment note | 17.3.0 |
| 2023-03 | SA#99 | SP-230193 | 0034 |  | F | Improve definition of network slice throughput analysis | 17.3.0 |
| 2023-03 | SA#99 | SP-230193 | 0040 |  | F | Correct multiplicity of attribute mDAOutputIEName | 17.3.0 |
| 2023-03 | SA#99 | SP-230193 | 0041 | 1 | F | Correction of terminology | 17.3.0 |
| 2023-06 | SA#100 | SP-230655 | 0044 | - | F | Correcting attribute type for Recommended 3GPP action and MDA type for Paging Use case | 17.4.0 |
| 2023-06 | SA#100 | SP-230655 | 0047 | 1 | F | Correction of attributes in MDAOutputs dataType | 17.4.0 |
| 2023-06 | SA#100 | SP-230655 | 0048 | - | F | Remove duplicate mdaType in MDA report | 17.4.0 |
| 2023-06 | SA#100 | SP-230655 | 0053 | 1 | F | Corrections of the requirements on MDA capability | 17.4.0 |
| 2023-06 | SA#100 | SP-230669 | 0050 | 1 | B | Add information elements related to service experience analysis | 18.0.0 |
| 2023-06 | SA#100 |  |  |  |  | Correction of a misimplemented CR | 18.0.1 |
| 2023-09 | SA#101 | SP-230954 | 0055 | - | A | Correcting datatype for Energy Saving Recommendation for NRCELL and UPF | 18.1.0 |
| 2023-09 | SA#101 | SP-230955 | 0056 | - | B | Update MDA capability of fault management for interruption scenario | 18.1.0 |
| 2023-12 | SA#102 | SP-231467 | 0063 | 1 | A | Correct issues for AnalyticsSchedule datatype | 18.2.0 |
| 2023-12 | SA#102 | SP-231467 | 0065 | 1 | A | Rel-18 CR TS 28.104 Correct issues for MDA information Model | 18.2.0 |
| 2023-12 | SA#102 | SP-231467 | 0069 | - | A | Correction on startTime and stopTime in MDARequest | 18.2.0 |
| 2023-12 | SA#102 | SP-231467 | 0073 | - | A | Correct issues for references of enabling data | 18.2.0 |
| 2023-12 | SA#102 | SP-231467 | 0077 | 1 | A | Rel-18 CR 28.104 Correction of attribute properties | 18.2.0 |
| 2023-12 |  |  |  |  |  | Alignment with the Forge | 18.2.0 |
| 2024-03 | SA#103 | SP-240186 | 0078 | - | F | TS28.104 Rel18 correction to Schema definition Issues for SubNetwork and ManagedElement of OpenAPI SS | 18.3.0 |
| 2024-03 | SA#103 | SP-240155 | 0079 | 1 | B | Add relations for NRMs related to AI/ML inference capabilities | 18.3.0 |
| 2024-03 | SA#103 | SP-240163 | 0080 | 1 | F | Rel-18 CR 28.104 correction on configuration data used as enabling data | 18.3.0 |
| 2024-03 | SA#103 | SP-240163 | 0081 | 1 | F | Rel-18 CR 28.104 correction on MDA request and reporting workflow | 18.3.0 |
| 2024-03 | SA#103 | SP-240162 | 0083 | 1 | A | Rel-18 CR 28.104 adding missing MDAEntity | 18.3.0 |
| 2024-03 | SA#103 | SP-240162 | 0085 | 1 | A | Rel-18 CR 28.104 correction on MDAReport IOC | 18.3.0 |
| 2024-03 | SA#103 | SP-240163 | 0086 | 1 | B | Add solution for MDA assisted service failure recovery | 18.3.0 |
| 2024-03 | SA#103 | SP-240162 | 0088 | 1 | A | Rel-18 CR 28.104 Fix error in definition of analyticsPeriod | 18.3.0 |
| 2024-03 | SA#103 | SP-240208 | 0090 | - | B | CR TS 28.104 Rel-18 eMDAS\_Ph2 Further enhancements into the Management Data Analytics (Phase 2) | 18.3.0 |